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DESIGN FOR SIX SIGMA:
STRATEGY AND MODELS FOR NEW SERVICE DEVELOPMENT

DESIGN FOR SIX SIGMA:
STRATEGIA E MODELLI PER IL NEW SERVICE DEVELOPMENT

Direttore della Scuola: Ch.mo Prof. Giuseppe Stellin

Coordinatore d'indirizzo: Ch.mo Prof. Cipriano Forza

Supervisore: Ch.mo Prof. Alberto F. De Toni

Dottorando: Ing. Matteo Campanerut

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"Si ringrazia la
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la realizzazione della presente tesi”

To my family

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SOMMARIO

Durante l'ultima parte del 20° secolo, il settore dei servizi ha registrato una crescita significativa in tutti i paesi sviluppati, al pari della competizione globale e della necessità di offrire nuovi servizi per soddisfare bisogni e aspettative dei clienti. Tuttavia, se da un lato vi è stato un volume cospicuo di ricerca sul Service Management, gli studi sul New Service Development (NSD) sono stati di molto inferiori.

Linderman *et al.* (2003) definiscono il Design For Six Sigma (DFSS) come un metodo organizzato e sistematico per il miglioramento strategico e per lo sviluppo di nuovi prodotti e processi tramite strumenti statistici, al fine di ridurre drasticamente i difetti e le variazioni percepite dai clienti.

Nel corso dell'ultimo decennio, la letteratura generale sul Six Sigma è cresciuta costantemente. Le applicazioni più frequenti hanno riguardato il miglioramento dei processi esistenti nel settore manifatturiero e dei servizi, utilizzando il noto modello DMAIC, mentre le pubblicazioni sul DFSS hanno rappresentato una percentuale molto minore. Inoltre, mentre numerosi sono stati gli autori che hanno studiato l'impatto del DFSS alla progettazione di prodotto (e.g. Chakravorty, 2009; Bañuelas e Antony, 2004; Goel e Chen, 2008), la ricerca scientifica sulle applicazioni del DFSS al NSD è stata scarsa e non ci sono studi empirici sull'applicazione della metodologia al NSD.

Le tipologie di servizio, infatti, sono eterogenee e in letteratura è difficile trovare metodologie olistiche a supporto del processo di progettazione del servizio.

Questa tesi ha tre obiettivi. Il primo è individuare quali sono le aree manageriali su cui concentrare gli sforzi e le risorse dell'organizzazione, al fine di applicare con successo la metodologia DFSS ai processi di servizio.

Il secondo è quello di individuare una serie di Best Practice per l'applicazione del DFSS ai servizi, che risultino trasversali ad ogni classe di processo di servizio.

Infine, poiché i processi di servizio sono per natura molto eterogenei, l'ultimo obiettivo è quello di formulare alcuni modelli, per adattare con successo l'applicazione della metodologia ai diversi processi di servizio e massimizzare i risultati ottenuti dall'organizzazione.

Sulla base di un primo studio esplorativo, al fine di rispondere a queste domande, dei casi studio multipli sono stati avviati, confrontando i risultati in quattro diverse organizzazioni che hanno applicato il DFSS ai loro processi di servizio.

I risultati empirici emersi in questi casi di studio sono stati raccolti e sintetizzati in quaranta Best Practice, in forma di asserzioni, e raggruppati nei cinque aspetti della metodologia individuati attraverso il caso studio pilota di cui sopra.

Successivamente, abbiamo effettuato una cross-case analysis per trovare similitudini e differenze tra le Best Practice, ed estrapolare i risultati per rispondere alla domanda di ricerca.

Come risultato finale, l'analisi dei dati ci ha permesso di individuare cinque modelli, corrispondenti ai cinque aspetti della metodologia accennati in precedenza, che mostrano come le organizzazioni dovrebbero adattare l'applicazione del Six Sigma a seconda del tipo di processo di servizio da progettare o riprogettare.

I risultati ottenuti con questo studio sono stati duplici. Da un punto di vista accademico, dal momento che la ricerca empirica sulle applicazioni del DFSS ai servizi era del tutto assente, questo studio colma una lacuna importante nella letteratura scientifica sul Six Sigma. Inoltre, importanti implicazioni manageriali sono state ottenute, spiegando quali sono le aree critiche per l'applicazione del DFSS ai servizi e identificando sia una serie di Best Practice generali, sia alcuni modelli specifici per adattare la metodologia ai diversi processi di servizio.

ABSTRACT

During the latter part of the 20^{th} century, the service sector registered a significant growth in every developed country, as well as global competition and the pressure to offer new services to satisfy customer needs and expectations. However, whereas there has been a respectable amount of research in the service management literature, research specifically in the context of New Service Development (NSD) was very little.

Linderman *et al.* (2003) define Design For Six Sigma (DFSS) as an organized and systematic method for the strategic improvement and for developing new products and processes using statistical tools in order to drastically reduce defects and variations perceived by the customers.

Over the last decade, the general literature on Six Sigma has steadily grown. The most frequent applications have regarded the improvement of existing processes in manufacturing and services, using its well-established method, i.e. the DMAIC model, while publications on DFSS have been fewer. Furthermore, while several have been the authors that have investigated the impact of the DFSS method to product design (e.g. Chakravorty, 2009; Bañuelas and Antony, 2004; Goel and Chen, 2008), scientific research on applications of DFSS on the NSD process is very scant and there are no empirical studies on the application of the methodology to NSD.

Service typologies, indeed, are heterogeneous and in literature is difficult to find methodologies to support the service design process and consequently reduce its variability.

This thesis has three purposes. The first is outlining the managerial areas on which to focus the efforts and resources of the organization, in order to successfully implement the DFSS methodology to service processes.

The second one is to identify a series of Best Practices for the application of DFSS to services that are transversal to every class of service process.

Finally, since service processes are for characteristics, very heterogeneous, the last purpose is to formulate some models, in order to successfully adapt the methodology to different service processes and maximize the results obtained in the organization.

On the basis of a first exploratory study, in order to respond to these questions, a multiple case study has been launched, comparing the results in four different organizations that have applied the Six Sigma methodology in order to design or redesign their service processes. Empirical results emerged in these case studies have been gathered and translated into forty best practices, in the form of statements, and grouped in five aspects of the methodology identified through the pilot case study above mentioned.

Afterwards, we carried out a cross-case analysis to find similarities and differences between the best practices, and extrapolate the results in response to the research question, finding how the best practices fit with different classes of service process defined previously. As a final result, the data analysis allowed us to identify five models, corresponding to the five Six Sigma aspects mentioned earlier, which show how organizations should differ Six Sigma application for each kind of new service process to design or redesign.

The main results of this study have been twofold. By an academic point of view, since empirical research on DFSS applications in service processes was totally lacking, this study fills an important gap in scientific literature on Six Sigma. Furthermore, important managerial implications have been developed, explaining what are the critical areas to manage to successfully apply DFSS to services and identifying both a series of general Best Practices and some specific models to better adapt the methodology to different service processes.

INTRODUCTION

In the new socio-economic environment, the innovation, which is connected with the introduction of new products and services, has become more and more a critical task. For a long time this process has been rather artisanal and manual oriented. It is important to make all the efforts to improve it as much as possible to make it more effective, efficient and economical.

During the latter part of the 20th century, the service sector significantly grew in every developed country, with the United States taking the lead (Heineke and Davis, 2007). In the most advanced countries, more than half of gross domestic product is in the service sector, which is expected to rule economics and job growth through the 21st century (Pilat, 2000). Moreover, global competition and technological change is growing worldwide, as well as the pressure to offer new services to satisfy customer needs (Menor *et al.*, 2002).

However, whereas there has been a respectable amount of research in the New Product Development (NPD) and service management literature, there has been very little research specifically in the context of New Service Development (NSD) (Alam and Perry, 2002). Existing research suggests that new services are mostly developed through unorganized and unsystematic processes and in literature there are no generally accepted methodologies on this focus (Menor *et al.*, 2002). Clancy and Shulman (1991) assert, for example, that in the financial service industry a new service failure rate of 80% has been reported. More in general, Johne and Storey (1998) claim that a large proportion of NSD is not successful. Therefore, it seems evident that further research on NSD is requested in order to overcome these problems.

Design For Six Sigma (DFSS) is an accepted application of the Six Sigma approach to design and develop new products or new service processes (Antony and Bañuelas, 2002; Schroeder *et al.*, 2008) that meet or exceed customer expectations, employing well-established tools and techniques (Kwak and Anbari, 2006). Linderman *et al.* (2003) define DFSS as an organized and systematic method for the strategic improvement and for developing new products and processes using statistical tools in order to drastically reduce defects and variations perceived by the customers. DFSS applies these tools combining them with a team approach.

In the last decades, several scholars have investigated Six Sigma methodology, e.g. Bañuelas and Antony (2002), Linderman *et al.* (2003), Antony (2006), Savolainen and Haikonen (2007), Schroeder *et al.* (2008) and Chakravorty (2009), carrying out their research on different aspects of the topic. However, as a matter of fact, only 20% of the Six Sigma literature deals with DFSS. At the same time, while different scholars have contributed to the research of DFSS applications for product design (Antony and Bañuelas, 2002; Bañuelas and Antony, 2004; Goel and Chen, 2008; Chakravorty, 2009), other authors have shown that empirical research on applications of DFSS on the NSD process is totally lacking (Campanerut and Nicoletti, 2010).

These considerations helped to formulate the three important research questions of this thesis, that are:

1. What are the aspects that organizations should manage to implement DFSS to design or redesign new service processes?

2. What are the best practices that firms must own to successfully implement DFSS to different typologies of service process?

3. What are the models to effectively manage the aspects of DFSS in the case of different typologies of service processes?

Service typologies are heterogeneous and because of this, in literature it is difficult to find methodologies to support the service design process and consequently reduce its variability. We have proposed a classification of service processes to demonstrate how in different situations the DFSS application needs to change to be the most effective, efficient and economical.
For these purposes, we thoroughly followed some steps, as follows. After a deep and systematic literature review on the Six Sigma topic, to address the research questions, an exploratory case study in Motorola Inc., an American telecommunications company was launched (Campanerut and De Toni, 2010). This pilot suggested to deeply analyze five specific aspects of the methodology, belonging to the three decision levels, i.e. strategic, organizational and operational:

1. *Strategic project selection*, dealing with the ability of the company to connect corporate strategy to Six Sigma project selection (Strategic level);

2. *Culture and intangible assets*, dealing with values, knowledge and Six Sigma training throughout the company (Organizational level);

3. *Actors and organizational structure*, dealing with the meso-structure of Six Sigma organization and the people involved in the project teams (Organizational level);

4. *Methodology implementation*, dealing with the models that organizations can use to apply the methodology and the procedures for its application (Operational level);

5. *Methodology tools*, dealing with the best tools that organizations can use in the model to improve its implementation (Operational level).

Afterwards, to respond to the research questions and find the best practices among different kinds of services, a multiple case study has been launched, comparing the results in four different organizations that have applied the Six Sigma methodology in order to design or redesign their service processes.
We decided to analyze several case studies, given the limited external validity of a single case results (Yin, 1981; Yin, 2005). After the first phase of literature review on Six Sigma, DFSS and NSD topics, we selected organizations operating in different service contexts that are innovative in introducing new services and products (which in turn would require new services). We used the method of retrospective analysis and we selected examples of Best Practice in order to analyze the critical factors of success (Voss *et al.*, 2002).
To increase the generalization of the results, we followed the indications of Miles and Huberman (1994) and Voss *et al.* (2002); we designed four polar case studies outlining common and contrasting characteristics. There are some common characteristics: all the four case studies are designed in big multinational private organizations that use Six Sigma for the development of new services. About contrasting characteristics, we chose the organizations' experience in the methodology application, the core business of the organizations and what kind of customers new service processes are normally directed to. These organizations are respectively Motorola, GE Oil & Gas, GE Capital, and UniCredit Group.

Empirical results emerged in these case studies have been gathered and translated into forty best practices, in the form of statements, and grouped by the five aspects above mentioned.

Afterwards, we carried out the comparative analysis of the case studies to find similarities and differences between the best practices, and extrapolate the results in response to the research question, finding how the best practices fit with different classes of service process defined previously. As a final result, the data analysis allowed us to identify five models, corresponding to the five Six Sigma aspects mentioned earlier, which show us how organizations should differ Six Sigma application for each kind of new service process to design or redesign.

Comparative analysis, following the dictates of Eisenhardt (1989) and Yin (2005), was characterized by an iterative process of systematic comparison of the four case studies with the literature references in order to integrate empirical evidence with the scientific basis, ensuring the external validity of results.

This doctoral thesis is structured in four main parts, i.e. Theoretical background (seven chapters), Empirical study (three chapters), Results (two chapters) and Appendix, as follows.

In the first chapter the general topic of quality management is outlined.

This synthesis introduces the second chapter, that is about the main subject of the thesis, i.e. the Six Sigma methodology, whose main characteristics and importance are explained.

In the third chapter, a rigorous systematic review of the literature that allowed us to achieve a synthesis on the methodology, highlighting the main areas of study and the most important features. In the end, have been identified eight areas of study in the literature, fall into four macro-areas, i.e. theoretical, operational, organizational and strategic.

With this review, in the fourth chapter it was possible to establish a framework of the main gap in the existing literature on Six Sigma and outline our research questions.

Due to the formulation of the research questions, in the next three chapters, the second part of the theoretical background is expounded. In chapter five, a summary of the service sector and service management in general is created.

In chapter six, the recent topic of New Service Development is explained, defining its main characteristics and showing with another brief literature review, its importance associated to the purposes of this study.

Finally, in the seventh chapter, the new classification of service processes is proposed on the basis of the previous study, in order to respond to the three research questions and offer a pillar for the rest of the thesis. To outline this classification, a thorough analysis of previous classification criteria in literature has been made.

Afterwards, the three chapters of the empirical study part are structured as follows. In chapter eight, the research methods of this thesis are explained in detail, from the systematic literature review to the multiple case study, passing through the pilot case and the confirmatory review.

In chapter nine, the above mentioned exploratory study in Motorola is expounded, to identify areas of the methodology on which to focus the investigation. The analysis was made explicit on the basis of the theoretical frame work consisting of the five areas previously identified, i.e. methodology tools, methodology implementation, actors and organizational structure, culture, and intangible assets, strategic project selection.

In chapter ten, we develop the multiple case study research, to respond to the research questions and find the best practices among different kinds of services. We explained the results in four different organizations that have applied the Six Sigma methodology in order to design or redesign their service processes. We selected organizations operating in different service contexts that are innovative in introducing new services and products (which in turn would require new services). We used the method of retrospective analysis.

The next two chapters, eleven and twelve belonging to the third part of the thesis, are aimed to explain the results of this study.
The former is about expounding the cross-case analysis and identifying the above mentioned management Best Practices through this research methodology, i.e. comparing similarities and differences among all the aspects of the four case studies.
The latter is about a synthesis of data gathered so far, in order to develop the five different management models for DFSS, one for each aspect of the methodology. These models allow organizations applying and adapt DFSS to the different service processes outlined in chapter seven, depending on the interface between the customer and the company, i.e. people or technology based and the extension of contact between such interface and the customer during service delivery.
Finally, the last section of this thesis summarize the conclusions of this work, outlining which are its major limits and overall suggesting what the future directions of this research might be.
In addition to these chapters, the appendix in the fourth part offer several information used in the thesis, e.g. a worldwide list of research centers on these topics, a scheme of the different publications quoted, a brief description of some of the main authors and a list with all the items gathered in the systematic literature review on Six Sigma in chapter three.

PART I – THEORETICAL BACKGROUND

Chapter 1 -QUALITY MANAGEMENT

"Quality is like art. Everybody loves it, recognize it, but they give a different definition."
(Richard J. Schonberger)

1.1 Historical background

Quality has always been an integral part of products and services, however, awareness of its importance from the business point of view and the introduction of formal methods for its control have had an evolutionary development.
At the beginning of the twentieth century, science and the majority of business and industry were based on determinism, or the widespread belief that physical laws and in general economic models of the real world were the "true reality" and that everything we need to be able to predict the future was a sufficient amount of data. With sufficient data and appropriate equations, we could predict future events with an almost absolute certainty.
The variability and statistical overview of the world were not as widespread nor highly valued, except in some areas such as genetics and agriculture. In this context, the variability in the response of the experiments was seen as a limit in some way to overcome. In academia, courses on statistical mechanisms began to appear in the faculties of physics and engineering.
As regards the approach to quality, before the advent of large mass production, when production was artisanal, each operator, dealing with all phases of the production process, had total control on product quality (Feigenbaum, 1987).
The development of interchangeable parts such as production techniques led to the origin of mass production in the late nineteenth century. The introduction by Taylor (1911) of some of the principles of Scientific Management, led then to the final development of this industry. Taylor was a pioneer, proposing the division of labor in different activities, so goods could be produced and assembled more easily. His work led to substantial improvements in productivity, also thanks to standardized production and assembly methods; the quality of goods produced was positively influenced by it. However, as with the methods of standardization of work, he developed the concept of standard work, a set time to complete a task or a specific number of units that were to be produced in a given period. Despite having a positive impact on productivity, the development of these practices shifted the focus from the quality of employment. Furthermore, the standard work could potentially stop the innovation and continuous improvement, two critical aspects of all activities.
During the Twenties, there comes the concept of inspection and the consequent separation between quality control and production. The huge demand of mass production was an incentive to seek more efficient methods of inspection control.
In the late Twenties there began the industrial application of control charts devised by W. A. Shewart of Bell Laboratories. In the same timeframe, HF Dodge and H.G. Roming, also employed at Bell Laboratories, developed a statistically based sampling inspection as a practical alternative. The development and dissemination of such practices during the Thirties, marked the transition to a new phase, with the formal beginning of statistical quality control (SPC). However, this practice, thought as an extension of the inspection phase, found widespread only in the Forties. During the Second World War, the spread of control charts allowed the U.S. to produce war supplies at low cost and in large quantities (Ishikawa, 1992).
Subsequently, Deming and other scholars disseminate the principles of statistical quality control. The most significant contribution was resolved in the sample inspections rather than

100%, but the work of quality control is confined to the areas of production and grew rather slowly (Feigenbaum, 1987).

As a result of increased pressure on companies, immersed in a global competition to meet the delivery and maintain high levels of quality and reliability of the product, the idea of preventing defects began to be taken seriously.

In the Fifties it was first introduced in Europe and the USA the Design of Experiments (DOE), a methodology for improving products and processes. The DOE was developed and used by Fisher in the Twenties, to improve the efficiency and effectiveness in the field of agriculture. In the industrial field instead, the first applications of this method were in the chemical and process industry.

Some Japanese, however, took the lessons of three Americans like Feigenbaum, father of Total Quality Control and two other pioneers such as J.M. Juran and W. E. Deming, adapting to their specific needs the culture of Total Quality. In this way, companies began to develop a decision-making structure and operational requirements for product quality, in which the existing statistical control tools could be combined with additional technical tools for metrology, reliability, quality and motivation. The philosophy and tools of Total Quality Control marks the return of responsibility for the quality production and ensure real results for companies with regard to quality and lower costs.

Between the late Seventies and early Eighties there was the beginning of the spread of the DOE, when many Western companies found that their Japanese competitors using this methodology and other statistical tools since the Sixties for the identification of problems in processes and developing new ones, for the evaluation of product design and in many other aspects of product design. This discovery led to efforts to introduce this methodology in engineering and in the academic curriculum of many engineering faculty. According to Montgomery (2010), the DOE is one of the most powerful tools for quality improvement, since it is an active approach, in which the changes are approved and introduced in a systematic way to observe the effects.

In 1986, Bill Smith, an engineer at Motorola developed the Six Sigma program[1] as a response to the need to improve quality and reduce defects in products. The focus of Six Sigma aims to reduce the variability in key features for the quality of products around specific target values. Motorola established the Six Sigma is a goal for the company either as a focal point of efforts to improve the quality of products and processes. Over the years, the methodology was widely circulated, becoming a program to improve quality, reduce costs and expand the market for products and services. The Six Sigma in various forms, has been adopted by thousands of companies, of various sizes (Montgomery, 2010).

Among the various concepts for quality management developed during the twentieth century, there is also Lean Thinking[2] (or lean production/manufacturing, depending on the environment), which focuses on the control of resources in relation to customer needs and reducing waste. The concept was introduced by Toyota in a large scale in the Fifties, but was not called Lean manufacturing until the appearance of the famous book "*The Machine That Change The World*" in 1990 (Womack *et al.*, 1991).

In the late Eighties, the focus of quality programs focused mainly on Japanese design, and when then the Total Quality Control began to have greater impact on management practices and engineering, the term "*control*" became increasingly close to indicate the use of quality as a strategic weapon. So it was finally replaced by management and the expression became Total Quality Management.

[1] All the aspects of Six Sigma will be deeply outlined in the next chapter.
[2] Lean Thinking will be explained in the next section.

The ending period of the Eighties was marked by great excitement on the face of issues related to quality management, in addition to the aspects mentioned above, in 1987 there was the issue by the international organization of standardization of ISO 9000 in addition to the simultaneous commencement of the first formal model of TQM, associated with the establishment of the U.S. premium for quality, the *Malcolm Baldrige National Quality Award*.
The evolutionary path that has characterized these issues has required organizations to address an expansive approach to quality management, a strong coordinated effort by all departments. This results in the effective implementation of three activities: planning and design quality, quality assurance, monitoring and quality improvement (Montgomery, 2010).
The planning and design quality is a strategic asset, vital to the long-term success of an organization almost since the plan of product development, financial planning, marketing plan and the utilization of human resources. This activity involves the identification of internal and external customers and their needs. Then the products or services that meet customer expectations must be designed and developed.
Quality assurance is a set of activities to ensure that the quality levels of products and services are maintained and the quality problems of customers and suppliers are adequately resolved.
The control and quality improvement involves a set of activities used to ensure that products and services meet certain requirements and be improved continuously. Since the variability is often the major source of poor quality, the use of statistical techniques, including SPC and DOE are the major tools for the improvement and quality control.

1.2 Key issues and methods in quality management

In this section the focus will be some issues of particular relevance to the theme of quality management, which emerged earlier in the historical excursus. The Six Sigma methodology will instead be addressed in detail in the next chapter.

1.2.1 Total Quality Management

The concept of total quality has its origins in 1951 from the book Total Quality Control of A. V. Feigenbaum.
The meaning of the three terms that constitute the term Total Quality Control, are (Feigenbaum, 1987):

- **Total**: Each organization is responsible for quality. It involves the entire life cycle of the product or service and business processes, from marketing to customer service;

- **Quality**: Refers to the greatest effort to satisfy the customer, which shows specific requirements in terms of use and price of the product or service;

- **Control**: The process for delegating responsibility and authority for management, believing that the means available are suitable to reach customer satisfaction; alternately it is *"the ability to influence the process and product testing results consistent with the standards"*.

The concept of Total Quality Control is:

> *"Effective system to complement the efforts for the development, maintenance and improvement of the*

quality of the various groups in an organization so that marketing, engineering, manufacturing and service guarantee complete customer satisfaction at minimum cost."

(Feigenbaum, 1987)

In order to avoid that quality, which should be everyone's duty, became nobody's task, Feigenbaum suggested that it was guided by a well-organized function, whose only area of specialization was the quality of the product and whose sole activity was the operational quality control (Ishikawa, 1992). Entrusting to the production staff the prime responsibility for the quality of the product, has differentiated the Japanese approach from the one of Feigenbaum. Therefore, the Japanese chose to update the term from Total Quality Control to Company Wide Quality Control (CWQC) or more simply, Total Quality. In this philosophy, the teachings are also incorporated two other Americans: Deming, who laid the foundations for the path to quality by offering the PDCA cycle, where great emphasis was on taking the statistical tools and J. M. Juran, who taught the Japanese about the pragmatic aspects of quality management, introducing the need for change of attitude of management and the concept of self-control operator.
Juran, Deming and Feigenbaum naturally spread the same message also in the U.S. and Western Europe. Perhaps the environment is the key factor that allowed this message was understood better in Japan rather than in the West.
The Total Quality approach, which aims to considerable improvement in the quality of products with a substantial reduction of costs related to it, can count on the following principles:

1. **Quality first**: Management that emphasizes quality first (and profit) is able to gain the confidence of customers and gradually obtain substantial profits in the long term that will allow the company to maintain stable management (Ishikawa, 1992);

2. **Customer focus**: Customer satisfaction is critical to ensure continuity and prosperity of the company. Since the quality is not determined by the engineers, marketing or general manager but by the customer (Feigenbaum, 1987), it is crucial to pay attention to the consumer and adopt an attitude that privileges;

3. **Internal customers**: The idea that every department, office or process further downstream should be treated as a customer is the extension of the previous principle (Ishikawa, 1992). For both kind of customers the main objective satisfaction;

4. **Management based on data**: Always start with the facts, analyze data using statistical methods based on analysis and make the proper assessments taking action and implementing the necessary plans;

5. **Emphasis on prevention**: Prevention means to manage and focus on the process to build quality into the product (Feigenbaum, 1987). Problems should be eliminated by removing the causes and by prevention, not only by designing and implementing ex-post solutions;

6. **Respect and full participation of staff**: Employees are the most important asset: a management system based overall on the people, where every person is at ease, allows the unlimited potential of human expression;

7. **Management commitment**: Without the commitment and involvement the total quality management cannot take off (Ishikawa, 1992). Management must take responsibility for disseminating the quality culture and values, supporting all initiatives that affect creativity;

8. **Continuous improvement or kaizen**: The management, in addition to support the culture of quality, must recognize that the implementation of a program of Total Quality never stops. The approach "kaizen" is, in fact, to continuously improve every business process: the sum of the improvements at various stages will result in an improvement in the overall process;

9. **Process management**: Hierarchical structures based on a clear separation of duties and responsibilities are not suitable to promote and support the Total Quality. Only a system implementation towards an organization managed by processes can help the company to be transversal, managing all the aspects that affect quality (Ishikawa, 1992).

Despite the great popularity obtained from TQM, however, this approach has not been immune to failure. In this regard, Andersson *et al.* (2006), quoted a survey conducted by consultancy firms, showing that in only one-fifth, or more than one-third of TQM programs in the U.S. and Europe significant results, or at least tangible in improving quality and productivity have been achieved.
These issues seem to emerge because of a vague definition, within organizations, of the meaning of TQM. A solution to this problem is related to the need by industry professionals to improve their knowledge of tools and methodologies on quality, in order to be prepared for a similar approach (Andersson *et al.*, 2006).
We will stress in the next chapter how this problem has been solved in the Six Sigma methodology, with the higher importance given to the training.

1.2.2 ISO 9000

ISO 9000 are not a quality system but a set of quality standards defined necessary so that business be effective and competitive. The standards are based on eight management principles that can be used by management to help organizations improve their performance and achieve the highest quality results. These principles are: customer focus, leadership, employee involvement, management by processes, systemic approach of management, continuous improvement and partnership with customers and suppliers. The experts participating in the International Organization for Standardization Technical Committee define such principles and requirements related to them, (Raisinghani *et al.*, 2005).

1.2.3 The Malcolm Baldrige Award

The Malcolm Baldrige National Quality Award is probably the most famous prize for quality. It was created by the U.S. Congress in 1987 to improve the competitiveness of American companies, in order to seek the best known methods and use them as a reference point. The award was named to honor Malcolm Baldrige, who was secretary of commerce from 1981 to 1987 and worked to improve the efficiency and effectiveness of the governmental structure.

There are five categories of businesses eligible for the award of the prize: manufacturing, services, small business, education and health. Not all categories receive the prize each year.
In addition there are seven areas assessed in each company during the selection process. These categories are:

1)Leadership;
2)Strategic planning;
3)Customer focus and market;
4)Focus on information;
5)Analysis of human resources;
6)Process management;
7)Business results.

These criteria are used by thousands of organizations to improve relations with employees, customer satisfaction and productivity (Raisinghani *et al.*, 2005).

1.2.4 Lean Thinking

As noted previously, the concept of Lean was introduced on a large scale by Toyota in the Fifties, but was not called Lean manufacturing until the famous book "*The Machine That Change The World*" was published in 1990 (Womack *et al.*, 1990).
The various definitions in the literature agree that Lean is a systematic approach to identify and delete items that do not add value to the process. In this sense, the definition given by the NIST [3] (2000) is limited to:

> *"A systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection"*
>
> (NIST, 2000)

The principles of Lean are fundamentally driven by customer value, which makes them suitable for many areas of manufacturing and distribution (Andersson *et al.*, 2006).
The five basic principles of Lean manufacturing are widely recognized:

1. Understanding the **value** for the customer. Only what is perceived as value by the customer is important;

2. Identify the **value stream**. After including the value for the customer, the next step is to analyze the business process to determine what really adds value. If an action does not add value, it must be changed or removed from the process;

3. Make it **flow**. Focus of the organization should be a continuous flow along the supply chain rather than using big lots;

4. Make the flow be **pulled** by the customer. Supply chain management application avoids the production of goods to be stored. Customer demand pulls finished products through the system, and no work should be undertaken unless it is expressly required by the downstream stages;

[3] National Institute of Standards and Technology

5. Search for **perfection**. Continue to eliminate the elements that do not add value (waste) is a process of continuous improvement.

The principles of Lean are not effective in case where customer demand is unstable and unpredictable.
The main elements that contribute to the elimination of non value added activities are: overproduction, delays, transportation, storage, and handling defects. A variety of approaches are available to reduce or eliminate waste, e.g. the value stream analysis, and engineering change management, and document management. The instruments used include Kanban systems and Just In Time (JIT) for the reduction of inventory in stock (Andersson *et al.*, 2006).
There are many reasons for introducing the techniques of Lean in an organization, as this approach actively helps to cut costs and provide significant competitive advantages. Some of the main benefits of using this method are the reduction of work in progress, reduced cycle time and better customer satisfaction.
Although there are many successful stories associated with Lean, this approach has limitations. In particular, the Lean requires a stable platform, where the efficiency of scale can be maximized. This approach does not sit very well with highly dynamic conditions, and there is little commitment for flexibility because of the focus on perfection, which could make misunderstand the special conditions of the market in a particular period.

1.3 Quality in the service sector

The quality of products is traditionally associated with technical specifications. However, even in an industrial company, trying to enhance the image and the intangible characteristics of products, for example referring to aspects related to brand, status and lifestyle, represents an important aspect.
Services are characterized by a series of processes in which production and consumption may be difficultly separated and often where the consumer is actively involved in the production process. For this reason this is perceived as an extremely complex phenomenon. However, to develop models of management and marketing for services is important to understand what customers are looking for and what are the aspects that really appreciate (Grönroos, 2002).
The interest in service quality has begun to emerge in the late Seventies, and since then has attracted substantial attention of researchers and experts active in the field. In the literature on service marketing, the approach to quality was introduced by Grönroos (1982) with the concepts of service perceived quality and total perceived quality model for services. This approach is based on research conducted on consumer behavior and the effect that expectations concerning the performance of products in consumer evaluations have occurred.
Over the years the focus of research on quality of service has been moved and the perceived quality of the original model has evolved to help managers and researchers to understand what are the essential components of a service in the minds of customers. The aspects of service are defined during the simultaneous processes of production and consumption of the service itself. Thus, the perceived quality model was introduced as a conceptual frame work to describe how customers actually perceive the characteristics of a service.
The literature on service quality often asserted that the quality of a particular service is equivalent to how the customer perceives it. Services are processes that are perceived in a more or less subjective way, in which production and consumption take place simultaneously, and involve interactions with number of important moments between the customer and the

service provider. What happens during these interactions, called interactions between seller and buyer, will obviously have a major impact on how the service will be perceived. According to Grönroos (2002), therefore, the perceived quality of a service has two dimensions, a technical dimension, related to the result, and a functional dimension, related to the process.

What do customers receive in their interactions with the supplier is of great importance in the way in which they assess their quality. However, this is just one dimension, called the technical quality of the result of the service process. Often, that size can be measured objectively by customers because it is defined as a technical solution to a problem.

However, since there are many interactions between supplier and customer, the quality dimension is not representative of overall quality that the customer perceives and has received. The customer will be influenced by how the technical quality, the result or outcome of the process will be transferred. For example, the greater the frequency with which customers agree to self-service activities or other routine activities related to service delivery, the better the assessment of that service. Other customers may experiment long lines, however the atmosphere can have a positive impact on the buyer-seller interactions. In summary, the customer is also influenced by the way the service is delivered, i.e. the service experience. This is another dimension of quality closely linked to the buyer-seller interactions and servicedelivery. For this reason, the functional quality of the process, in literature is also defined as process quality.

As can be seen in the figure here below there are, according to Grönroos (2002), two key dimensions of quality: what the customer receives, i.e. the technical result or outcome of the process (technical quality) and how it is received, i.e. the functional dimension of process (functional quality). It seems evident that the functional quality cannot be assessed objectively, as it is normally perceived subjectively.

Even the corporate image is an issue of great importance in most services. It may affect the perception of quality in several ways. If in the mind of the customer, service provider is good, and therefore has a positive image, perhaps some small errors will be forgiven. But if these errors occur often, the image will change in worse. If the image is negative, the impact of each error is often higher rather than things were otherwise. In summary, regarding the perception of quality, the image can be viewed as a filter.

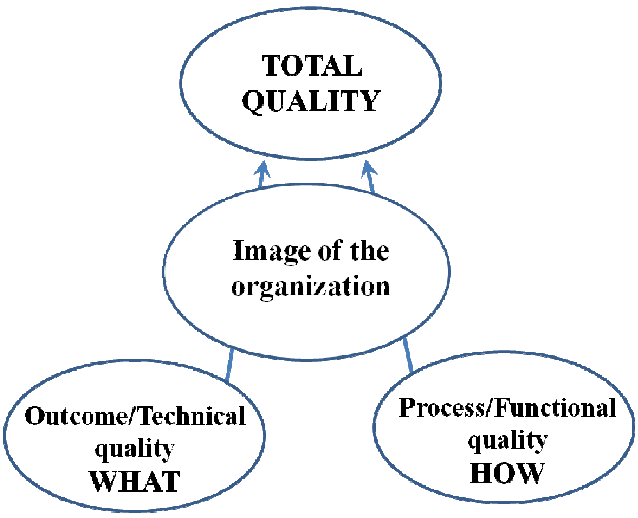

Figure 1.1: The two dimensions of service quality (Adapted from: Grönroos, 2002).

However, the process of quality perception is much more complicated. The experiences of the quality dimensions are not the only reason to determine if the service is considered good, bad or neutral.
The figure here below shows how the experiences of quality are linked to traditional marketing activities to result in the perceived quality of service. A good perception of quality is achieved when the experienced quality meets customer expectations, namely the quality they expect. If expectations are unrealistic, the total perceived quality will be insufficient, even if the quality is good respect standards. The quality that the customer expects is a function of many factors such as market communication, word of mouth communication, corporate image and customer needs. The communication market includes advertising, mail order, sales promotions, websites, and word of mouth marketing campaigns that are under the direct control of the company. Brand and word of mouth communication, as well as public relations, are only indirectly controlled by the company. These factors are a function of previous behavior of the company, argued, for example by advertising. Finally, even the customer's needs have an impact on their expectations.
When programs related to quality are implemented, which may also relate to aspects of functional quality, the perceived quality of service can continue to be insufficient, or even worse if, for example, the company simultaneously has launched advertising campaigns promising more than what it could do. The total level of perceived quality is not determined only by the level of technical and functional quality, but rather by the gap between the quality that was expected and perceived service quality (Grönroos, 2002).

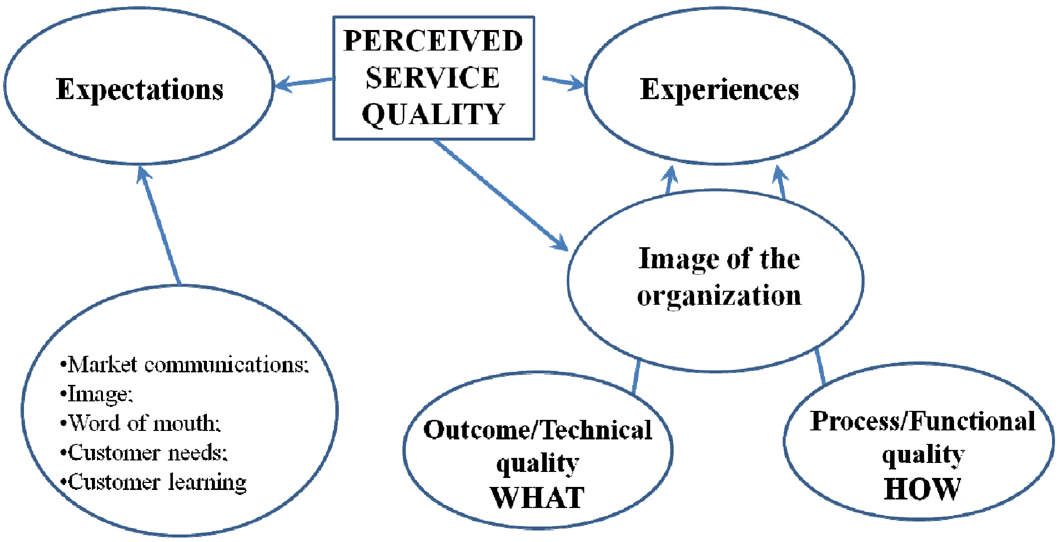

Figure 1.2: Perceived Service Quality (Adapted from: Grönroos, 2002).

1.3.1 Determinants of service quality and SERVQUAL

In the Mid-Eighties, Berry, Parasuraman and Zeithaml began to study the determinants of service quality and the way customers evaluate service quality based on the concept of perceived quality of service. The survey ascertained that ten determinants characterized the perception of the service by customers. One of them, the responsibility is clearly related to the technical quality of the result, while another, credibility is closely linked to the appearance of

the perceived quality. The other determinants are linked more or less directly to the size of the perceived quality of the process, focusing on the dimension of functional quality.
Following further studies, the ten determinants of service quality have been reduced to the following five (Parasuraman *et al.*, 1988):

• **Tangible aspects**: it includes the appealing of facilities, equipment and materials used during service delivery, as well as the appearance of employees;

• **Reliability**: the service company provides customers with excellent first time service without making mistakes, and provides what is committed, at the right time;

• **Responsiveness**: employees in a service company are ready to help customers and respond to their requests, as well as provide information on when the service will be provided, obviously providing it with care;

• **Safety**: the behavior of employees give customers a sense of confidence in the company that makes them feel safe. It also means that employees are always gentle and have the competence to respond to customer inquiries;

• **Empathy**: the company includes customer problems and gives a performance that best matches their interests; furthermore, it devotes personal attention to individual customers and to choose suitable times for their activities.

SERVQUAL is an instrument for measuring how customers perceive the quality of service. This tool is based on the five determinants mentioned above and on the comparison of customer expectations with respect to how they should operate the service and their experiences on how it is delivered. Usually, to describe the five determinants are used twenty-two attributes, and respondents are asked to indicate on a scale of 1 to 7 (1 is equal to "*strong disagree*" and 7 is equal to "*strong agree*"), what they expected from the service and how they perceived it. Based on the discrepancies between expectations and experiences regarding the twenty-two attributes, an overall quality score can be calculated. The higher the score, it indicates that the experience is below expectations; this results in a lower perceived quality. However, it seems more important to determine the scores on individual attributes, adding them to each factor.
The use of the SERVQUAL instrument has however raised some concerns. In several studies some authors have reported that the drivers were stable for several types of services, while in others there was no verification for the standard set of five determinants. Furthermore, sometimes the analysis of a factor reveals a number of determinants for the expectations and different ones for the experience. Finally, the twenty-two attributes used in the original model do not always describe accurately all the aspects of a particular service.
The SERVQUAL scale should be carefully applied, and before taking this assessment tool, the determinants and their attributes should be always reviewed, in order to adapt them to the situation. It might be necessary adding to the original series some new aspects of the service to consider, and sometimes drop some others. From the management point of view, the five determinants provide a valuable starting point for understanding the features of the service provided. However, when using a SERVQUAL approach to measure the perceived quality of a service, the number of determinants and attributes used in the specific situation should be always adapted (Grönroos, 2002).

Chapter 2 -THE SIX SIGMA METHODOLOGY

After making an overview of quality management in this chapter we will focus on the main aspects of Six Sigma methodology. The first section will introduce the topic throughout a brief view of the literature. The second section will consider its fundamental characteristics, metrics, tools and cycle. The third section will analyze its declination in the services sector, trying to identify similarities and differences with the traditional approach. Finally, the fourth section will discuss the approach of the Design for Six Sigma, i.e. the Six Sigma method for design or redesign new products and services.

2.1 Introduction to the topic

In the last decades, several scholars have investigated on Six Sigma methodology, e.g. Bañuelas and Antony (2002), Linderman *et al.* (2003), Antony (2006), Savolainen and Haikonen (2007), Schroeder *et al.* (2008) and Chakravorty (2009), who have carried on their research on different aspects of the topic.

Some authors (Sousa and Voss, 2002; Chakrabarty and Tan, 2007; Zu *et al.*, 2008; Nakhai and Neves, 2009) studied how Six Sigma and the theory of quality management has evolved through the years. The origins of the methodology are connected with Frederick Gauss, who at the beginning of the 19^{th} century introduced the statistical concept of normal distribution. Walter Shewhart, in 1922 introduced three sigma as a measurement of variability, claiming that quality is low when output went beyond this limit. The three sigma concept can be compared to a process yeld of 99.97 percent or a defect rate of 2700 Defects Per Million Opportunities (DPMO) in the long term. This defect rate was considered the standard for most manufacturing companies, at least until the early 1980s when Six Sigma was created (Raisinghani, 2005). In literature, the benefits that Six Sigma projects bring to the firm have never been disputed, however, some authors (e.g. Näslund, 2008; Kumar *et al.*, 2008) have investigated if Six Sigma is actually an innovative quality improvement method or only a management fad, i.e. a repackaged version of TQM. In summary, both methodologies offer similar and rather general critical success factors, but overall, in TQM seems to be missing the need for a systemic approach to organizational change and improvement (see also Andersson *et al.*, 2006).

The purpose of Six Sigma is decreasing the defect rate and costs by reducing the variability in the processes (Näslund, 2008). Authors agree that the method brings to different kinds of benefits, e.g. increasing financial results, reducing wastes and improving customer service.

In the companies, Six Sigma has been implemented in several ways. Harry and Schroeder (2000) refer to the methodology as a top-down company-wide managerial strategy. Breyfogle *et al.* (2001) assert it is simply a set of quality tools and techniques, while other authors (Johannsen and Leist, 2009) consider Six Sigma as a systematic improvement program in which business processes are optimized by means of a prescribed methodology. Several different definitions are present in literature and Linderman *et al*. (2003), defining it as "*An organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates*", stress the need for a common definition. For Bañuelas and Antony (2002) is "*A philosophy that employs a well-structured continuous improvement methodology to reduce process variability and drive out waste* *within the business processes using statistical tools and techniques*"; Chakrabarty and Tan (2007) claim it is "*A quality improvement program with a goal of reducing the number of defects to as low as 3.4 parts per million opportunities or 0.0003 per cent*"; Kwak and Anbari (2006) consider it as "*A business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceeds customer needs and expectations*". Finally, about taxonomy, besides "*philosophy*", "*program*", "*strategy*" and "*method*", Sousa and Voss (2002) refer to Six Sigma as a "*practice*".

In order to explain the nature of Six Sigma and building theory on the topic, Schroeder *et al.* (2008) outlined five elements in this methodology.

First regards the importance of management's involvement in executing several Six Sigma activities, e.g. selecting improvement specialists, identifying project selection, and facilitating the methodology's implementation. Also Antony *et al.* (2007) underline the relevance of management's involvement in on-going projects for sustainability of Six Sigma programs. Second, the Six Sigma organizational structure, also known as parallel-meso structure, in which improvement specialists, i.e. Green belts or Black Belts, receive internal or external training. Third, Six Sigma programs have performance metrics and measurements based on cost, quality, and schedules. Fourth, the implementation of Six Sigma is based on a five-step systematic procedure, i.e. the DMAIC (Define, Measure, Analyze, Improve, Control) model. Fifth, project selection is a fundamental element in Six Sigma programs. As regards project prioritization, Bañuelas *et al.* (2006) suggest several tools, e.g. cost benefit analysis or the Pareto priority index.

Beyond these elements, Brady and Allen (2006) include two more principles. The first stresses the care to the bottom line in initiating projects. The second emphasizes the significance of the training of non-statisticians in order to use some statistical tools with minimal theory.

Although the scholars have paid much more attention on the implementation of the methodology to the manufacturing sector, in the last years there is a growing number of publications on the applications of Six Sigma to services. Several are the common myths about Six Sigma that have been debunked in literature (Kumar *et al.*, 2008). In particular, Nakhai and Neves (2009) have investigated if the methodology is good only for manufacturing processes, highlighting the possible limitations and opportunities of Six Sigma applications in service industry. Therefore, the authors, after summarizing the potential applications on this context, assert the effectiveness of the methodology in improving the quality of services (see also Antony, 2006; Antony *et al.*, 2007).

Implementing the Six Sigma approach to NPD or NSD in order to deliver products or processes at a six sigma level of quality has been defined Design For Six Sigma (DFSS) (Antony, 2002). Kwak and Anbari (2006) have claimed that DFSS is a systematic approach that can enable organizations to design products or services that meet or exceed customer expectations, employing well-established tools and techniques.

Benefits from the application of DFSS are potentially much more evident than DMAIC, since its implementation starts with scratch in the early stage of new product or new process development. In summary, extensive research has already been developed on the application of DFSS in a manufacturing context, and considering new areas of DFSS implementation, such as service processes, could represent a valuable opportunity.

2.2 Six Sigma

The Six Sigma can be seen as a strategy to identify and eliminate causes of errors or defects in the process, which focuses on the critical output for the customer. In addition, Six Sigma is

also a qualitative measure that aims to eliminate defects by applying statistical methods. The basic objective of this methodology is the implementation of a strategy by quantitative connotation, focus on improving processes and reducing variability.
Bañuelas and Anthony (2002), have taken all these issues, claiming the following definition of Six Sigma:

> *"…A philosophy that employs a well-structured continuous improvement methodology to reduce process variability and drive out waste within the business processes using statistical tools and techniques…"*
>
> (Bañuelas and Anthony, 2002)

Chakrabarty and Tan (2007), have instead emphasized the quantitative aspects of Six Sigma methodology, defining it as:

> *"…A quality improvement program with a goal of reducing the number of defects to as low as 3.4 parts per million opportunities or 0.0003 per cent…"*
>
> (Chakrabarty and Tan, 2007)

Gibertoni (2008), proposes a definition of Six Sigma focuses on issues related to customer satisfaction:

> *"Six Sigma is an approach for managing a company that, starting from the voice of the customer and the correct understanding of their needs, implement a continuous improvement of its internal processes to ensure continuous satisfaction over time."*
>
> (Gibertoni, 2008)

The control of variability in the processes is the core of the Six Sigma system. Sigma is a synthetic indicator that expresses the ability of a particular process or product to include a series of events within limits set by the customer. Furthermore, in statistics and in the literature of quality management it is a parameter that represents the standard deviation of a set of data compared to an average value. Consequently, the variation of a process can be described by how many sigma, or standard deviation, are within specific limits. The higher the sigma number, the better the quality. All aspects of the process variability and the statistical basis will be discussed in detail in the next paragraph.
According Gibertoni (2008), the Six Sigma approach, linking the variability in the processes to customer satisfaction, meets three main objectives:

- identify critical issues in the quality for the customer;
- minimizes the variability in business processes;
- eliminate or reduce the business that do not produce value.

In summary we can say that Six Sigma is an approach to dramatically reduce costs and inefficiencies in every business process, leading to some tangible benefits in financial terms for the company.
The very early signs for the birth of Six Sigma are in 1979, when Motorola through its executive Art Sundry, declared that the main problem of low economic performance of the company was the poor quality of its products, demonstrating the correlation between high

level of quality and costs incurred for the development and production controls. Motorola at the time wasted by 10% to 20% of its annual revenue due to poor quality of its products. Subsequent analysis showed a direct correlation between the variability in production processes and the subsequent complaints of customers.
The president of Motorola's Robert Galvin, in the light of these results gave way to a substantial improvement in quality and a drastic cost reduction, entrusting this project to a team of 23 engineers, independent of the formal structure and led by Mikel Harry , Senior Staff Engineer. In this group there was Bill Smith, an engineer of the communication sector, which was conducted shortly before the hidden costs of Motorola related to waste. Mikel Harry drew from this experience a set of guidelines, together in a document called *The Yellow Brick Road to Six Sigma*. The document was shown the validity of a method to improve the design while reducing time and cost of production called Six Sigma and already applied within Motorola.
From that moment on, Motorola established the Six Sigma is a goal for the organization as the focal point of efforts to improve the quality of products and processes. It was estimated that through the application of the methodology, Motorola reduced the defects in its products by 94% between 1987 and 1993, with savings of $2.2 billion. Subsequently, the Six Sigma has begun to spread beyond the borders of Motorola, and was adopted by thousands of companies worldwide, both large and small.
According to Montgomery and Woodall (2008), there were three generations of Six Sigma implementations. The first generation focused on eliminating defects and variability, mainly in the manufacturing sector, of which Motorola is the classic example. In the second generation, the emphasis on reducing variability and elimination of defects remained, however, there was a big effort to connect these aspects in projects and activities that improve business performance through improved product design and reduce costs. General Electric is often cited as a leader of this phase. Finally, the third generation has added to the previous focus on issues throughout the organization create value for stakeholders, employees, customers, suppliers and society in general. The creation of value can take many forms, such as an increase in share value and dividends of the company, expansion into new markets or increased levels of customer satisfaction.

2.2.1 The variability in the processes and the statistical basis of Six Sigma

Six Sigma is first and foremost a strategy to accelerate improvements in products and services, creating the basis for a substantive change, but at the same time is also a system to measure the effectiveness of actions taken to eliminate defects and changes in processes. The final result Y of a set of processes will be dependent on the result of individual independent variables Xs in individual processes.
It follows that if:

$$Y = f\,(Xs)$$

Only by knowing and controlling the vital variables Xs can reduce the number of defects. Check the variables Xs therefore means preventing, while keeping the Y, it means to make reactive maintenance.
The product used or the service are received at the end of the assessment of business processes. The variability causes defects, and then it creates dissatisfaction with the customer,

if you can create jobs without variables, the final result is reliable and repeatable, and the customer is satisfied, (Gibertoni, 2008).
According to the author of the causes of variability are found:

- Measurement systems;
- Variability in the input;
- In the design and development of the product or service;
- Process capability.

The variability can be defined as the difference, even infinitesimal, which is found by measuring the same type of product or service originates from the same process. With the Six Sigma approach, we intend to minimize the possible variability of processes, which according Gibertoni (2008), can be derived from two families of causes:

- *Common, normal or accidental*: it is difficult to identify causes and individually not of great importance. Generally, these factors are numerous and are called errors of the system with an incidence of about 80-85% of the total variability. The term is synonymous with accidental variability of normal variability. Although different values of the features in question can be grouped into a Gaussian curve of normal distribution or predictable and constant;

- *Special or abnormal*: they are easily detectable and causes related to a single factor "special cause", which is the source of variability. Normally account for about 15-20% of the total variability.

Relations between the two types of causes of variability, are graphically expressed by the control chart of Shewhart through two limits conventionally called:

- Upper Limit (UCL = Upper control limit);
- Lower Limit (LCL = Lower control limit).

Anything that falls within these limits is generally considered conventional in statistical control. Quality is assessed through the ongoing confrontation between input and output or, in other words, through the analysis of the causes and process variability.
To carry out these activities, there is a strong use of statistical concepts, and in particular to understand clearly the Six Sigma, you need to know the Gauss curve.
According to Gauss, whenever an event is governed by phenomena completely random, the distribution of its measurements and its frequency may be represented by the "normal curve of distribution of probabilities."
Whenever you are in the presence of a variation of the characteristics of quality caused by the sum of a large number of independent and timing errors resulting from various factors, the distribution is very close to the Gaussian curve, which takes the form of an inverted bell (Gibertoni, 2008).

The distribution of measured values and the frequency is found every time you go to sample a single feature within a process, a product or a service. Results outside the tolerance limits are called non-conformities or defects of varying severity.
The normal probability distribution curve has the following features:

- Absolute frequency represents the highest value in the middle of the range, and takes values gradually decrease toward the ends;

- It is symmetrical and specular respect the average;

- It is unimodal, that can have only one mode, and enjoys the property whereby mean = median = mode;

- It is completely identified by two main parameters:

Mean = **μ**

Standard deviation = **σ**

In addition, the normal curve of distribution of probabilities can be expressed mathematically as follows:

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \; e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Formula 2-1: Normal curve of distribution of probabilities.

The normal distribution is defined by the letter N (μ, σ2), and is determined by two parameters:

- **μ**: is the central location of the normal distribution (the average);

- **σ**: represents the loss of the normal distribution respect the median.

To ensure that the characteristic that is represented by the curve is above a value assigned, a standardization is made, transforming the random variable x in μ variable with mean 0 and variance 1, as follows:

$$\mu = \frac{x-\mu}{\sigma}$$

Formula 2-2: Standardization of random variable.

There are specific normal distribution tables, providing the probability that a random variable μ takes on a value to a generic value of K. While a normal random variable can assume any value between ± ∞, the corresponding causal variable varies within ± 3 standard. It follows

that we pass through the standardization from a field of infinite variation to a range of variation with extreme ± 3. The probability that the causal variable μ are in the range with extreme ± 3 identifies a certain event in 99.73% of cases, rendering meaningless the likelihood that x falls outside the limits of μ ± 3.
The *standard deviation* is represented graphically by the distance between the mean value [4]and the inflection point, i.e. the point where the curve becomes convex to concave. Sigma is, in short, a measure of changes in processes, through analysis of standard deviations. It is called *dispersion* the scattering range over which the measurement values are distributed. The interval around the mean value is related to the probability values are observed inside the same range.
In particular:

-$P(-\sigma, +\sigma) =$ 68,27%
-$P(-2\sigma, +2\sigma)=$ 95,45%
-$P(-3\sigma, +3\sigma)=$ 99,73%
-$P(-4\sigma, +4\sigma)=$ 99,9937%
-$P(-5\sigma, +5\sigma)=$ 99,999943%
-$P(-6\sigma, +6\sigma)=$ 99,9999998%

In a two Sigma process data are widely distributed along the center line, showing a high variability of the process. In a Six Sigma process, however, the data are very close to the center line, showing less variability of the process. The theory states that then produce at a 6 Sigma qualitative level means having six standard deviations between the upper specification limit and the center of production and also between this and the lower limit. In other words, production must have a standard deviation not exceeding one twelfth of the width of the specification.
Experience has shown that the processes usually do not have the same performance in the long term and short term. As a result, the number of sigma that exist between the average of the process and the nearest specification limits may drop over time as compared with the initial study of the short term. To account for this increase in process variation over time, calculations have introduced a shift of 1.5 sigma. Consistent with this idea, a process that provides 6 sigma between the mean and the nearest specification limit in the short term, in the long term will provide only 4.5 sigma. This is because the average of the process of moving over time or because the term of the standard deviation of the process will be greater than that observed in the short term.
Finally, a concept concerning the DPMO index, which indicates the number of Defects Per Million Opportunities to make mistakes on the job. It has always been defined defect what does not meet the customer's wishes, and this anomaly is indicated by an index PPM, i.e. Parts Per Million. Six Sigma, conversely, does not focus on the number of faults, but measures the possibility of not making mistakes in the process. The formula for the calculation of DPMO is as follows:

$$DPMO = \frac{1.000.000\ X\ number\ of\ defects}{number\ of\ units\ X\ number\ of\ opportunities\ per\ unit}$$

Formula 2-3: Defects Per Million Opportunities.

[4] Equivalent to the projection on the measures of the point of maximum of Gaussian distribution.

At every level of Sigma, there is a corresponding number of DPMO.
The concepts in this section are summarized in the table and figure below:

Table 2.1: Relationship between DPMO and Sigma level.

SIGMA LEVEL	%	DPMO[5]
6σ	99,99%	3,4
5σ	99,97%	230
4σ	99,38%	6.200
3σ	93,32%	66.800
2σ	69,15%	308.500
1σ	30,85%	691.500

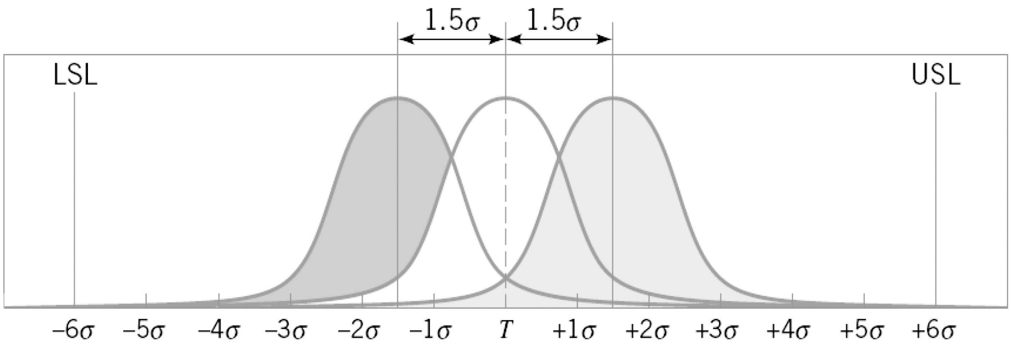

Figure 2.1: Normal distribution with 1.5 sigma (Montgomery and Woodall, 2008).

2.2.2 The DMAIC cycle

The Six Sigma methodology is based on the ability to create an organization able to identify and meet the needs of the customer, first in the chain of internal customers, and lastly the external ones.
According Gibertoni (2008), in order to achieve this business:

- Try to understand what the customer really wants, through the construction of specific indicators called Critical To Quality (CTQ);

- Improve the performance of all staff through a training and subsequent involvement;

- Measure the parameters on the processes of non-compliance that have an impact on customer satisfaction;

[5] Already considered the 1.5 sigma shift in the long-term.

- Analyze and intervene in the causes of non-compliance, promoting action for improvement;

- Systematically monitor that the results achieved are maintained.

The goal is to make all processes and all business activities reach a variability contained six times within a predetermined value, identified in 3.4 defects per million opportunities. In most cases, the Six Sigma methodology is implemented in companies through the DMAIC cycle, a comprehensive, very useful in managing change and improvement. DMAIC stands for Define, Measure, Analyze, Improve and Control, is a structured problem solving process used widely in quality and process improvement. This approach is a generalization of the PDCA (i.e. Plan, Do, Check, Act) cycle of Shewhart and Deming, which provided a map to help people understand how to integrate the various instruments in a comprehensive approach to quality improvement. The DMAIC structure also encourages creative thinking approach to solving problems concerning the definition of products, processes or services. Below is detailed description of each stage of the approach, which are illustrated in the figure below.

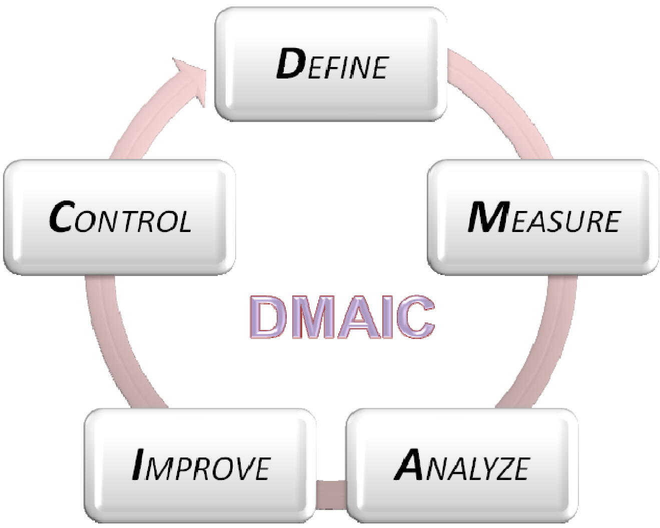

Figure 2.2: The DMAIC cycle.

<u>The Define phase</u>

The objective of the Define step of DMAIC approach is to identify opportunities for the project and to verify the potential of improving it.
One of the first item that must be completed in the Define phase is certainly the project charter. This is a short document, usually one or two pages, which contains:

- A description of the project and its purpose;

- The dates of start and end of the project;

- An initial description of the metrics used to measure the results and see how those are aligned with organizational goals;

- The potential benefits to the customer;

- The potential financial benefits of the organization;

- Milestones to be achieved during the project;

- Team members and their roles;

- Additional resources needed to complete the project.

Usually, a team should be able to complete the project charter in 2-4 business days, otherwise the scope of the project may be too broad. The charter should also identify the customer CTQ of greater impact on the project (Montgomery and Woodall, 2008).
In the Define step are very useful aids such as graphics-based value stream maps, process maps and flow charts. These tools provide a greater visual detail and facilitate understanding of what needs to be changed or improved in the process. These diagrams are especially useful in the environments of many manufacturing and service companies, where the process approach is often difficult to understand. In addition, the project team needs to prepare an action plan on steps to be followed in the following step of the DMAIC cycle, (Montgomery and Woodall, 2008).

The Measure phase

The purpose of the Measure step is to evaluate and understand the current state of the process. This phase involves the collection of data on quality measures, cost and cycle time. It is also important to develop a list of all the key variables of input and output, identified in the Define phase. The data collected during the measurement can be explained in several ways, such as histograms, run charts or the Pareto chart, (Montgomery and Woodall, 2008).
Data can be collected by examining historical records, however, this practice may not always be satisfactory, since such sources may be incomplete, methods of storing the data may have changed and information of interest is not present. Consequently, it is often necessary to collect recent data through observation or sampling. In service companies, it may be necessary to develop appropriate measures and measurement systems to gather the information necessary for the organization.
In addition, the measurement capabilities of the system should be evaluated to ensure that the team are not trying to solve a fake problem in which actually the performance of the process is valid and to be wrong is the measurement system. The project team requires accurate data for the resolution of the problem, so the analysis of the measurement system should be carried out using a formal study to quantify the accuracy and variation of the measurement process. At the end of the Measure step, the team should update the project charter if necessary, review the objectives and scope of the project, and reassess the composition of the team. The team could consider a possible expansion to include members of the business unit upstream or downstream if the activities of the phase indicate that these individuals would be useful during the next steps of DMAIC cycle. Any problem or concern that might affect the success

of the project needs to be documented and shared with the process owner or the project sponsor (Montgomery and Woodall, 2008).

The Analyze phase

In the Analyze phase the objective is to use data from the Measure phase to begin to determine the cause-effect relationships in the process and to understand the different sources of variability. Also during this phase the potential causes of defects, quality issues and customer or waste and inefficiencies that have led to the definition of the project will be outlined. It is important to separate the sources of variability in common causes and assignable causes. The removal of the common causes of variation usually means changing the process, while removing an assignable cause usually involves the removal of a specific problem.

There are many statistical tools that are potentially useful in the Analyze step. Among these are surely the control charts, regression analysis, the DOE and FMEA analysis. The techniques of discrete event simulation computer is a very powerful tool to use in this phase of the cycle, particularly useful in business and transactional services, (Montgomery and Woodall, 2008).

In many cases the purpose of the Analyze phase is to explore and understand relationships between different variables and processes and to develop ideas about possible improvements to them. A list of opportunities and basic causes to intervene in the Improve phase should be developed.

The Improve phase

In Measure and Analyze steps, the team decide which key variables of input and output to study, determine what data to collect and how to represent and analyze them, identify potential sources of variability and determine how to interpret the data obtained. Moreover, during this phase, team members try to think creatively to the specific changes that can be applied to processes to improve performance.

The redesign of projects to improve the work flow and reduce bottlenecks requires extensive use of value stream map and flow chart, but the DOE is probably the most important statistical tool to use in the Improve phase. The DOE can be applied to real physical processes on a computer simulation of those processes. It can also be used to determine which factors influence the outcome of a process to determine optimal combinations.

The objectives of the Improve phase is to develop a solution to the problem and launch a test pilot of the solution. The pilot test is a form of confirmatory experiment; it assesses and documents the solution confirming that the same conditions to obtain the results of the project. This may be an iterative, with the original solution gradually refined, revised and improved several times as a result of the pilot test (Montgomery and Woodall, 2008).

The control phase

The objectives of the control steps are to complete all remaining tasks of the project and to deliver the improved process to the process owner, together with the control plan of the same and other procedures necessary to ensure that the gains resulting from the project to be institutionalized.

It should be provided to the process owner with data relating to key metrics of the process before and after the project, the documentation produced during the project and a mapping

process for date; finally, the financial benefits should be quantified. The plan should be a process control system to monitor the new implemented solution, including the methods and metrics to perform the periodic audits.
It is important to ensure that the results are implemented on a permanent basis in order to make the financial impact sustainable. It is not unusual to find in fact that something has gone wrong in the transition from the existing process to the improved process. For this reason, the ability to respond quickly to unexpected failures should be planned within the project plan.

2.2.3 Six Sigma, and human resources

Once an organization has decided to undertake a Six Sigma program, is especially relevant training staff at various levels in order to implement the methodology in the company (Gibertoni, 2008). Although with some differences between a company and another, in literature you can define five types of professionals:

1) Executive Leader or Sponsor;

2) Champion;

3) Master Black Belt;

4) Black Belt;

5) Green Belt.

According to Schroeder *et al.* (2008), Six Sigma operates as a meso-structure, parallel to the traditional organizational structure, dedicated to improving the company. This structure is hierarchical, and the leader (the Champion), starts, supports and reviews the projects for improvement. The Black Belts act as project leader on the other hand, in order to support the Green Belt in the efforts of solving problems.

<u>Executive Leader or Sponsor</u>

This role can also be found under other names such as Quality Leader, Chief Sigma Implementation Leader, depending on the type of company.
This figure defines all of the company's commitment to Six Sigma, a highly specific and managerial autonomy, reporting directly to the board of directors or chief executive officer. The Executive Leader must have a specific expertise in quality, but also must be a true leader, recognized by peers within the company, which combine a long-term strategy, with the results in the short (Gibertoni, 2008).

<u>Champion</u>

Normally the sponsor or Champion is a young executive or a manager that starts and supports the training of Black Belt DMAIC and guide the team in charge of the most critical projects. This role is very important within the company and its responsibilities include:

• Check the alignment of all the projects with shared objectives;

- Inform the executive leaders on the progress of the various teams;
- Make available the necessary resources;
- Conduct periodic audits of ongoing projects;
- Manage conflicts, disagreements, disconnections between the various groups.

Master Black Belt

The Master Black Belt is a professional with extensive experience in the implementation of Six Sigma methodology, which plays the role of internal consultant to support the Black Belts who work in various projects. MBB in a Motorola has played the role of Black Belt for at least five years and has taught at least five candidates for Black Belt certification. In addition, to achieve this role, there is a need for a recommendation from the Upper management of their own and other business function (Ingle and Roe, 2001).
In General Electric, a MBB is a leader in implementing Six Sigma methodology and is usually formed directly from the Six Sigma Institute. Moreover, this figure plays a role in promoting and spreading the culture of the methodology within the company.

Black Belt

The Black Belt is a figure in the use of specialized tools and techniques of Six Sigma methodology. These resources possess an extensive experience in the use of appropriate tools of business to the area of employment (Ingle and Roe, 2001). The Black Belt Green Belts support projects in general regarding to their areas of expertise.
According Gibertoni (2008), a Black Belt has many skills, including the ability to collect and analyze data, project management skills, leadership, and above all common sense and strong character. Usually the role is given to young executives, who are dedicated to the position of monitoring most teams for approximately 18-24 months.
In GE in the formation of the Black Belt begins with a two-week course, during the first week we stress the DMA phases of the cycle, in second stage IC, followed by written tests on each of the five DMAIC phases. Later, during 18 months there are two quality projects that are presented to a commission in order to obtain a certification. The request is then forwarded to the function and then the approval for the certification comes directly from the corporate.
There are no special rewards or bonuses resulting from obtaining certification, but the resources are given time during normal working hours to complete the training program. In some organizations, the status of Black Belt is necessary for managerial positions.

Green Belt

A resource company certified as Green Belt has a basic practical training concepts and tools of Six Sigma in order to implement this method properly every day in the and continuous improvement processes. Most American companies have already made mandatory the basic training for Green Belt around the staff and operations personnel with appropriate education, (Gibertoni, 2008).
At GE, the resources are educated through a training course, recently redesigned and brought back from two weeks to one week for the Green Belt. During this week of theoretical

knowledge they acquire skills for managing quality projects. This course is overseen by some Black Belts which follow later in the development of the project to be developed the Green Belt. Once completed the project, the activities and results will be included in a Power Point presentation package to be proposed to the board for certification.

Project Team

Each project team normally consists of 4-5 people, work for 3-4 months and involves: Master Black Belt, Black Belt, Green Belt and industry experts that the group examined. In many cases there is also an external consultant acting as facilitator. Following this logic, you create a well structured with multiple skills, capable of addressing all aspects relating to the CTQ (Gibertoni, 2008).
The presence of the different roles that have to operate within the Six Sigma projects makes it even more important to an internal mechanism for selecting and training a precise, almost always certified. Being part of a DMAIC project team is in many companies is a sign of prestige, even if it involves an additional commitment and constant focus on achieving the expected results.

2.2.4 Project selection

The success or failure of Six Sigma in an organization is related to the selection of projects that can be completed within a reasonable time, leading to tangible benefits in financial terms or the business that lead to customer satisfaction (Antony *et al.*, 2009). The projects are the key activities that lead change within companies. This observation is underlined by the following words of Jack Welch, CEO until 2001 of General Electric:

> *"…The best Six Sigma projects begin not inside the business but outside it, focused on answering the question: how can we make the customer more competitive? What is critical to the customer's success? Learning the answer to that question and learning how to provide the solution is the only focus we need…"*
>
> (Jack Welch)

Project selection is a critical factor in the success of each program of business change, whether long or short term. The identification of projects with high impact in the early stages of a program will lead to significant results in short time.
The projects require money, time and interfere with normal activities and standard routine. For these reasons the project should be focused on the strategic objectives of each business. It is responsibility of senior management to design inter-functional duties and allow access to interdepartmental resources (Antony *et al*., 2009).
Antony (2004), considers Six Sigma as a strategic initiative of the business, so projects coherent with the strategic objectives should be selected. Such projects should meet or exceed the expectations and changing demands of customers, and also should have a big focus on the stakeholders.
The problems that emerge within organizations can be classified into two categories: problems with known solutions and problems with unknown solutions (Panda *et al.,* 2000). The problems with a known solution are usually assigned to a project manager with the skills and resources necessary to the resolution. The problems with unknown solutions can be addressed through an approach to Six Sigma. This would require the use of technical

specialists with certification from the Green Belt or Black Belt in the methodology (Snee and Rodebaugh, 2002).
The analysis of the relevant literature led Antony *et al*. (2009), suggesting some guidelines in the projects selection process:

- A sense of urgency should be created, based on the priority of the project (Antony, 2004);

- Projects should be aligned with the strategic plans and objectives of the company (Antony, 2004);

- The Six Sigma team should start with a meaningful and understandable project, so that the tasks can be easier raising the possibilities of success (Goldstein, 2001; Panda *et al*., 2000; Antony, 2004);

- The project objectives must be clear, concise, specific, achievable, realistic and measurable with a high likelihood of success (Goldstein, 2001; Panda *et al*., 2000; Antony, 2004). Also the best selection of projects is based on identifying projects that meet the current needs of the organization, its capabilities and its objectives;

- Projects must have the approval and support of senior managers (Snee and Rodebaugh, 2002); It is a key to the success of each program Six Sigma training leaders in identifying and select suitable projects, an issue often neglected in leaders development plans in many organizations (Antony, 2004, Panda *et al*., 2000);

- The process of selection of projects should start by creating a simple array of customer expectations and focusing on critical characteristics of process performance (Antony and Ferguson, 2004; Goldstein, 2001);

- The criterion for selection of projects should be established and should be realistic based on metrics that are easily measurable (Panda *et al*., 2000, Harry and Schroeder, 2000; Goldstein, 2001). Select metrics to monitor the project development is perhaps the most critical aspect of the project and provides measurable benefits in terms of cost, quality and timing.

The Six Sigma does not automatically resolve the issues by entering data into a software analysis of the results. In fact, the methodology requires some good thinkers with excellent creativity and analytical quality (Goldstein, 2001). A project selected for deploying Six Sigma can be fit but at the same time a failure if the wrong people are assigned to it.
Finally, staff with the task of identifying and selecting projects should include managers such as a Champion, as well as other resources with a training on the methodology as Master Black Belts, Black Belts and Green Belts, whose experience and competence is important (Panda *et al*, 2000).

2.2.5 Tools of Six Sigma

Six Sigma refers to a bundle of very diverse and varied tools to be used in appropriate situations. Some tools are quantitative characteristics as Minitab or DOE, others qualitative characteristics as the Value stream mapping or GRPI.

The following table, derived on the basis of literature, provides an overview of what tools should be used at each stage of the methodology. A more detailed description of the main tools is presented in the chapter on the empirical in-case analysis.

Table 2.2: Main tools of Six Sigma grouped by phase.

	TOOLS	PHASE				
		D	M	A	I	C
1	**Project Charter**	✓				
2	**SIPOC**	✓		✓	✓	
3	**Gap Analysis**		✓			✓
4	**Project Mapping**	✓		✓	✓	
5	**Gant Diagram**	✓		✓	✓	
6	**Risk Assement**	✓				
7	**Stake & Shareholder Analysis**	✓				
8	**Brainstorming**	✓	✓	✓	✓	✓
9	**Flow Chart**	✓				
10	**QFD**		✓	✓	✓	
11	**Cost-Benefit Analysis**	✓		✓		
12	**Ishikawa Method**		✓			
13	**Process Capability**		✓		✓	
14	**Kano Model**		✓			
15	**Banchmarking**		✓			
16	**Spaghetti Charts**		✓			
17	**FMECA**		✓			
18	**Value Steam Map**		✓	✓	✓	
19	**Process Diagramm**		✓	✓	✓	
20	**FMEA**			✓		
21	**Benchmarking**			✓		
22	**ANOVA**			✓		
23	**Risk Analysis**			✓	✓	
24	**Critical To Quality (CTQ)**			✓	✓	
25	**Root Cause Analysis**			✓	✓	
26	**Hypothesis Testing**			✓	✓	
27	**TOC**			✓		
28	**Lean Tools**			✓	✓	
29	**Scorecard Analysis**	✓		✓	✓	
30	**Selection Matrix**				✓	
31	**Process Monitoring**		✓			✓

Adapted from: Carleysmith et al.*, 2009.*

2.2.6 Similarities and differences between Six Sigma, TQM and Lean

Although TQM, Six Sigma and Lean have the same origin, i.e. the evolution of quality in Japan, the concepts have developed differently.

TQM has become a very popular term in the early nineties between researchers and professionals to describe the ways in which organizations should work to achieve better performance and improve customer satisfaction.

The Six Sigma methodology has found its origin in Motorola, the Lean approach in Toyota, while no company has instead helped to coin the term TQM. George (2003) states that the main difference between Six Sigma and Lean is the fact that the former focuses more on eliminating defects and the second is most suitable in the case of improving the flow of production and disposal of waste . TQM is also characterized by elements that aim to reduce defects and waste, but its main objective the improvement of internal and external customer satisfaction, with a minor amount of resources.

The improvement projects in a Six Sigma program are conducted in different areas and levels of complexity, with the aim of reducing variability. The positive results achieved through the projects for improvement are appreciated and recognized by top management, which offer strong support to the program. The strong link between process improvement and financial benefits to the enterprise can be seen as an explanation for the success of Six Sigma compared to TQM. Lean on the other hand, is a discipline that focuses on speed and efficiency of processes, to increase the value perceived by customers. While Six Sigma and Lean focus on introducing improvements through projects, TQM emphasizes the commitment and involvement of all employees in order to improve and standardize the processes (Andersson *et al.*, 2006).

There are many similarities between the improvement cycle of TQM and Six Sigma methodologies; they both are cyclical and consist of similar phases, with the DMAIC cycle evolution of the PDCA cycle. The principles of Lean are different in that they do not have a cycle and are not focused on how to make improvements.

In Six Sigma, Lean and TQM there are several tools that can be used to detect errors and problems in a system. TQM consists of both statistical instruments and analytical. The Six Sigma has a large bundle of instruments, which are used but with a more structured approach, with a major focus of the more appropriate tool in each situation. In Lean, however, the bundle of tools available is more focused on the reduction and elimination of waste. According to Andersson *et al.*, (2006), although the Six Sigma also points to customer satisfaction, this target is not achieved with the same efficiency obtained instead from TQM and Lean. The reason is that the primary emphasis is placed on Six Sigma financial benefits and only secondarily on customer satisfaction.

2.2.7 Criticisms on Six Sigma and future developments

In literature there have been published many criticisms of the Six Sigma, however, according to Andersson *et al.* (2006) the methodology has the same features of TQM, and does not contain, basically, anything new. Specifically, the authors state that Six Sigma is, like TQM, a structured approach, top-down and data-driven, that use statistical decision-making tools. Innovation on the methodology concerns the explicit link of the same strategic aspects of the business. For example, statistical techniques are used in a systematic way, with a strong focus on results, including the customer's needs. For this reason, critics see the Six Sigma methodology as seen in the conceptual frame work of TQM.

Regarding future developments of the methodology, Montgomery and Woodall (2008), argue that in an ideal implementation, Six Sigma, Design for Six Sigma, which is discussed later in detail, and Lean are used simultaneously in the organization to achieve high performance levels and significant improvements in all the processes of the business. The following figure illustrates many of the complementary aspects of these three sets of instruments. Six Sigma, often combined with DFSS and Lean, is actually much more successful than previous initiatives in quality management, including TQM.

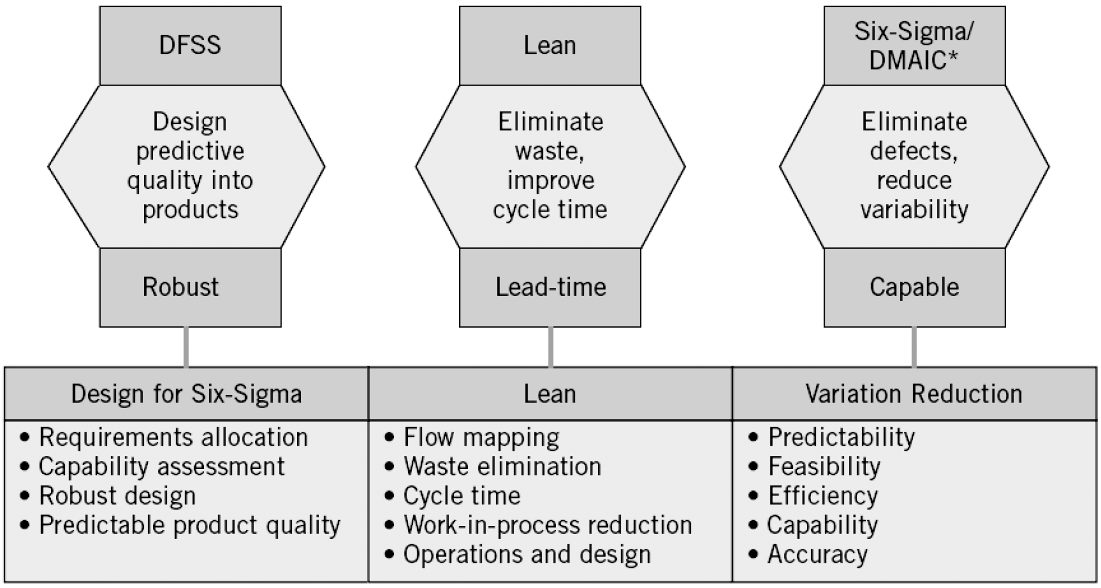

Figure 2.3: The Business Improvement Triad (Montgomery and Woodall, 2008).

2.3 Six Sigma in the service sector

Although Six Sigma approach to quality and process improvement has been mainly used by manufacturing companies, the popularity of that in service companies is growing exponentially, especially in the banking and financial sector and in hospitals. Several studies have shown that most of the service processes have performance lower than 3.5 sigma with a defect rate of more than 23,000 DPMO (Antony, 2006). If you consider the sigma level of quality at a value equal to 4, the defect rate fell significantly in 6210 DPMO. This would bring significant improvement in financial returns, a reduction in complaints from customers and a better customer satisfaction; hence the growing popularity of the methodology is also for service enterprises.

Manufacturing companies build their efforts in the application of Six Sigma on a set of measurable processes and established quality management programs. Service enterprises is often difficult to develop and implement systems for measuring quality. Moreover, in many cases the internal processes to service companies are not easily understood and controllable because of external factors. Such external factors or events (e.g. the behavior of the service provider), do exist while providing the service. In addition, many decisions in the service sector come under the personal evaluation, for which the criteria are less precise. For this reason, the link between process measures and characteristics of the service performance is more difficult to establish (Antony *et al*., 2007). The characteristics of human behavior, such

as friendliness, willingness to help, honesty, have great influence in the processes that determine the quality of service provided to customers. In service processes, the emphasis should be placed on the temporal characteristics, such as delivery time, and characteristics of non-compliance of the service (Antony, 2004).
Many service-oriented businesses, however, are still convinced that Six Sigma is for the exclusive privilege of manufacturing companies. The best way to convince the service companies is to start, develop and implement its strategy of Six Sigma through three principles of statistical thinking proposed by Hoerl and Snee (2002):

1. All activities take place in a system of interconnected processes;

2. All processes have variability;

3. All processes create data that explain the variability and is the responsibility of understanding the sources of variability and devise effective strategies to reduce or eliminate it.

Rather than a shared vision by many people employed in service companies, the Six Sigma methodology requires complicated statistical tools and techniques. In fact, the services organizations do not need most of the tools and techniques available in the bundle of Six Sigma tools. Most of the problems associated with processes and quality in service organizations can be easily addressed by simple tools for problem solving, which will be discussed in a later section.

2.3.1 The Six Sigma methodology for service processes

As discussed above, the Six Sigma methodology uses a series of well-defined steps, which are identified in the DMAIC cycle. Antony (2006), proposed a variation to the processes of service activities to be carried out at each stage of the cycle. The following figure, later described in detail, summarizes the application of the DMAIC cycle for the service processes.

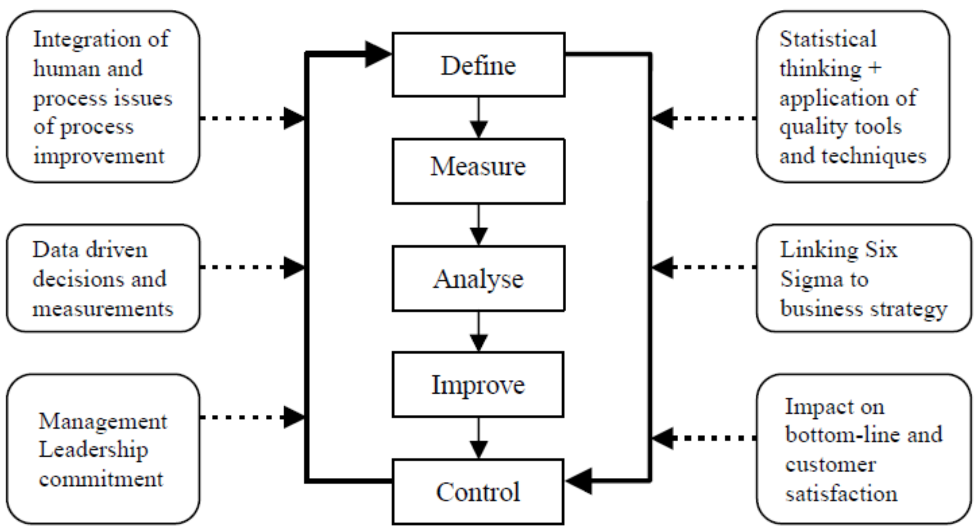

Figure 2.4: The DMAIC cycle for service processes (Antony, 2006).

The Define phase

The following steps should be undertaken during the define phase:

- Define the problem as a project, both succinctly and specifically;
- Identify stakeholders;
- Understand the connection between the problem at hand and the criticality of the problem from the perspective of the customers;
- Carry out a simple mapping of the processes both up- and down-stream to determine where the problem lies;
- Establish the process inputs, outputs and various controls of the processes;
- Form a six sigma project charter which clearly illustrates the roles of people and their responsibilities for the Six Sigma project. Define the resources required for the project and allowed time-frame for the project at hand. The charter should also reveal the scope of the project, the project boundaries and the key benefits to internal or external customers;
- Identify the project sponsor and stakeholders and determine whether this project is worth an effort using cost-benefit analysis;
- Identify all customers, both internal and external, and justify how this problem is linked to customer satisfaction.

The Measure phase

The following aspects should be considered during the measurement methodology:

- Determine the current performance of the target service process (process yield, DPMO, short-term and long-term capability);
- Decide what to measure (critical-to-quality characteristic – CTQ) and how to measure;
- Establish a simple measurement system study (if it is possible);
- Make an efficiency analysis, i.e. determine how well our process is performing compared to others through benchmarking exercise;
- Identify the strengths and weaknesses and determine the gaps for improvement.

The Analyze phase

These steps must be observed in this phase:

- Uncover the root causes of defects in processes;
- Comprehend the root causes of variability which lead to defects and prioritize them for further investigation;
- Understand the nature of data and the distribution or patterns of data;
- Determine the key service process variables that may be correlated to defects;
- Financially quantify the improvement opportunity, i.e. estimate the potential financial benefits.

The Improve phase

The Improve phase must deal with the following problems:

- Develop potential solutions to fix the problems and prevent them it may happen again;
- Evaluate the impact of each possible solution using a criteria-decision matrix;
- Further analysis for the solutions that have a high impact on customer satisfaction and bottom-line savings to the organization; it is necessary to determine how much time, effort and capital will need to be expended for implementation;
- Assess risks associated with potential solutions;
- Validate improvement, i.e. reduce defect rate or improve sigma quality level of the process, by pilot studies;
- Re-evaluate the impact of chosen potential solution.

The Control phase

Finally, the Control phase should comprehend the following steps:

- Develop corrective actions to sustain the improved level of service process performance achieved;
- Develop new standards and procedures to ensure long-term gains in the future;
- Implement process control plans and determine the capability of the process;
- Identify a process owner and establish the role in this process;
- Verify benefits, cost savings/avoidance;
- Document the new methods;
- Close project, finalize documentation and share key lessons learned from the project;
- Publish the results internally (e.g. with monthly bulletins) or externally (e.g. with conferences or journals) and recognize the contribution made by the Six Sigma team members.

2.3.2 Tools and techniques used for the improvement of service processes

As noted previously, most of the problems related to processes and quality in service organizations can be easily addressed by simple problem solving tools available in the bundle of Six Sigma tools. These tools and techniques are usually used by project teams and especially black belt with expertise to deal with these types of issues. The following table, proposed by Anthony (2006), provides some guidelines for those working in services about which instruments and which techniques should be used and at what stage:

Table 2.3: Six Sigma tools grid for service processes.

	TOOLS	PHASE				
		D	M	A	I	C
1	**Process mapping**	✓				
2	**Brainstorming**	✓		✓	✓	
3	**Root cause analysis**			✓	✓	
4	**Quality costing**	✓	✓		✓	
5	**Hypothesis testing**			✓		
6	**SPC**					✓
7	**SERVQUAL**		✓		✓	
8	**Gantt diagram**	✓	✓	✓	✓	✓
9	**Process capability analysis**		✓		✓	
10	**Correlation and regression analysis**			✓		
11	**Benchmarking**		✓			
12	**Control chart**					✓
13	**Pareto chart**			✓		
14	**Cost-benefit analysis**	✓				
15	**Bar chart**		✓	✓		
16	**QFD**	✓				
17	**Affinity diagrams**			✓		
18	**Project team charter**	✓				
19	**Kano Model**		✓			

Adapted from: Antony, 2006.

2.3.3 Metrics for the measurement of performance used by service companies

KPIs (Key Performance Indicator), usually vary from job to job and from company to company. Nevertheless, there are some key performance indicators and metrics commonly and widely used by many service companies, of which Antony (2006) has compiled a list:

- Cost of poor quality (COPQ);
- DPMO;
- Process capability;
- Time to respond to customer complaints;
- Processing time (mortgage applications, insurance cover, bank loans, etc.);
- Delivery time or speed of delivery;
- Time to restore customer complaints;

- Waiting time to obtain the service;
- Service reliability;
- Accuracy of information provided to customers.

2.3.4 Benefits of Six Sigma adoption by service organizations

Besides the usual financial results, the application of Six Sigma methodology by the service companies can bring the following benefits (Antony, 2004; Antony, 2006; Antony *et al.*, 2007):

- More effective management decisions based on data and facts instead of feelings and intuitions;

- Greater understanding of customer needs and expectations, especially the critical performance characteristics of the quality of the service, which will have the greatest impact on customer satisfaction and loyalty on her;

- Internal activities more efficient and credible, leading to a better market share and shareholder satisfaction;

- Better knowledge in the organization of the various tools and techniques for problem solving, leading to greater employee satisfaction;

- Reduced number of non-value added activities through the systematic elimination of the same, for a faster delivery service;

- Reduction of variability of performance of the service, to a level of service more predictable and consistent;

- Transformation of organizational culture from reactive to proactive;

- Improved cross-functional teamwork across the organization.

2.4 DFSS

As outlined in previous sections, Six Sigma is a strategy for improving business performance, which aims to reduce the number of defects to less than 3.4 per million opportunities. For Antony (2002), most companies produce at a rate of between 35,000 and 50,000 defects per million opportunities, which is equivalent to a sigma level of quality between 3 and 3.5. The same author states that organizations that have adopted the principles and concepts of Six Sigma have realized that once quality level equal to 5 sigma (233 DPMO) is reached, the only way to keep on improving is to redesign their products and services. This has led to the development of Design For Six Sigma or DFSS. The DFSS was developed at General Electric to reduce the gap between the basic Six Sigma approach, directed towards the prevention and removal of the causes of customer dissatisfaction and the desire to focus on product and processes.
Antony (2002) proposed the following definition of DFSS:

"…DFSS is a powerful approach to designing products, processes and services in a cost-effective and simple manner to meet the needs and expectations of the customers while driving down quality costs…"

(Antony, 2002)

In this sense, the DFSS can be seen as a methodology to introduce new products, processes and services more efficient, credible and able to meet the expectations and demands of customers.
The focus on customer expectations and the information is highlighted in the following definition, proposed by Gibertoni (2008):

"... The DFSS is a specific application of Six Sigma to develop new products based on the demands and expectations of customers and critical CTQ parameters ..."

(Gibertoni, 2008)

Another definition, by Montgomery and Woodall (2008):

"…DFSS is a structured and disciplined methodology for the efficient commercialization of technology that results in new products, services, or processes. DFSS spans the entire development process from the identification of customer needs to the final launch of the new product or service…"

(Montgomery and Woodall, 2008)

VOC activities are designed to determine what the customer really wants, to set priorities based on their requests and to see if the business can meet those demands at a competitive price, providing returns. The VOC data are usually obtained through interviews with clients, direct interaction with them and their observation, focus groups, surveys and analysis of data on customer satisfaction. The aim is to develop a set of Critical To Quality requirements (CTQ) for products and services.
Traditionally, the DMAIC methodology is used to achieve operational efficiency, while DFSS focuses on improving business results by increasing returns on sales generated by new products and services or finding new applications for existing ones. In many cases, an important source of advantage of DFSS is the reduction of development lead time, i.e. the time required to commercialize a new technology and get the results of the new products from the market. The DFSS is directly focused in increasing the value of the organization (Montgomery and Woodall, 2008). To confirm this, according to Antony (2002), the DFSS has the potential to simplify the configuration of the design, eliminating non-value added steps or the number of processes in the design of a product or service, thus reducing material and labor costs.
In general, the DFSS brings out the fact that any decision on the design is a business decision, and that the cost, the manufacturability and product performance are to be determined during design. Once the product is designed and delivered for production, it is almost impossible for the manufacturing business do better. In addition, the overall improvements of the business cannot be achieved by focusing exclusively on the variability of production, and DFSS is required to focus on the customer's requirements keeping in mind the process capability. In fact, when discrepancies arise between the process capability and requirements for the design, it must be considered possible changes in the design of different production alternatives for resolving conflicts.

2.4.1 The DMADV cycle

Most organizations, in implementing the DFSS, use variants of the traditional DMAIC cycle, including, for example, the cycle IDOV, i.e. Identify, Design, Optimize, Validate, introduced by Antony (2002). Contrary to DMAIC, indeed, DFSS does not have a unique model, and the literature on the topic offers several models, depending also on the characteristics of the process. Some of the most famous are the DMADV model (Define, Measure, Analyze, Design, Verify), the above quoted IDOV model and the DMEDI model (Define, Measure, Explore, Develop, Implement).

However, the DMADV cycle, i.e. Define, Measure, Analyze, Design and Verify, appears to be the most widely quoted in literature.

The following figure illustrates clearly the differences and connections between the DMAIC cycle and the DMADV cycle:

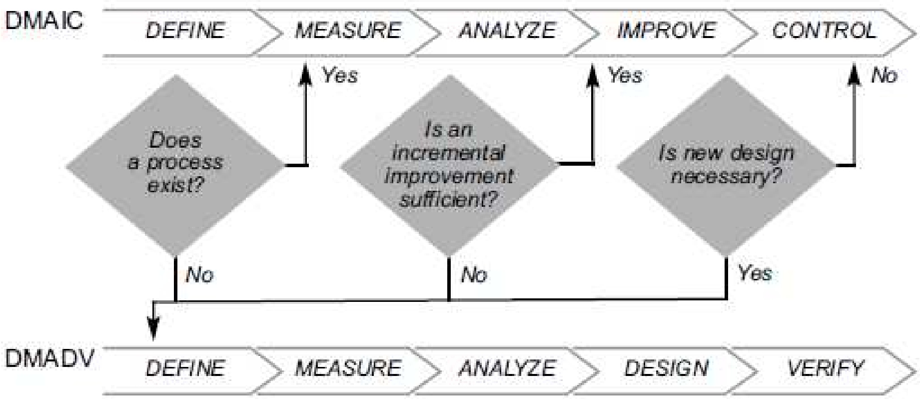

Figure 2.5: Comparing DMAIC and DMADV cycle (Staudter et al.*, 2008).*

The following table summarizes the activities that are associated with each phase of the DMADV cycle:

Table 2.4: Activities of DMADV phases.

PHASE	ACTIVITIES
DEFINE	•Define business case; •Project planning and scoping
MEASURE	•Understand customers' requirements; •Make requirements specific and measurable; •Obtain target values and tolerances
ANALYZE	•Develop a optimum concept
DESIGN	•Design the product in detail •Planning production and implementation
VERIFY	•Pilot test •Complete implementation •Monitoring KPI

Adapted from Staudter *et al.* (2008).

2.4.2 Tools used in DFSS

DFSS uses different methods of reference in addition to QFD tools and problem-solving. These methods can be divided into two categories, depending on the level of knowledge (know-how) of the product or process in the company (Gibertoni, 2008):

- High know-how;
- Lacking know-how.

In the former case, the parameters of the product or process are known, and this means that you know the failure modes, the CTQ, and causes of non-quality of a product. These techniques are aimed at increasing reliability and improving the product prior to exercise, both in functional terms and in terms of cost reduction. The main techniques are:

- Value analysis;
- FMEA;
- Design for Manufactured Assembly;
- Design of Review;
- Fault Tree Analysis;

- Analysis of variance (ANOVA).

The latter case is the situation when you do not know well all the parameters involved in the product or process. This category of techniques is involved in the actual design optimization that covers both the current product and the development of new products and services. The main techniques are:

- Value analysis;
- Design of Experiment (DOE);
- FMEA;
- Design for Manufactured Assembly;
- Design of Review;
- Fault Tree Analysis;
- Taguchi Methods;
- Robust Design.

2.4.3 Differences between Six Sigma and DFSS

The Six Sigma methodology is defined as reactive, since it implies to find and fix problems in existing processes. Instead, DFSS involve the design or redesign of processes in advance, in order to achieve Six Sigma levels of quality. This qualitative approach is considered proactive and more aggressive (Bañuelas and Antony, 2003). As noted above, the two approaches also differ in the reference cycle, the DMAIC for Six Sigma and DMADV for Design for Six Sigma.

In the figure here below, the contrast between DMAIC and DMADV:

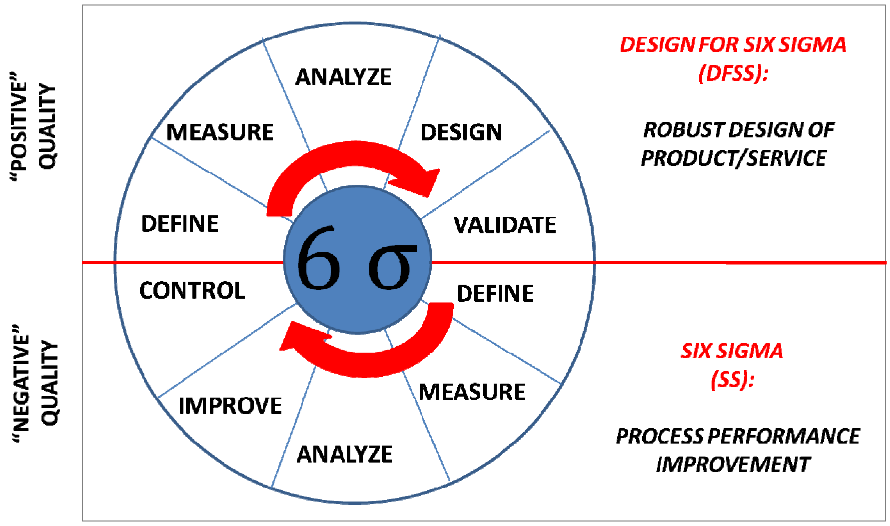

Figure 2.6: Comparison between DMAIC and DMADV cycle (Adapted from: Bañuelas and Antony, 2003).

When using the DMAIC, Six Sigma teams aim to achieve incremental improvements, reducing or minimizing the causes of variability of existing processes. This approach facilitates change for continuous improvement on a progressive and consolidated basis. It then seeks stability by reducing or eliminating the variability that leads to additional costs and customer dissatisfaction.

As noted, many of the Six Sigma efforts are focused in reducing the variability of existing processes using the DMAIC. However, at the same time, the variability is introduced when launching new products and services. To avoid this, efforts are focused in the DFSS prediction and improvement of quality before products and services are launched. Furthermore, this approach can also be used to redesign existing products and processes. The DFSS can be seen as an effective way to achieve Six Sigma quality levels and avoid future problems in production and services, so we can say that it does not only increase efficiency in processes, but also their effectiveness.

According to Harry and Schroeder (2000), the DMADV aims to create projects that are:

- Efficient in the use of resources;
- Able to achieve very high yields;
- Resistant to process variability;
- Highly linked to customer demand.

When the DFSS approach becomes a priority compared to a methodology of continuous improvement is not well documented in the literature and it is a matter under discussion. Some authors and consultants such as Antony (2002) and Harry and Schroeder (2000), claim that organizations that have adopted the concepts and principles of Six Sigma methodology have realized that, once achieved quality levels equal to 5 by the sigma DMAIC, the only way to overcome it, is to redesign their products, processes and services through the DFSS. For other authors, such as Panda *et al.* (2000), the boundary is less clear, or at least not defined by a numerical value. The same authors propose to base this decision on two main criteria:

• If there is a *greater need*, there is a threat or an opportunity. For example, changes in customer needs, demand for greater flexibility, new technologies, changes in rules or laws, changes in competitors, disorder in the existing process;

• If the *risk is acceptable*. Greater lead time for change acceptable, resources and talent are available, the leader and the organization support the effort, risk profile is acceptable.

Similarly, Eckes (2001) proposed that the redesign of the process is suitable when at least one of the following three conditions is present:

1. When a new process would help the organization to achieve a strategic objective;

2. When an existing process is irreparably damaged;

3. When a process has achieved the best result possible.

In some cases, the Six Sigma team decided early during a project if there is a need to redesign a inadequate process or just to improve it. However, in other situations, that decision is taken at an advanced stage of DMAIC. Actually, the latter scenario is not the best option because it can cause delays, consumption of time and resources, as well as the possible cancellation of the project.
There are so many variables involved when considering the redesign as an alternative to continuous improvement: the scope and capacity of the process until the urgency of further gains in performance. Consequently, the choice for the best approach is the result of a process based on multiple criteria (Bañuelas and Antony, 2003).

2.4.4 Benefits for using DFSS

According to Antony (2002), using the principles of DFSS for introducing new products and services can bring the following benefits:

•Faster introduction for new products and services;

•Reduced costs associated with the life cycle of the product;

•Greater understanding of customer expectations and priorities in relation to the attributes of products and services;

•Reduced number of design changes and reduced number of prototypes required;

•Increased trust of the customers towards products and services;

•Better approach to risk management in the design process;

•Reduction in warranty costs.

Even Staudter *et al.* (2008) have proposed a number of benefits arising from the use of DFSS, by grouping them for each of the three groups of stakeholders in the development process:

Table 2.5: Benefits of DFSS.

PRODUCTS/SERVICES	ORGANIZATION	EMPLOYEES
•Perceived value; •Products and services fit with requirements •Trust in products and services; •Good cost/benefit ratio	• Decrease risks; • Decrease time to market; • Decrease maintenance costs; • Improvement of brand; • Repeatable success	•Effective tools; •Common language; •Safety in every phase of the project; •Repeatable success; •Higher motivations

Adapted from: Staudter et al. (2008).

Chapter 3 -LITERATURE REVIEW

This chapter analyzes the literature on Six Sigma methodology in a systematic way. Both the methods used for the literature review and the results are shown and commented. The first section discusses the guidelines for the systematic review, i.e. the protocol, which is used in this thesis, the second section presents the results based on different classification aspects.

3.1 Protocol for the literature review

In this section the guidelines of the methodology for a systematic review of the literature on Six Sigma are explained, which is used in this paper. All the indications in literature have been followed carefully, creating a "*modus operandi*" as more thorough as possible.

3.1.1 Types of reviews

In general, the review can be divided into three different types or categories, each of which is characterized by its quality and objectives in the revision of a topic: systematic review, best-evidence synthesis and narrative reviews (Centre for Reviews and disseminations, 2006).
The following is a brief explanation of the three different types, and then a deeper analysis of the systematic review, i.e. the one used in this thesis.

<u>Systematic review</u>

A systematic review identifies, evaluates and summarizes the results of research on a specific topic and then make available a source of valuable information. This rigorous approach ensures that they have been considered all the possible and relevant sources, and it allows a detailed analysis of the studies in the literature, minimizing the risk of error and providing a potentially replicable study (Centre for Reviews and disseminations[6], 2006). The same reader should be able to obtain the same conclusion or to express views on the shortcomings of research conducted by the researcher who made it. Systematic reviews are the most appropriate topics for focus (Collins and Fauser, 2005).
In summary: a systematic review aims to achieve the same level of rigor and analysis that would be present if any other scholar perform research in the first person (Collins and Fauser, 2005).

<u>Narrative review</u>

The narrative review summarizes the primary studies and their conclusions can develop an interpretation of the subject through the experience of the researcher, existing theories and models. The results are primarily qualitative rather than quantitative. One of the strengths of this technique is the willingness to understand the diversity and plurality of opinions on the topic and still be able to deal with the subject of study with appropriate skills (Johnston and Jones, 2004). Narrative reviews are recommended for topics in which comprehension is particularly important (Collins and Fauser, 2005).

[6] http://www.york.ac.uk/inst/crd/

Best-Evidence Synthesis

This type of review offers a viable alternative to both the method of meta-analytic review (systematic) and narrative. It offers a combination of systematic quantitative methods with the focus on individual studies and narrative ones that highlight the most important topics about the research under analysis. In addition, it uses systematic methods in the selection of studies. To prevent errors in the analysis, it emphasizes the importance of selecting large studies, with appropriate justification, and comprehensive compliance with the principles of selection used in the meta-analysis.
All findings emerged from the analysis are possible starting points for developing a critical analysis of literature. This way of thinking runs counter to the meta-analysis where the size of a topic is the starting point for developing the conclusions. All the procedures followed in the review are described in a comprehensive manner to allow the reader to have enough information on primary research. Therefore, all players must be able to develop independent conclusions (Slavin, 1986).

3.1.2 Principles of systematic review

The systematic review has emerged from a clearly identified need to improve research "evidence-based" between the medical profession in the UK and since there it has expanded across many general and social sciences, including research management (Pittaway *et al.*, 2004; Tranfield *et al.*, 2003).
The goal is to bring together as many as possible of existing evidence-based studies that appear to be relevant to the research undertaken, regardless of place of publication or disciplinary experience.
The principles underlying the adoption of a system of systematic review are:

-*Transparency*: any analysis of research or study available is documented and recorded. Describing each step of the research and the rational reason is that underlying it, the review can be repeated to test its rigor and update the conclusions (Pittaway *et al.*, 2004);

-*Clarity*: a clear and describing the steps of the research allows any reader a full audit trail of how the review has reached the final list of studies that drew on their considerations (Tranfield *et al.*, 2003);

-*Focus*: The review ensures that there is a close relationship between the clear formulation of the research question and the identification of the primary evidence regarding the question itself (Pittaway *et al.*, 2004);

-*Union of research and practitioners communities*: by expanding the scope of dissemination, emphasis on evidence and the form of evidence; the methodology of the review is set for a uniform policy and for a purpose useful to practitioners (LeSeur *et al.*, 2004);

-*Equity*: the review makes no distinction in principle between the nature of the type of magazines and other kinds of publication. The studies are reviewed on its own merits, and the inductive and iterative method means that the prejudices and preferences are eliminated as much as possible (Pittaway *et al.,* 2004);

-*Accessibility*: the reviews are made available outside of specialized academic communities in the form of reports and search database;

-*Extended coverage*: the systematic use of strings and protocols without increasing sophistication of electronic databases allow the experts to cover a plethora of places and forms of publication;

-*Summary*: To compare, contrast and connect results from a number of sub-themes of research using a variety of research methodologies.

Consequently, as described above, a systematic review is designed to help inspire a sense of collective enterprise, relevance and openness between researchers so that we can prevent costly and unnecessary repetitive strain, in order to assist the link between future studies and existing thematic concepts (Tranfield *et al.,* 2003). Eventually, the final purpose is to improve the methods used to collect and summarize previous empirical findings.

3.1.3 The literature review process

As stated previously, in order to perform the analysis of the literature on Six Sigma, it was considered appropriate to perform a systematic literature review. Many authors in the literature have investigated what are the guidelines and steps for conducting this typology of literature review. With regard to this paper the indications of Tranfield *et al.* and Pittway *et al.* (2004) have been considered.
In the table here below, the steps that, according to the authors mentioned above, you must follow to properly carry out the systematic review, have been shown:

Table 3.1: Steps to perform a systematic review.

Stage I – Review planning
Step 0 – Identify the need for the systematic review Step 1 – Create a proposal for the review Step 2 – Develop a protocol for the review
Stage II – Performing the review
Step 3 – Identify the research Step 4 – Selecting the items Step 5 – Evaluate the quality of the study Step 6 – Data mining and monitoring the progression Step 7 – Synthesize the data
Stage III – Reporting and dissemination
Step 8 – Report and recommendations Step 9 – Finding practical evidences

Before to deepen each of the nine steps, it seems necessary to briefly describe some key factors in the process of review.

It seems clear that, before undertaking the review process, it is necessary to define the team that will play, group members should have certain skills, in fact. Ideally, these skills should include experience in the methods of systematic review, in the retrieval of information in the field of study and qualitative research methods. It would be a good idea to have at least two researchers involved in every step of the analysis so as to minimize possible errors. Any conflict of interest must be explained at the beginning of the process so that it does not impact on the entire process of review.

In addition to the research team, according to Centre for Reviews and Dissemination, should establish a group of advisers. This group consists of persons who may be consulted in each step and include such industry experts, service users and experts in research methods. According to the Centre for Reviews and Dissemination they have the same task of commenting on the protocol and final report and provide input to develop a more appropriate analysis. In the event that the research team is sufficiently experienced and does not require ongoing advice, just define a group consisting of members who will be consulted only at the key stages considered.

A second important factor on which to place their attention is the language of the sources with which you decide to do the research.

The basic idea for many systematic reviews is to include all relevant sources available. According to the Centre for Reviews and Dissemination should include studies in each language in order to avoid errors caused by faulty translations from the authors. This view is supported by the fact that the studies not in English and which have obtained significant results are most probably been published in journals of international importance, i.e. in English. However, if the reviews use only sources in English, their results may be affected by errors of translation.

By the way, trying to address this issue in a realistic way, is not always possible to consider all studies, both for reasons of time, availability of resources and translations. It is however recommended to identify all the articles covering the subject in any language and then discard them because of "language" if you are not able to translate.

Another factor to be considered in the definition of the sources is the fact that not always the case studies are published as full articles in scientific journals can be published as reports, book chapters, conference summaries, or thesis may be submitted informally or remain unpublished. A review should ideally include all relevant studies regardless of the type of publication, so as to exclude errors due to distortion of information. This type of error is due to the fact that the use of only one type of publication could not make realistic results due to, for example, an overestimation of them.

There are practical reasons that limit the inclusion of all studies regardless of the type of publication. The unpublished studies are very difficult to recover from those published. It can also be useful to obtain information deemed appropriate by the conference summaries since they offer a different level of detail. One aspect that may be interesting for research could be the identification of the working papers, because in the conclusion they allow supporting possible directions of research in the future.

In the final analysis it is necessary deepen on the selection of the databases that are used in research. It depends on the main topic the review is focused on. The database lists are available in libraries and database vendors, while experts might know the bibliographic databases in their field.

In addition to using the electronics databases, the review team can rely on other sources to find relevant publications for their study. Among these possibilities the Centre for Reviews and Dissemination quotes:

- *Analysis of the bibliographies of the most interesting articles*: this technique can allow researchers to identify other studies of interest that were not from the database search;

- *Manual search in the most relevant journals*: this technique allows the search through "page by page" in scientific journals to detect very recent publications that have not yet been incorporated into electronic databases. In addition, this research also allows you to analyze any comments or insights that are not attached in electronic publishing. To figure out which journals to submit to this research it is advisable to classify the items revised to better understand what the argument deals with;

- *Contact the experts*: this mode allows searching the possible identification of any unpublished studies or studies that have not yet been found with other search methods. The experts may also be asked to provide an assessment of the sources identified and to identify any gaps;

- *Searching the Internet*: this mode allows finding several unpublished studies and conference abstracts, with the use of this tool is more appropriate to conduct a specific search in specific sites rather than simply use the most common search engines;

- *Research citations*: this mode provides the selection of the most significant items among those found, and afterwards identify the research articles that cite them in their bibliography. Through this research can often be closely related to the topic and find articles of great importance.

Starting from the premises described above, the steps to be taken to carry out a proper systematic review are described:

<u>Stage I: Review planning</u>

Before beginning the review is proper to develop a roadmap through the opinions of experts or by looking through the main literature contributions on the topic to be explored. This tool can help to address the process through regular meetings and to solve out any argument that arises on the exclusion or inclusion of some study. The first steps of the systematic review should be an interactive process of definition, clarification and refining.
In order to check the theme and the size of the literature of that topic, it may be necessary to conduct some focused studies in order to limit the study area.
These studies require interdisciplinary analysis to evaluate the different methods of conducting the research. After analyzing the problem in a comprehensive and deeply way, the researchers can identify easily a refined purpose for the study.
The next step is the creation of a research protocol, it is a document that specifies what is the purpose of each step you will follow until you reach the final. The protocol also contains information on the specific question that the study wants to find an answer on search strategy and selection criteria of studies. If deemed necessary, the protocol can also be published for the involvement of other interested researchers and prevent recurrence of similar studies in the future. Each protocol of the review may also include a brief discussion and definition of the problem being researched.
Therefore, usually, is not the optimum to plan once for all the activities of the review of the literature, but it is better to use a more flexible approach that allows explaining what are the

objectives that can be changed during the course of the study . The goal is to create a protocol that does not limit the possibilities to exploit the creative skills of researchers.

Stage II: Performing the review

Although systematic reviews require much more time and greater attention to detail than other types of analysis, they lead to the best quality and efficiency in identifying and assessing the existing literature (Mulrow, 1994).

A systematic search starts with the identification of keywords or search words. Such activity is carried out through the analysis performed during the first stage, the study of literature itself and the debates internal to the research team. The search strategy should be described in order to ensure future reproduction by third parties. The research, as mentioned previously, can also be performed in unpublished studies, conferences and web sites, not only in magazines published and inserted into the database. The output of the research should also contain the complete list of all sources analyzed during the research, e.g. books or articles.

Only studies that meet the characteristics and criteria specified in the protocol can be considered in the review. Such a restricted use of selection criteria allows for an analysis of high quality. This phase may include working more contemporary researchers: despite the exclusion or selection decisions are subjective we can use the selection rules in the protocol to resolve the debate on the relevance or otherwise of the study in question.

The selection process of studies in systematic review involves two steps: the first step may be to carry out an initial screening of titles and abstracts that meet the selection criteria to identify articles of potential interest. Then you should try to find the full text of these in order to enhance their relevance and put them in the appropriate sources considered. The number of resources analyzed at each stage should be reported, as well as the items that are not included. In the case of exclusion the reason of this choice should be always explained.

Systematic reviews are combined with studies that use quantitative methods such as experimental projects, studies on cost-benefit and cost-efficiency. As for qualitative studies however, there is no way to test for statistical relevance of the results.

Systematic reviews expose methodological studies to rigorous analysis. A possible technical analysis of the articles is to assess their relevance to the topic. However, in many cases, researchers use the implicit quality indices referring to the importance of the various journals.

To reduce human error, systematic literature reviews use information extraction modules. These often contain general information (e.g. title, author, publication details), future research, specific information (details and methods) and notes on emerging topics of study. The process of extracting data requires documentation of all steps performed. Very often it runs parallel analysis by different researchers to obtain such a dual control analysis. As a result, they are compared in order to bring out any discrepancies and solve them out.

Data mining can be done on paper or computer. The development of the summary sheet of data is flexible and can vary depending on the nature of the study. When it was decided to form, you must decide what information is most important to create the summary tables with. These should include details about the sources (e.g. title, author, journal, publication information) and other notes on the context of the study and the assessment attributed to it. In addition to these, several other information could also be included, e.g. regarding the results of other articles and limitations of the research.

The summary of the research is a general term for methods that aim to summarize, integrate, and where possible to group the conclusions of several studies in a single document (Murlow, 1994).

Stage III: Reporting and dissemination

A good systematic review should help readers understand the topic through the synthesis of primary research that have been analyzed. The review report can be produced in two steps. The first provides a complete description of the topic. This is achieved through a simple set of categories using different classification, e.g. the authors, the different contributions of European and American studies, the year the articles were written, etc. Items can even be grouped in different aspects depending on historical trends. Moreover, case studies can be divided according to the sector of origin.

The researcher should therefore be able to provide a broad description of the problem with specific examples and stating its conclusions. They should report the results and underline what has already been studied and described in the literature in the past. They should also identify new issues and directions of research.

In addition to defining the main categories, a summary should be completed, to describe the main topics covered in the literature to support the conclusions offered. The part of the description of the main contributions of the literature is one of the most important phase of reporting. This phase allows to the readers, indeed, to understand how the conclusions of the researchers have been developed.

In the next figure we have summarized the general process used for the identification of the scientific papers, followed in this thesis.

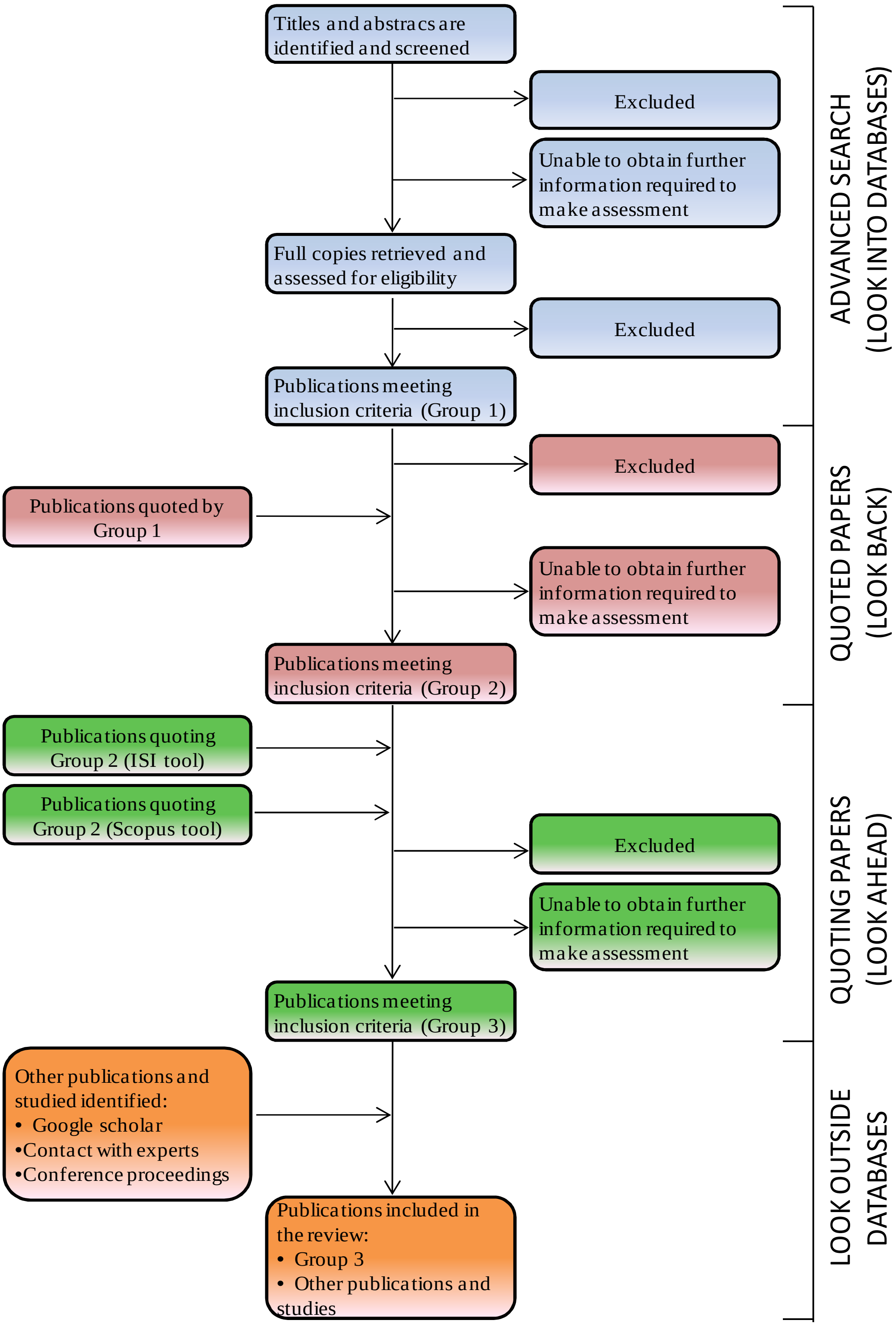

Figure 3.1: The process used for the identification of the scientific papers.

3.2 The protocol for this study

The systematic literature review has followed the guideline of the authors described above. The steps that actually were used are summarized here below:

1. Gather information on the topic;
2. Define the research team;
3. Choose the databases for the systematic literature review;
4. Define the keywords for the research;
5. Application of keywords;
6. Criteria for items’ selection;
7. Identify the items and adding the new sources.

As we can notice, these seven steps represent the first two stages of the protocol above mentioned. The remaining stage, i.e. Reporting and dissemination, will be outlined in the following section which will be discussed in detail the findings from the analysis.

1) Gather information on the topic

The first step of the review was to gather information on the subject to be studied in order to understand what trends are present in the related literature about Six Sigma and understand what are the issues of Six Sigma and DFSS to study.
In this step we have used other sources that can be summarized in three categories:

- Manual analysis of the major scientific journals (International Journal of Production Economics, Journal of Operations Management, Production and Operations Management, etc.);

- Analysis of key books on service and Six Sigma (Johnston and Clark, 2005; Fitzsimmons and Fitzsimmons, 2010, Grönroos, 2002; Gibertoni, 2006, George, 2003; Akpolat, 2004);

- Collecting information through Google Scholar tool.

2) Defining the research team

The research team is composed of one researcher, two assistant researcher and the assistance of a supervisor. The two assistant researchers were in charge to perform the same analysis of the researcher in a further period. This was requested to test the validity of the previous analysis of the researcher and verify that no important sources were missing. After every refinement by the assistant researchers, the researcher itself has revised such refinement in order to check if the protocol has been followed thoroughly.
The main information on the components of the study group are shown in the table below.

Table 3.2: Research team.

NAME	ROLE	POSITION
Prof. Alberto F. De Toni	Supervisor	Dean of engineering faculty at the University of Udine
Ing. Matteo Campanerut	Researcher	Ph.D. Candidate at the University of Padova
Noemi Molina Sanchez	Assistant researcher	Undergraduate student at the Universitat Politecnica de Catalunya
Davide Bortoluzzi	Assistant researcher	Graduate student at the University of Udine

3) Database used for the analysis of the literature

The database used to conduct the research were selected by considering the most important for the field of scientific research. The table shows the five databases used, the categories used for research and the last period when the query has been performed.

Table 3.3: Database used.

DATABASE NAME	CATEGORIES	UPDATED TO
Cilea	Business; Management and Accounting; Decision Sciences; Economics; Econometrics and Finance	November 2010
Emerald	All	November 2010
ISI Web of Knowledge	Business and Finance; Economics; Management; Operations Research & Management Science	November 2010
JSTOR	Business; Economics; Public Policy & Administration	November 2010
Sciente Direct	Business; Management and Accounting; Decision Sciences; Economics; Econometrics and Finance	November 2010

4) Defining keywords

As suggested by Tranfield *et al.*, (2003), the research team needs to define which keywords to query the database and in this way locate potential sources of information from which to begin the study. The keywords specified in this discussion for the analysis of Six Sigma and DFSS are as follows:

- Six Sigma;
- SS;
- DFSS;
- Design For Six Sigma;

- DMADV;
- DMAIC.

5) Application of keywords

Afterwards, it was necessary to choose the fields of application in which the keywords were to be found. For this study we have identified all the items with at least one of the keywords above mentioned in the title or abstract.

6) Criteria for selecting items

For the selection of the items we proceed as follows:

- Selection of articles in English only;
- Articles were selected only if Six Sigma or DFSS were the main topic, apart from the comparative evaluation between the different methods in quality management;
- Editorials, book reviews and executive overview were excluded;
- In order to understand if the article was important for the research we proceed first reading title and abstract; we kept on reading the full article only if it was interesting for the study.

7) Identify the items and adding the new sources

From the query of the database with the keywords chosen 1635 sources were found. In this portion a large part was discarded after reading the abstract or title. The main reason is due to the fact that the use of the keyword Six Sigma, led to the inclusion of sources referring to the use of statistical techniques, not directly related to the methodology under study. In addition, some of them were not available for consultation as we did not have the necessary credentials to do it.
After the first collection and selection of sources, the same were divided according to their type: international articles, national articles, books, theses, conferences. All sources obtained were included in a summary table, which will be analyzed and described during the presentation of results, and evaluated with a score of 1 to 5 in relation to the quality of the paper in the researcher’s opinion. Particular emphasis was given to international articles, which were subjected to further analysis, and used in subsequent stages of the research. The next step provides the analysis of the bibliography of international articles analyzed that have received a vote in the degree of interest equal to 4-5, searching for other articles of potential interest for the study.
Furthermore, the cross-reference function available on the ISI Web of Knowledge database has been used. This allows, given the title of an article, finding out the studies citing that study in the references. The tool just described has identified another 15 articles that emerged from the previous step. It is considered appropriate to specify that at this stage were used only those items considered most interesting having obtained the highest ratings in order to increase the chances of finding items of interest to the study. Only those items that have received a vote of at least 4 have been used. Also, not all these articles may have been used in the cross-reference as this feature is available only for articles in ISI journals.
The last step of the identification of the items reports the use of systems such as Google Scholar and search of lectures on the topic.

The flow scheme proposed can show the number of sources that were considered for the study and the final distribution of selected sources. The tag "Sources in the field of interest" correspond to those articles obtained after the first stage of skimming plus those identified through the use of references and cross references.
In total, 355 sources were selected in the area of Six Sigma and DFSS, including articles from 251 international journals and 104 from other sources as outlined above. Specifically, 14 international books, 72 proceedings of international conferences, 6 articles from national magazines and 12 thesis of Master's Degree and Ph.D. Degree.

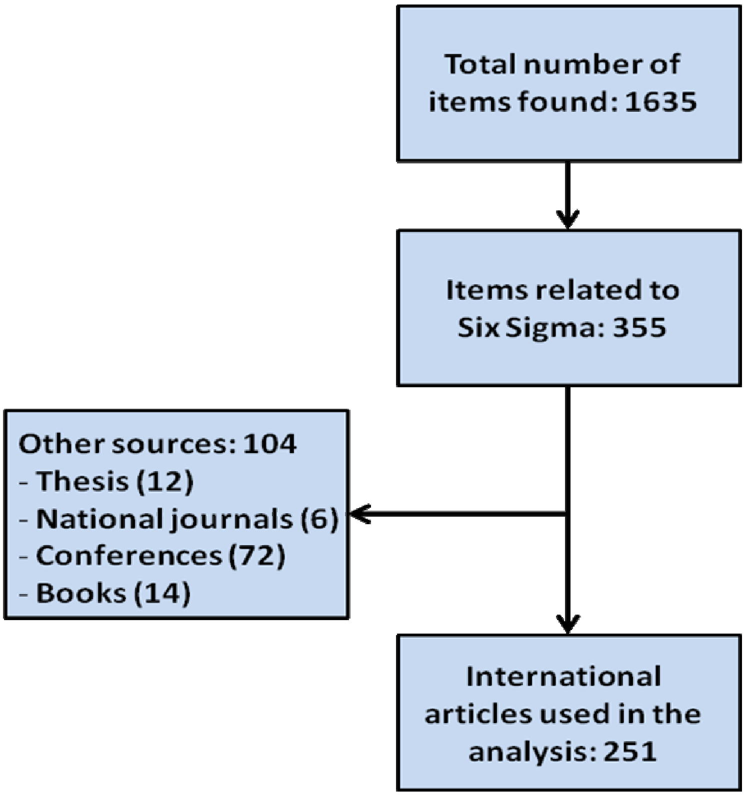

Figure 3.2: Distribution of the sources.

3.3 Results of the literature review

This section presents the results of the literature obtained following the guidelines described above. Such results are presented on different classification variables.
The references of all selected sources (355) have been reported in an Excel table and classified on the basis of the following variables:

- Type of document (i.e. thesis, national journal, international journal, national book, international book, etc.);
- ISSN or ISBN (for international journals and international books only);
- Name of the authors;
- Year of publication;

• Title of the publication;

• Name of the journal;

• Volume number;

• Issue number;

• Pages where the contribution can be found;

• Publishing house;

• Keywords of the item;

• Abstract;

• Language of the item;

• Research Approach (i.e. Description, Empirical, Theoretical, Point of View, Literature Review);

•Empirical method, in the case of Empirical Research Approach (i.e. Action research, Case study, Meta-analysis, Simulation, Survey);

• URL to directly access the publication;

• Connections with other areas (e.g. Knowledge management, BPR, etc.);

• Company environment (i.e. private or public);

• Industrial sector (service, manufacturing, general)

• Kind of process (i.e. application of Six Sigma to design/redesign or improve the process);

• Kind of company;

• Evaluation on a scale of 1 to 5.

Furthermore, on this basis, it has been possible create a new pattern for the Six Sigma literature. All the items, indeed, belong to a different field of study; at the same time each of the eight fields of study corresponds to a macro-field of study.
These eight fields of study, i.e. what the item is focused on, are (in brakes the corresponding macro-field):

1)Theoretical foundation (Theoretical);

2)Comparative evaluations (Theoretical);

3)Culture and intangible assets (Organizational);

4)Actors and organizational structure (Organizational);

5)Methodology implementation (Operational);

6)Methodology tools (Operational);

7)Strategic project selection (Strategic);

8)Strategic choices (Strategic).

Starting on the following variables was then possible to analyze literature from multiple significant points of view, in order to effectively direct and facilitate the subsequent stages of this thesis.
The following are some of the most significant distributions:

Distribution of sources for type of document

The first classification consists in discerning what kind of documents are the items we have found containing some information about Six Sigma. As is shown in the table below, most of the items (70.7%) percent of the items have been acquired from International Journals. The fact that so many articles belong to this category is very important because from this point, all classifications will be made taking into account only these 251 International Papers, which represent the most important source for our academic interests.
Moreover, a good majority of the sources is due to the proceedings of international conferences (20.3%), which often provide interesting ideas on the future trends of research in a specific field. The contribution of theses, books and magazines is limited.

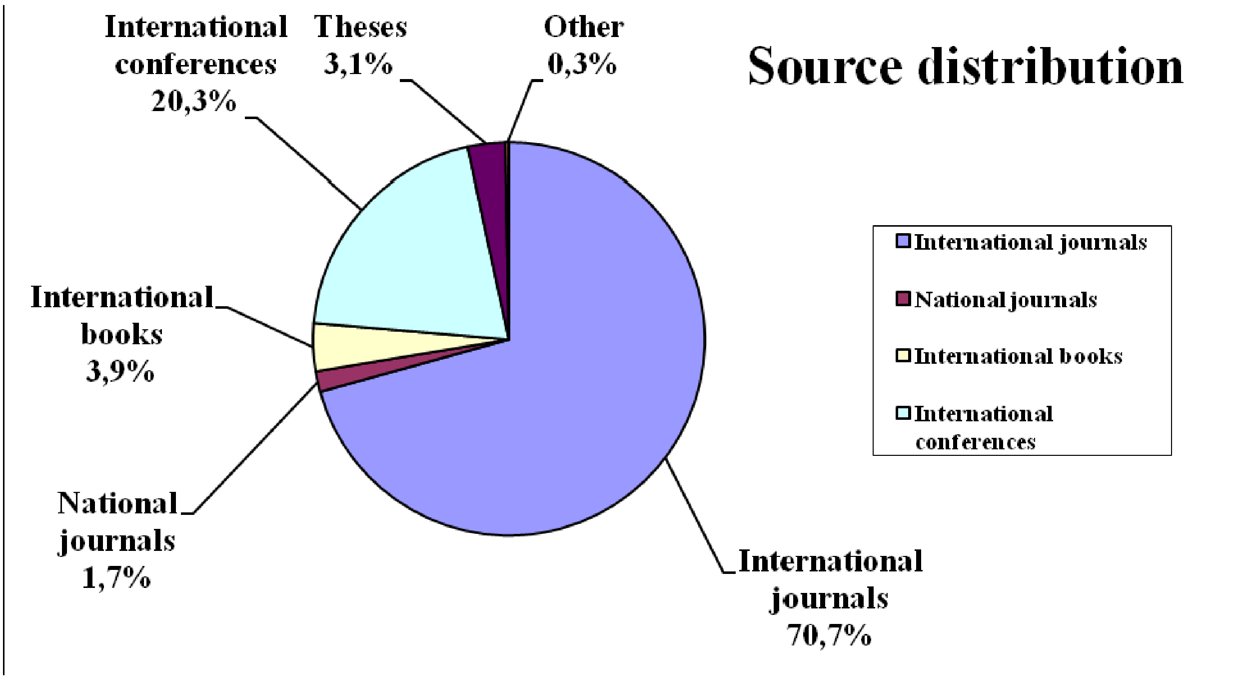

Figure 3.3: Source distribution in the literature review.

Yearly distribution of papers from international journals

The international distribution of the articles, analyzed by year of publication, illustrates how the first evidence in the literature on Six Sigma methodology date back to the early 90s, in line with the introduction of the same in Motorola in 1986. In the first years after birth, the study of this methodology has not had a great response in the literature, and the number of articles per year is very low.
This number has remained limited until 2002 and then began to increase steadily until reaching its peak in the period 2004-2008, years that correspond to 49 items. In 2009 there was a decrease in the publications, however, partial data for 2010, updated in October, seem to imply the continuation of the upward trend, visible manifestation of academic interest in respect of the methodology.

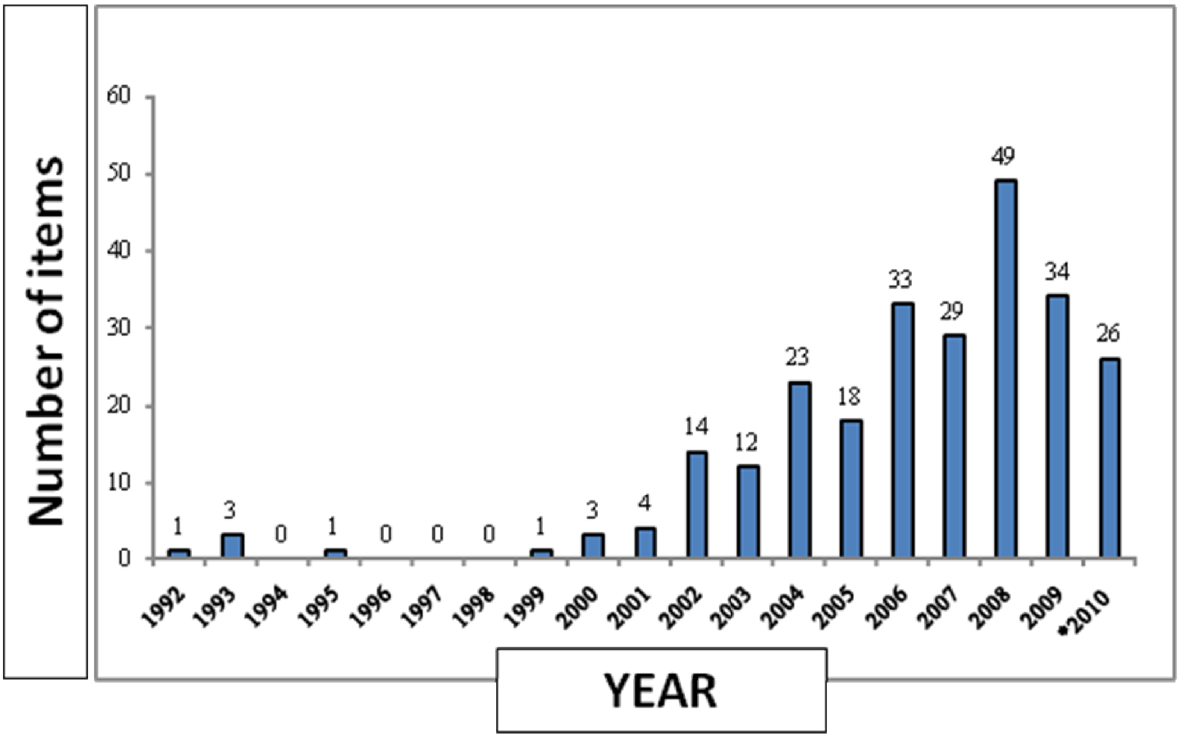

Figure 3.4: Yearly distribution of items from International journals.

Geographical origin of publications

As shown in the table below, most articles on Six Sigma was collected come from the U.S.A. (43%), followed at a big distance from the United Kingdom (21.5%) and India (6%). Interestingly, the fourth and fifth place to classify the emerging countries such as Taiwan (4.4%) and South Korea (3.2%), showing that the contribution of Asian research on Six Sigma is quite relevant. Overall, the data obtained shows a scenario where there is a clear predominance of articles from North America, continent of birth of the methodology, followed by Europe and close to Asia.
Insignificant in numerical terms the contribution from South America and Oceania, while no contributions have been reported from the African continent.

Table 3.4: Geographical distribution of the papers from International journals.

COUNTRY	N. PAPERS	PERCENTAGE
USA	108	43,0%
United Kingdom	54	21,5%
India	15	6,0%
Taiwan	11	4,4%
South Korea	8	3,2%
Sweden	8	3,2%
Singapore	5	2,0%
Canada	4	1,6%
Netherlands	4	1,6%
Germany	4	1,6%
China	3	1,2%
Finland	3	1,2%
Saudi Arabia	2	0,8%
Australia	2	0,8%
Brasil	2	0,8%
Hong Kong	2	0,8%
Ireland	2	0,8%
Switzerland	2	0,8%
Spain	2	0,8%
Turkey	2	0,8%
Argentina	1	0,4%
Belgium	1	0,4%
Croatia	1	0,4%
United Arab Emirates	1	0,4%
Kazakhstan	1	0,4%
Pakistan	1	0,4%
Portugal	1	0,4%
Thailand	1	0,4%
Total	**251**	**100%**

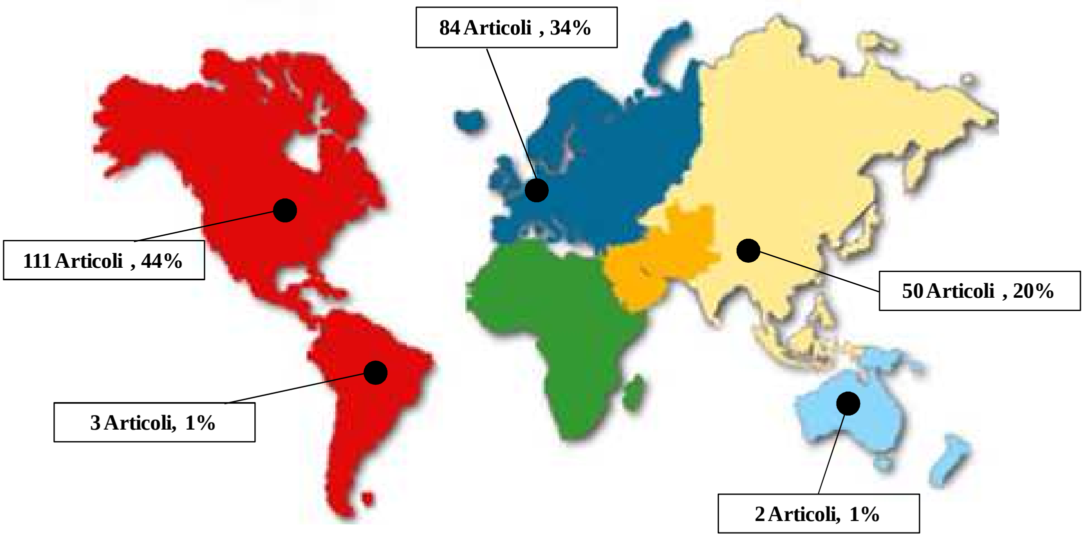

Figure 3.5: Summary of geographical distribution of the papers from International journals.

Classification per Journal

The journals in which they were published at least two articles on the Six Sigma 29. Among these The TQM Journal, which was consulted many times in this study, takes the lead with 39 papers. Following the list in order of articles published on Six Sigma there are the International Journal of Quality & Reliability Management (17 papers), the International Journal of Productivity and Performance Management (10 papers), then Manufacturing Engineer and the International Journal of Production Research (9 papers). The prestigious Journal of Operations Management has offered 8 publications on Six Sigma, all of them recent, further evidence of the interest shown in the academic discipline of Six Sigma.
As can be easily inferred from the graph, the journals with a greater number of articles on the subject of Six Sigma are focused on quality management and production management.
In summary, as Six Sigma has been applied in many research fields, we can find articles related to the methodology in journals of all kinds, from medical, innovation, technology and applications in services.
In the figure below the classification per journal:

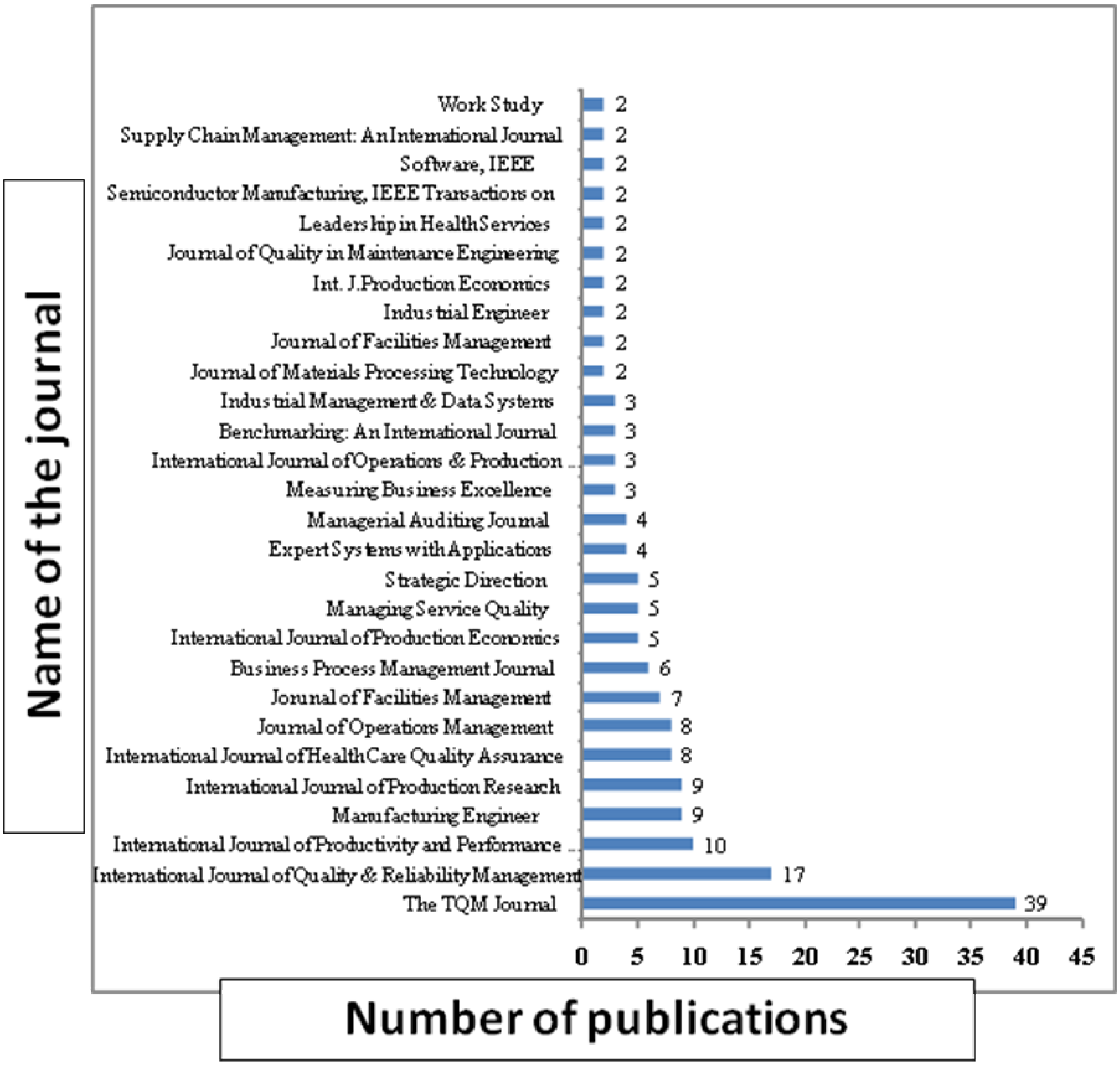

Figure 3.6: Classification by journal of the International papers of the review.

<u>Classification per research approach</u>

The following chart shows the results of the analysis of articles by research approach used by the authors. As result, most of the authors have addressed the topic of Six Sigma through an empirical approach, as evidenced by the large number of articles of this type. The second type as reflected in literature is the theoretical one, with many articles on the theoretical foundations of Six Sigma and comparisons with other quality methodologies. The third type in number of papers regards the descriptive approach, characterized by a less rigorous method than the conceptual theory, often used for a general understanding on the methodology and tools. As shown on the chart, among the papers there are a limited number of review of the literature. For this reason, there is a particular need for systematic literature reviews, to demonstrate how issues on the Six Sigma still offer several improvements and ideas for research and future developments.
In the figure here below, the classification per research approach:

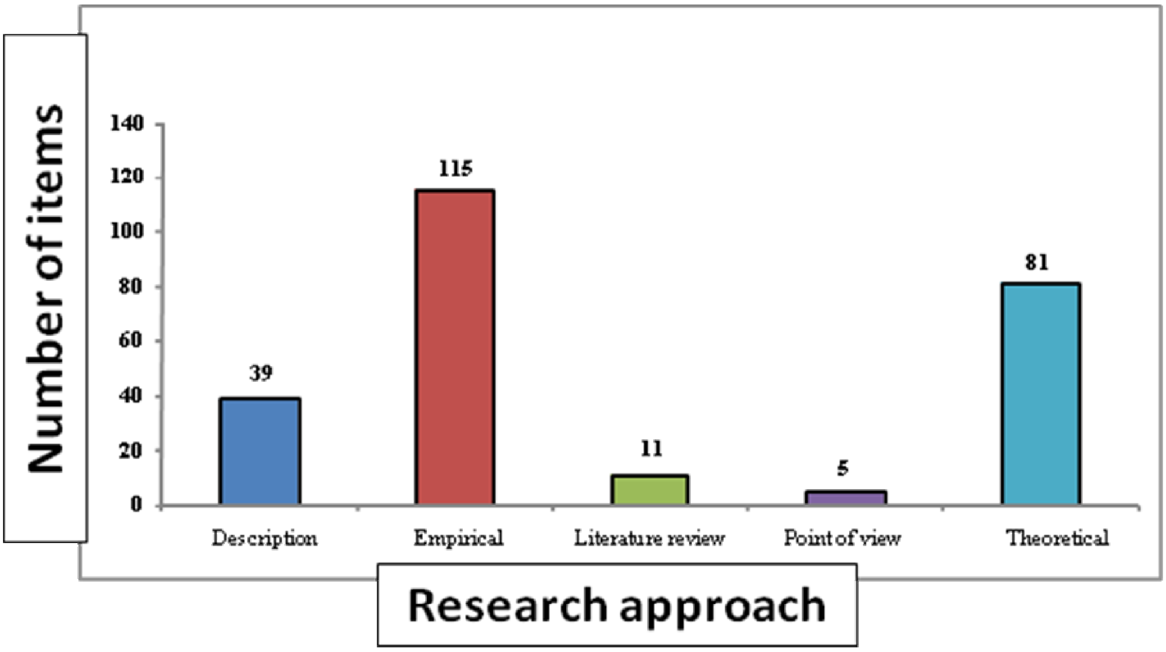

Figure 3.7: Classification of the papers from International Journals by research approach.

A deeper analysis of the items with empirical research approach has been made. Those papers can be divided into five sub-categories, depending on the research methodology used by the authors. The figure is made explicit, the utilization rate of the five techniques identified: survey, case study, simulation, meta-analysis and action research. The methodology most used is the case study with 74 articles or 64%, followed by the survey (32, 28%) and simulation (5, 4%). The remaining methodologies, meta-analysis and action research were used only by the remaining 4% of the sample analyzed.

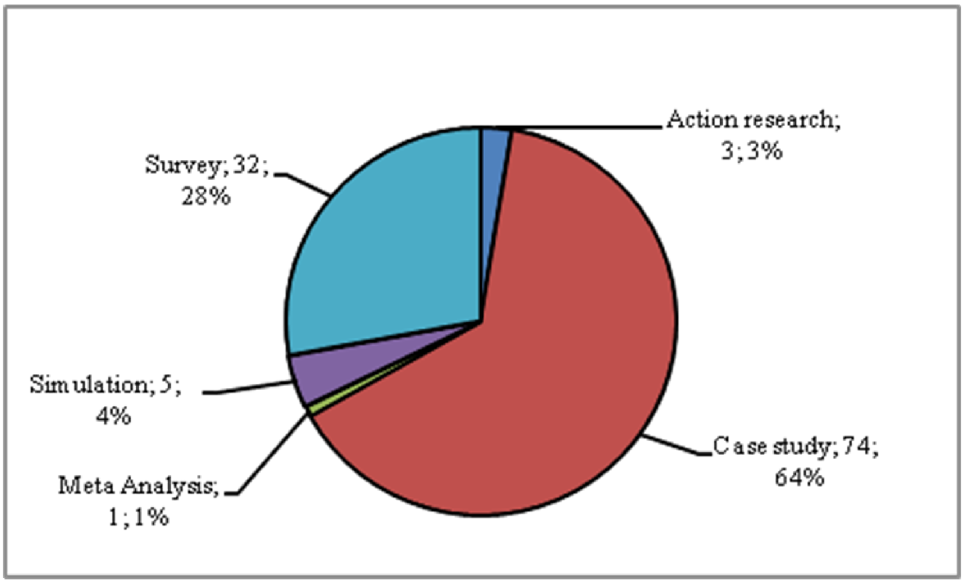

Figure 3.8: Distribution of the International papers by empirical methodology used.

Classification of articles by industrial sector

The majority of papers, where specified, refer to the manufacturing sector, in line with the fact that the methodology was first introduced in this sector. In some of the items other hand, there are reference to the application of cross-sectional methodology, independent of the sector, as indicated in the chart as "general". It should be noted that there is a good contribution to the literature of articles referring to the service sector; many of them are recently published, demonstrating how this sector has great margins for growth in terms of research on Six Sigma. As for the articles included in the category "Not specified", we underline that often they refer to introductory theoretical articles, reviews or comparative assessments of the literature.

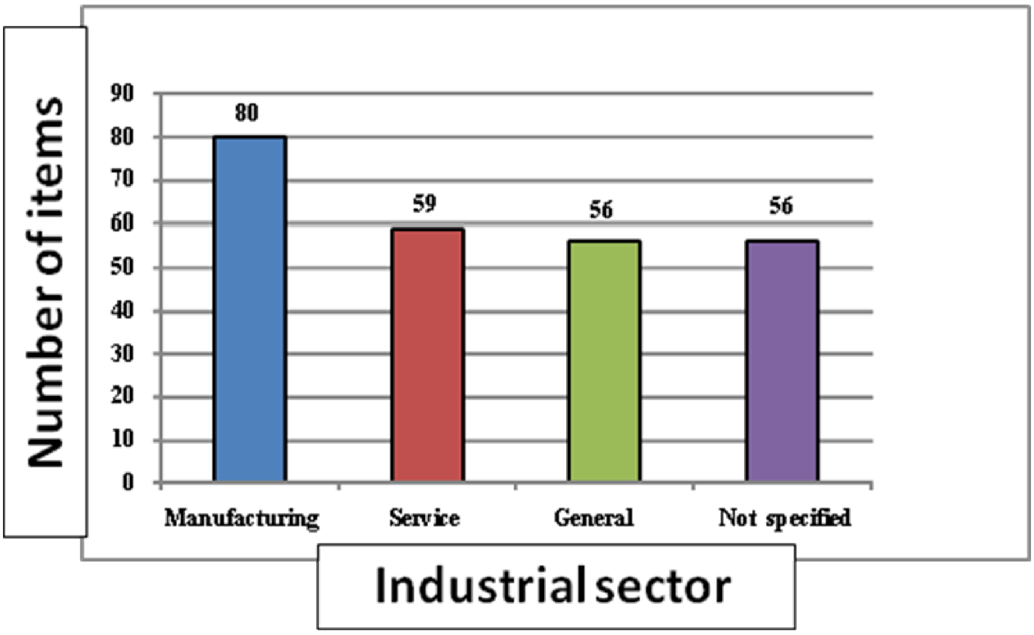

Figure 3.9: Classification by industrial sector.

The following chart classify the papers according to the kind of company which the methodology is applied to (for those in which at least a company is involved). Nevertheless, in some cases the authors did not mention the kind of the company. As result, a large number of articles refer to the electronics industry (22), the first in which the methodology was introduced in 1986. In addition, a number of articles (7) refers to the field of computers and software, always connected to the electronics.
However, an indication concerns the very interesting finding identified among the articles referring to the health sector (11), and hospital (13), which seems to be the current trends in the application of the methodology, together with the bank (2) and financial (4) and that of culture and education (6). These observations seem to confirm the findings in the chart above, with regard to the increasing application of Six Sigma in the service sector.

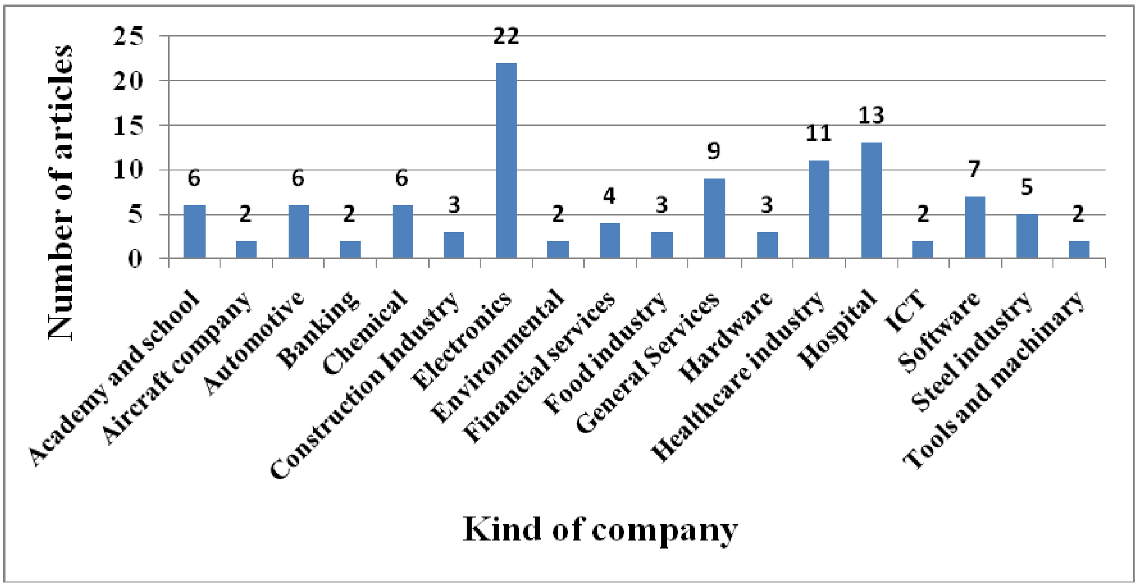

Figure 3.10: Classification by kind of company.

<u>Classification for field of research and macro-field of research</u>

In the following chart, papers are classified on the basis of the eight research fields introduced in the frame work of reference for this thesis. The sum of the articles in this graph is 247, against the total of 251 collected. This is due to the fact that four articles of the type of literature review, are transversal and cannot be classified in a specific type. It has been outlined from the chart, that more than half of the items belongs to the operational macro-field (145), with particular relevance on the implementation of the methodology (93), followed by the tools used (52). The second macro-field in terms of number of items is the theoretical (51), which refer to the introductory theoretical articles (31), and the comparison with other methods for quality management (20). A good number of items also refers to the organizational scope (35), with particular relevance to human resources and organizational structure (22). The other research field in the organizational area regards the culture and the intangible assets, with 13 articles. Finally, there are 16 papers in the strategic area, only 6 for the strategic choices between DMAIC and DFSS and 10 regarding the strategic project selection.
These statistics seem to indicate the practice connotation of Six Sigma methodology, given the prevailing focus on issues related to the implementation and its tools, rather than the theoretical foundations underlying.

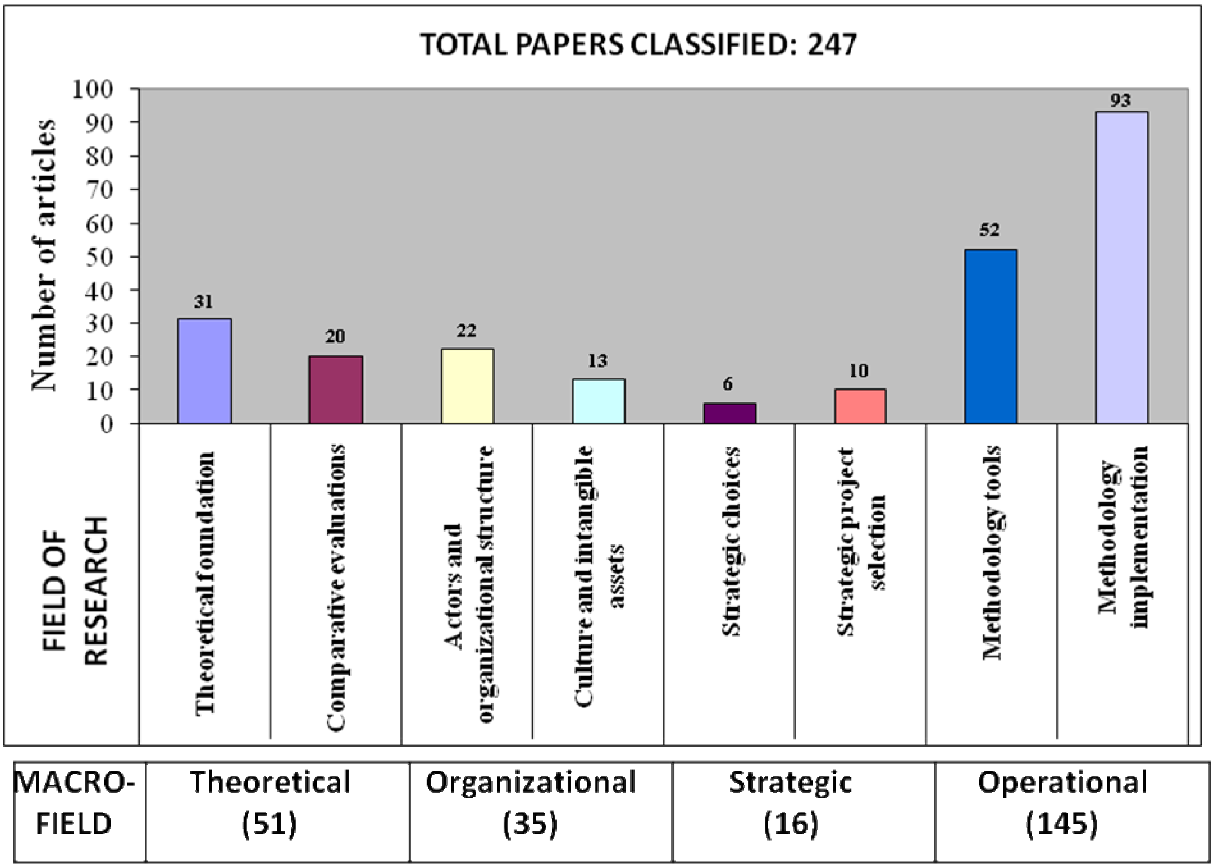

Figure 3.11: Classification of articles by field and macro-field of research.

3.4 The frame-work of the literature

After an exhaustive analysis and classification of articles, now is the time to analyze exactly what they explained.
Each of the 251 articles has been tried to catalog in most categories or fields, and then, each of these "dimensions" or macro fields have been divided in other more specific fields, which have been called research fields.
Each of the three macro fields represents a dimension, or direction, in the purpose of the research, clearly identified. These macro fields are:

-**Theoretical**: the articles in this macro-field try to study what are the foundations of the methodology and how can be compared to the other quality management methodologies, e.g. lean management, theory of constraints, Business Process Reengineering (BPR), etc;

-**Operational:** the articles belonging to this macro-field consist in applications to various environment of the methodology; moreover, most of them offer a deeper focus on the tools used in the methodology;

-**Organizational**: the articles in this macro-field try to study how the Six Sigma methodology is related to various aspects of the organization, e.g. the organizational structure, the culture, the vision, etc;

-**Strategic:** the aim of these articles is to deepen the strategic reasons to utilize this methodology rather than others; furthermore it has been considered strategic outline where to apply the methodology, i.e. what kind of Six Sigma project to launch in the company.

Each of these macro-field has grouped two different research field, that is related to what the authors have investigated specifically in the article.
The following table shows the classification of macro-field and research fields, with the most important contributions of each research field:

Table 3.5: Classification and most important references of the Six Sigma literature.

	MACRO-FIELD	RESEARCH FIELD		N. OF ARTICLES	MAIN CONTRIBUTIONS
A	Theoretical	1	Theoretical foundation	31	Linderman *et al.* (2003); Schroeder *et al.* (2008)
		2	Comparative evaluations	20	Black and Revere (2006); Bendell (2006); Naslund (2008)
B	Operational	3	Methodology tools	52	Bunce *et al.* (2008); Hensley and Dobie (2005); Setijono and Dahlgaard (2007)
		4	Methodology implementation	93	Sekhar and Mahanti (2006); Antony *et al.* (2007); Kumar *et al.* (2008)
C	Organizational	5	Actors and organizational structure	22	Buck and Tolentino (2006); Agarwal and Bajaj (2008)
		6	Culture and intangible assets	13	Bañuelas and Antony (2002); Dahlgaard and Dahlgaard-Park (2006); Savolainen and Haikonen (2007)
D	Strategic	7	Strategic project selection	10	Bañuelas and Antony (2004); Bañuelas *et al.* (2006)
		8	Strategic choices (DMAIC vs DFSS)	6	Bañuelas and Antony (2003, 2004); Antony (2004); Klefsjö (2008)
			TOTALE	**247**	

3.4.1 Theoretical macro-field

In the first macro field category, it has been possible to outline the theoretical basis of the method as well as carry out several studies in which a comparison between Six Sigma and other quality management methodologies has been made.
In turn, this macro field is divided into three research fields, as we explain below.

Theoretical foundations

The articles that belong to this research field are those that have been created in order to expose the trends and the characteristics of Six Sigma. The authors set out theories written previously and already accepted, and then they discusses about its veracity, often giving their own opinion and approving or disproving assumptions written in them.
Many of these articles aim to provide the reader useful contributions in order to understand the foundations of the methodology.
According to Schroeder *et al.* (2008):

> *"Understanding Six Sigma first requires providing a conceptual definition and identifying an underlying theory."*
>
> (Schroeder *et al.*, 2008, pp. 536)

Hence, the aim of articles is to present and describe what these concepts and theories on which are supported all the definitions of the Six Sigma methodology are.
One of the most important aspects is the goals which meet the exposed theory. Goal theory is well developed in the behavioral literature. It specifies conditions under which goals can be easily achieved or are found to be difficult or unattainable. For example, goal theory states that goals which are clearly specified and measured result in higher performance than fuzzy or "do-best" goals (Linderman *et al.,* 2003, page 194).
This is also completely valid for the case of Six Sigma, because it is important for companies to know their goals vey well to see if this method will help to achieve them.
Sometimes, these articles are also supported by some brief case studies to analyze the factors that this company took into account when it decided to implement Six Sigma.
In these case studies, firms are subjected to a series of interviews and surveys to find out the result of the incorporation of the methodology in their organizations.
Thus, authors can discuss the level of knowledge of the Six Sigma methods which firms have before embarking on a project of this magnitude.
These examples are also useful to know which factors have caused more difficulty in its implementation, and the staff satisfaction after incorporating Six Sigma.
According to Linderman *et al.* (2003):

> *"Six Sigma is a phenomenon that is gaining wide acceptance in industry, but lacks a theoretical underpinning and a basis for research other than "best practice" studies."*
>
> (Linderman *et al.*, 2003, pag. 193)

For this reason, many authors claim that that the only thing known about the Six Sigma is the success of its implementation in important worldwide companies such as Motorola or General Electric, but there is no still solid basis on which firms could base on in order to not run the risk of failure in their attempts to implement Six Sigma.
Understanding the key features, obstacles, and shortcomings of the six sigma method allows organizations to better support their strategic directions, and increasing needs for coaching, mentoring, and training. It also provides opportunities to better implement six sigma projects. (Young Hoon and Anbar, 2004, page 708).
Maybe if companies had a solid base where to lean on to start their implementations, their results would be better as well as their profits would grow significantly.

Comparative evaluations

In the articles in this research field, an exhaustive comparison between two or more theories is performed. One of the two theories is always Six Sigma, the others are theories such as Lean Thinking, Total Quality Management, Just in Time, Business Process Reengineering, Shainin System [7], Taguchi's method or the Theory of the Constraints.
Usually, the authors' extensive practical and experience with Six Sigma and others methods and business process improvement programs make that the examination and comparison were more real and more exhaustive.
According to Bendell (2006):

> *"Companies pursuing six sigma and lean implementation programs need to carefully examine how the proposed initiatives relate to each other and other initiatives before fully committing, or at least to review the programs, to enable sensible programs design and management."*
>
> (Bendell, 2006, pag. 255)

Thus, this type of articles are very necessary and useful because they can help companies to decide which, among of all quality management systems that exist, is the most suitable to be implemented in their production processes.
The articles which expose the similarities and the differences between TQM and Six Sigma are very abundant, due to their closely relation related to their origins.
For example, in Black and Revere (2006), it is explained that:

> *"Six Sigma is a very popular and widely-used methodology for quality improvement in healthcare organizations today. Six Sigma is a powerful expansion of TQM because it repackages some of the stronger TQM principles while adding its own distinct concepts and methodologies."*
>
> (Black and Revere, 2006, pag. 265)

Other articles deal with the comparison of other quality systems.
Six sigma and the lean organization approaches are exposed in Bendell (2006), but the author in this article not only makes a comparison of the two methodologies, both of its origins and its goals, but also presents the possible merger of the two approaches with the aim of applying the advantages of both.
Precisely, this merger is called *Lean Six Sigma*, and in words of the author:

> *"This alleged combination is no more than a "philosophical" or near-religious argument about professed compatibility of approaches. Some attempts to do this exist in which one of the two approaches is taken as the "dominate" one, and the other approach as a "subordinate" one."*
>
> (Bendell, 2006)

The lean approach offers a set of solutions to muda (waste) in a high variety production environment. Six Sigma is applied to the common problems in production. Six Sigma does not directly address process speed and so the lack of improvement in lead time in companies applying Six Sigma methods alone in understandable. (Antony *et al.*, 2003, pag. 40).

[7] The Shainin system is a problem solving system, with its strategies and tools, developed by Dorian Shainin, and widely used and promoted in the manufacturing sector.

Similarly, profits obtained by companies that have only implemented the Lean methodology have also been very limited due to the absence of an organizational structure like the Six Sigma hierarchy.
According to Antony *et al.*, (2003):

> *"In essence, an integrated approach utilizing the best of Six Sigma and lean strategies will maximize shareholder value by accomplishing dramatic improvements in customer satisfaction, cost, quality, speed and invested capital. While the fundamental principle of Six Sigma is to take an organization to an improved level of Sigma capability through the rigorous application of statistical tools and techniques, lean production has a role in eliminating waste and non-valued added activities across the entire supply chain."*
>
> (Antony *et al.*, 2003, pag. 41)

That is, these two methods are complementary to each other, and companies that decided to implement both at the same time can actually enjoy a synergy of effects that would improve their financial results.
Therefore, this kind of articles may also discuss the validity of possible mergers of existing quality management systems as well as the benefits they can bring to the organizations.

3.4.2 Operational macro-field

The second macro-field classified has been defined *operational*, because it deals with the study of the application of the methodology in different environments and the special focus on the use of specific tools in the methodology. This macro-field represents a big part of the literature in terms of items found; indeed, more than half of the publications (145) have studied these issues and authors still claim the necessity for more research for these topics, nowadays.

<u>Methotology tools</u>

This is one of the most important research field ever, as regards the number of articles. Thus, in this subdivision are found articles that expose case studies of companies which have used Six Sigma methodology, but making an important distinction of the tools used in each phase.
Here, the articles resort to the Six Sigma typologies again (DMAIC technical, DMAIC transaction, DFSS technical and DFSS transactional) used previously.
There has been a search for these tools and techniques from all the articles. The following table lists the main tools, which are classified according to the Six Sigma typology where they are used. Respect the first classification made in the previous chapter, in the next two tables we list the main tools used in the Six Sigma methodology grouped by different approach (i.e. DMAIC for incremental improvement or DFSS for radical improvement) and the typology of target process (i.e. technical process, for a product or transactional process, for a service). The abundance of references on this aspect has allowed this more specific and detailed classification.

Table 3.6: Tools and techniques used in all typologies (1).

	TOOLS	METHODOLOGY AND KIND OF PROCESS			
		DMAIC MAN	DMAIC TRA	DFSS MAN	DFSS TRA
1	Survey	✓	✓	✓	✓
2	Kano analysis				✓
3	Brainstorming	✓	✓	✓	✓
4	Affinity diagram		✓		✓
5	Tree chart	✓	✓		✓
6	Matrix chart	✓	✓		✓
7	Benchmarking	✓	✓	✓	✓
8	Process map		✓		✓
9	Quality Function Deployment	✓	✓	✓	✓
10	Gantt chart	✓	✓		✓
11	Pert chart	✓	✓		✓
12	Data gathering	✓	✓	✓	✓
13	Stratification	✓	✓	✓	✓
14	Pareto chart	✓	✓	✓	✓
15	Cause-effect chart	✓	✓	✓	✓
16	Bar chart	✓	✓	✓	✓
17	Control charts	✓		✓	
18	Correlation charts	✓			✓
19	Sample	✓	✓	✓	✓
20	Statistical index	✓	✓	✓	✓
21	Process capability	✓	✓	✓	✓
22	Short/Long term capability	✓	✓	✓	
23	Normal distribution	✓	✓		
24	Student t distribution	✓	✓		
25	Snedecor F distribution	✓	✓		
26	Estimation theory	✓	✓		
27	Hypothesis testing	✓	✓		
28	Monte Carlo simulation			✓	✓
29	FMEA	✓		✓	✓
30	Design Of Experiment	✓		✓	

MAN: Manufacturing processes
TRA: Transactional processes

Source: Conti and De Risi, 2002, pag. 515; Bunce et al., 2008, pag. 603; Antony, 2006, pag. 242; Antony et al., 2005, pag. 361; Goudarzlou and Tan Kay, 2008, pag. 6.

Table 3.7: Tools and techniques used in all the typologies (2).

	TOOLS	METHODOLOGY AND KIND OF PROCESS			
		DMAIC MAN	DMAIC TRA	DFSS MAN	DFSS TRA
31	Taguchi methods	✓		✓	
32	Multivariate statistics	✓		✓	
33	Root cause analysis	✓		✓	
34	Robust design			✓	
35	Response Surface Methodology	✓		✓	✓
36	Creativity tools			✓	✓
37	Poka Yoke	✓	✓	✓	✓
38	5 S	✓	✓	✓	✓
39	Scatter plot	✓		✓	
40	SIPOC	✓		✓	
41	Value Stream Mapping	✓	✓		✓
42	ANOVA	✓		✓	
43	Impact-Effort matrix	✓	✓		
44	Focus group			✓	✓
45	Audit findings	✓			
46	Measurement system analysis			✓	✓
47	VOC analysis			✓	✓
48	Service FMECA		✓		✓
49	Cost-Benefit analysis	✓	✓	✓	✓
50	Analytic Hierarchy Process		✓		✓
51	Stakeholder analysis			✓	✓
52	SMED	✓			
53	Pugh matrix	✓	✓	✓	✓
54	Balance scorecard	✓	✓	✓	✓
55	Risk evaluation	✓	✓	✓	✓
56	Conjoint analysis			✓	✓
57	TRIZ	✓	✓	✓	✓
58	Gap analysis		✓	✓	✓
59	Rapid prototyping			✓	
60	CTQ analysis		✓	✓	✓

MAN: Manufacturing processes
TRA: Transactional processes

Source: Conti and De Risi, 2002, pag. 515; Bunce et al., 2008, pag. 603; Antony, 2006, pag. 242; Antony et al., 2005, pag. 361; Goudarzlou and Tan Kay, 2008, pag. 6.

We can conclude that, the majority of the articles are classified in the tools research field, outlining a great activity of the scholars. This division has a very high weight in the literature because the companies have to know how tools have been used in order to achieve what they want.

Methodology implementation

In this apparently generic research field are collected the articles which outline practical and real cases where companies from different sectors develop and perform Six Sigma methodologies. In this research field some recurring difficulties for implementing Six Sigma in the companies will be outlined and the advantages that this methodology could bring to SMEs as well as a big company will be stressed.
These applications can affect various parts of the company, for example, supply chain, marketing, transversal process or other function, as we explain here below.

1) Supply chain

Articles dealing with the supply chain show how important it is to have good relations with all the elements of the business. Efficiently managing this process involves overseeing relationships with suppliers and customers, controlling inventory, forecasting demand and getting constant feedback on what's happening at every link in the chain (Kumar *et al.*, 2008).
Another supply chain's elements are the location (facilities of the company) and transportation. After the companies have determined all of the elements, they have to know how manage their supply chain.
To achieve this, there are three main ways in the process which have been controlled: product flow (which includes the movement of goods from de supplier to a customer, as well as customer returns), information flow (which involves transmitting orders and updating the status of delivery) and financial flow (which consists of credit terms, payments and payment schedules).

2) Marketing

This issue is one of the most significant of the Six Sigma methodology because precisely, Six Sigma was thought to create a level of quality that meets the customer requirements: in a word Six Sigma is a Customer-Focused philosophy.
Six Sigma professionals and Sales and Marketing professionals have similar objectives in mind – finding the way of least resistance and major benefits. (Byrne *et al.*, 2007). For this reason, Six Sigma and marketing are two closely related concepts within the company.
In recent years, a tool that included both marketing and Six Sigma has been created. It is called *Six Sigma Marketing*. This tool challenges the way both the Six Sigma community and the marketing area think about business and the way they currently do this business.
This method is a fact-based, data-driven disciplined approach to growing market share by providing targeted product/markets with a high value. Hence, these articles explain what kind of steps the marketing department should follow to make their product the best of the market, always following the Six Sigma methodology.

3) Transversal processes

This general kind of articles deals with companies which have decided to implement the Six Sigma method in all the departments and areas of their process. The articles are more general and not focusing on a specific functional area of the company.
Half of the selected papers belong to the category of Methodology implementation and Methodology tools. Although it can be concluded that they are the research fields on which the scholars have dedicated more study and efforts in the Six Sigma literature, these two

research fields still offer several aspects to deepen both from an academic point of view and from a managerial one.

3.4.3 Organizational macro-field

This second macro field is related to the intangible aspects related to business culture and on the organizational structure that authors consider important to implement in the best way the Six Sigma methodology.
The articles that belong to this macro field have also been divided into two subdivisions which are explained here below.

<u>Actors and organizational structure</u>

Reading the several articles on this field, it seems clear that human resources involved with Six Sigma are not a huge part of any company's business, but it has a huge effect on any company's business. Human resources should be considered as human capital. It must ensure that there's good return on investment in human capital.
Typical human resources functions include benefits management, compensation, recruitment and skills development. Innovation and change management must also become key functions in this department. In addition to managing these functions well, managing idea to innovation, improving human resources functions, and accountability of employees and executives must also be implemented.
Hence, these articles are related to those topics which affect the company employees, the human resources department and the training that companies must give them if they want to adopt Six Sigma methodology.
It is well known that Six Sigma systems present a novelty with regard to its quality management systems predecessor in terms of hierarchy of the company. Hence, as explained above, the Six Sigma corporate hierarchy establishes roles very clearly marked for each category of employee.
In order to name each of these categories, the names of the different rankings which are used in traditional martial arts were adopted. One of the topics that this type of articles cover, it is the importance of that the employees feel part of the project, and feel involved in it.
The easiest way that the company has to find out if your employees feel good and know what you think about Six Sigma implementation is doing a survey.
An example of this issue is the article Buch and Tolentino (2006a), in which it can be found:

> *"It is clear that training and reward systems are integral components of a successful Six Sigma program, and the two must be linked so that learning and new responsibilities that follow are perceived by employees as rewards of the program. If, employees perceive that the rewards of Six Sigma primarily benefit the organization, the program may be perceived as exploitation and its sustainability would be threatened."*
>
> (Buch and Tolentino, 2006)

For this reason, it is very important that employees feel good in the process. Employees have to receive the organizational support needed to translate their knowledge into new job behaviors and organizational practices that define the Six Sigma method. (Buch and Tolentino, 2006).
In this way, they work harder in their teams and their efficiency will be higher.
Another topic is the problems that can arise from the fact that companies do not possess a very well structured and defined organization chart (i.e. an organigram of the company).

Every employee and every manager has to know what is their commitment and their role into the production process, and what tasks have to carry out.
This is one of the assumptions which has to be met in order to achieve a successful methodology implementation.

Culture and intangible aspects

In this category of articles, topics such as culture, vision, leadership or commitment are examined with their relationship with Six Sigma.
Nowadays, organizations are aware that their ability to differentiate themselves from its competitors is not in physical assets, labor force and capital. There are other important aspects in the company called "intangible or intellectual capital", i.e. the sum of everything everybody in a company knows that gives it a competitive advantage.
All these aspects are related to the capacity for innovation and adaptation to the changing environment such as expected returns from patents, the knowledge of all the staff and their expertise, intellectual property, customer loyalty and customer relationships, brands names, or relationships with the environment.
These elements are key factors to the future of a company, which should not forget them. Unfortunately, companies still have tendency to invest more in tangible assets than intangibles, because the returns on the intangibles assets are more difficult to measure.
These intangible aspects can be divided in a three categories: (The Knowledge Management RC[8], 2010):

1. Internal structure: are the tools used to package knowledge and permit it to be used time and again in the creation of value, such as organization's culture (corporate practice), core processes (operating guidelines), data and information (documented expertise, technical designs, R&D results), standards and procedures (corporate procedure), methodologies (manufacturing technologies), business plans and strategies (knowledge of the firm);

2. People competence: is the knowledge embedded in the people of the organization, and include skills (professional, management and operational expertise), know-how (technical know-how), experience (lessons learnt, knowledge-based systems), and education;

3. External structure: refers to the relationship that organization has with its external environment, e.g. the organization's image in the market and relationship with its stakeholders that enhance the likelihood that the organization's customer will keep doing business with it. It also includes market centered assets (knowledge of the market), suppliers related assets, the relation of the stakeholder, society related image, brand names and trademarks.

According to Haikonen *et al.* (2004):

> *"Although Six Sigma focuses on the operational level process improvements, it affects the entire organization's performance. The Six Sigma approach starts with business strategy and ends with top-down implementation"*
>
> (Haikonen *et al.*, 2004, pag. 369)

[8] http://www.kmresource.com/

This approach is a combination of both "soft" and "hard", in other words, leadership and the use of statistical techniques. Thus, since the implementation of Six Sigma affects all levels of the company, both internally and externally, a large number of professionals have studied in depth before its implementation to make it happen.

3.4.4 Strategic macro-field

In the strategic macro field, articles discuss the strategy for the trade-off of using a DFSS or DMAIC approach can be analyzed. In other words, these articles detail the selection process carried out by companies with the aim to know which Six Sigma projects are viable and which do not. Moreover, authors have outlined that the choice of the areas and thus of the projects to which to implement the methodology can be considered a strategic issue.
This macro field has been divided into three research fields, as we explain here below.

Strategic choices

This research field develops business cases where the companies struggle between to implement DMAIC method in order to improve the process or redesign the process completely, from the earliest stages, using a DFSS approach.
This is not an easy choice. For this reason, companies need a lot of information on how these typologies can make their processes more efficient and profitable before taking a direction or another.
Making good strategic choices to optimize impact on the value stream requires thinking more broadly about change, outside the traditional organizational boundaries. It also requires ongoing dialogue with customers and suppliers about needs and opportunities for maximizing added value.
For example, the article Bañuelas and Antony (2004), aims to identify when one approach is a priority over the other. To make this, a multicriteria decision technique is used. The literature presents two main directions about this issue.
This contribution of Bañuelas and Antony (2004) outlines these two directions:

> *"One of them considers organizations that adopted the principles and concepts of Six Sigma methodology and have realized that once they have achieved five sigma quality levels (i.e. 233 defects per million opportunities) employing DMAIC improvement methodology, the only way to surpass the five sigma quality level barrier is to redesign their products and processes from scratch by means of DFSS"*
>
> (Bañuelas and Antony, 2004, pag. 251)

The other hypothesis states that:

> *"This decision is not straightforward, given the fact that many variables need to be taken into account, consequently just a general guideline can be provided."*
>
> (Bañuelas and Antony, 2004, pag. 251)

As it is shown, this is not an easy decision. Moreover, companies have taken into account other factors. For example, although to carry out the methodology approach selection could guide companies in their Six Sigma applications and could help them to focus all their efforts using the appropriate approach, companies have to be aware that these efforts will be unsuccessful if the fundamental design of the process to improve is erroneous.

The fact that companies can identify the "critical points" of the process which must be improved may help the choice of methodology to implement. As a result, the efforts can be focused on these points and the implementation becomes more effective.
One tool which can be used to decide to implement DMAIC or DFSS is the AHP (Analytic Hierarchy Process).
AHP combines the priority weightings of objectives and attributes with the comparison rating for alternatives by multiplying the priority weight of each objective ***i*** by the comparison for alternative ***j*** with respect to objective ***i*** (Bañuelas and Antony, 2004, pag. 255).
There were many factors involved when one company considers to redesign the process instead of trying to improve it, and with this technique, these factors, which affect the final decision, can be found. Among others, they can be financial benefit, cash avoidance, risk and capability.
So, it can be concluded that there is no better methodology than another, but the method chosen will depend on the company's needs.

Strategic Project Selection

As it has discussed above, these articles discuss how companies decide which projects to undertake and which not. Companies should thoroughly analyze a high number of factors, all these very important, such as its objectives, the available budget, their capacity and their human resources.
In order to implement the DMAIC or DFSS concepts successfully, the decision maker have to choose a group of projects in order to minimize the investment as well as maximize the company profit. Company benefits translate into enhancing performance, productivity and profitability by decreasing defects, wastes, lead time through improving product quality and reliability.
Typically, organizations lean on a decision support system, based sometimes on multi-objective models, which provides them more flexibility of adjusting the weight of all the factors in the decision making process.
These factors can be of different nature, and they can be divided into (Conti and De Risi, 2002, pag. 505):

1.External indicators (the voice of the customer), which can come from:

-The evolution of the needs of the customer and then, the market;
-The behavior of competitors;
-The returned feedback by customers;
-Surveys on customer satisfaction;

2.Internal indicators (the "voice" of the process), which are generated of:

-Costs of production or excessive structure;
-Presence of inefficiency or ineffectiveness in the company's process;
-Low return on investments;
-All the problems of a domestic nature that affect the performance business;

3.Strategic indications (the voice of the stakeholders).

During the structuring phase of the implementation of a project, the following points can be identified: analysis of both external and internal environment, definition of the improvement goals, deployment of the goals and definition of Six Sigma projects to be carried out.
In the last phase, candidate projects to be implemented are evaluated and defined.
Thus, the following factors must be taken into account (Conti and De Risi, 2002, pag. 505):

-What objectives previously defined have major priority;
-At what level can give rise to a Six Sigma project;
-How to start with groups of multiple projects simultaneously.

Once all potential Six Sigma projects have been submitted, companies must choose one that adapts better in their process. They should base their choice on other factors which may be (Conti and De Risi, 2002, pag. 505):

-The accessibility / difficulty degree;
-The resources to be used;
-The time required to achieve the process implementation;
-The consistency with the objectives of a higher order;
-The consistency with other Six Sigma projects with the program;
-The consistency and compatibility with other business activities.

Hence, to increase the chances of success is not sufficient to plan, manage and control with efficiency, but companies must also carefully choose the project, having in mind the risks.
For this reason, companies have to work to reduce the uncertainty related to the duration of the project, minimizing the probability of occurrence of uncertain events and bad effects, improving the process and analyzing data and information.
To sum up and to finalize this chapter, it can be said that the classification in macro fields and research fields has been very useful to order and classify all the articles in different topics and types, making order in all the literature about Six Sigma.
This classification is also very useful to give the further directions in the future research about Six Sigma, which is an area that actually has still many academic questions to set and that might bring several important contributions for the growth of the companies.

Chapter 4 -RESEARCH QUESTIONS

In the previous chapters we have deeply shown the topic object of this thesis, i.e. the DFSS, outlining the state of the art of the scientific literature. In this chapter we conclude the process of theoretical analysis, explaining which are the existing gaps in the Six Sigma literature that allowed us setting a valuable research agenda. Considering what are the trends and the directions in the academic world, indeed, is fundamental to address a research and define the research questions, eventually. Furthermore, to reach this purpose, we even approached the border areas of this topic, i.e. the literature of service management and New Service Development, as in the next chapters is explained.
An first formulation of the research questions, in rather general terms, represents a very important step in building theory from case studies (Eisenhardt, 1989). About this, Mintzberg (1979) claimed:

> *"No matter how small our sample or what our interest, we have always tried to go into organizations with a well defined focus, to collect specific kinds of data systematically"*
>
> (Mintzberg, 1979)

Without a research focus, indeed, it would be easy to be overwhelmed by the volume of data available.
A preliminary specification of constructs can help to define the design of research, since it allows the researcher to more accurately measure the same constructs. If the constructs are valid, as the study continues, then the researchers can handle empirical foundation for the emerging theory.
Furthermore, according to Eisenhardt (1989), despite an early identification of research questions and constructs could be useful, it is equally important to recognize that those constructs are hypothetical at that time. No construction is ensured in the resulting theory, no matter how well was measured. In addition, the research questions may change during the progress of the study.
Finally, the search for theory building should be conducted on the assumption that there is no existing theory or hypothesis to be tested into account, even if that purpose is objectively impossible to achieve in practice. Nevertheless, this approach is important because the use of too static theoretical paradigms may deny or limit the findings. In addition, researchers should formulate the research problem and possibly specify some potentially important variables, with some reference to the existing literature. However, they should avoid thinking about specific relationships between variables and theories as much as possible, especially early in the process.
Although Six Sigma methodology was born almost 25 years ago, the scientific research on the topic has definitely exploited only in the 21st century. The gaps in its literature, consequently are several and relevant for the academic world. Such research gaps can regard anyone of the eight research field we have outlined in the previous chapter, and overall they can deal not only with general aspects, but even imply the necessity to study these aspects of the methodology in the manufacturing or service sector, rather than the application to private or public administration.
Antony *et al.* (2007), for example, claims that there are no studies on the integration of DFSS with a holistic improvement strategy, but only specific events to redesign single processes or products. Setijono and Dahlgaard (2007) assert that modern tools used in DFSS do not

express adequately the customer's value and Goh (2002) thinks that the tools for innovation management and creative thinking are scant. About the organizational aspect, Hoerl (2001) claims that there are no standard processes for the "Belts" certification; although the hierarchy among the belts is widely accepted, any company can adopt its own set of trials to certify the employees as Green, Black, or Master Black Belt. In the same area, but involving even the cultural aspect, Pandey (2007) asserts there is a need to study the impact of the methodology on the organizational structure, on leadership roles and on organizational culture. Moreover, Savolainen and Haikonen (2007) aim to explain the effect of certain organizational learning on the implementation of DFSS methodologies. Another gap for the cultural aspect of the methodology is that nobody has found systems for reducing start-up costs of introducing DFSS in the organizational culture (Antony, 2006); the author thinks this is true in particular for the case of SMEs.

As regards the public sector, there are several literature gaps as well. Byrne *et al.* (2007), for example, claim that new approach for improvement/redesign in the public sector should be developed. At the same time, the advantages and limitations of implementing DFSS in the universities and, in general, in the academic world are not clear (Jenicke *et al.*, 2008).

The lacks of the literature in the service sector are several and, in my opinion, the most interesting and evident. Antony *et al.* (2006) assert that in those kind of organizations the priorities for DFSS project selection are led by subjective decisions and there are no proper tools for that. Moreover, in service companies the statistical meaning of 3.4 DPMO must be redefined, since that in a service environment a defect is represented by anything does not meet customer expectations and it is more difficult to define a list of possible defects in advance (Antony, 2006).

Finally, there are several authors, e.g. Sewall and De Jong (2003), Antony (2004), Hensley and Dobie (2005), who consider particularly difficult and time consuming gathering data in the service sector; for this reason, they claim the lack of studies regarding the possibility to automate this process in order to make the DFSS projects more efficient. Regarding this gap, it would be interesting even study which are the tools that could facilitate this process in this kind of organizations.

Our study outlined that there are several other gaps that could define a research agenda during next years. Focusing on specific contexts, for example, could give the possibility to study the environment of Italian SMEs and understand why this methodology is not so fully implemented, although the relevant advantages offering. Finally, another suggestion for further developments might be studying the impact of tools and techniques on performances, particularly on customer satisfaction in the organizations applying DFSS.

In the table below we have summarized the presence of all the literature gaps identified, regarding the eight research fields previously outlined, the industrial sector, i.e. service, manufacturing or general (i.e. it does not matter what), and the public or private environment. Normal font means that the gap regards only private organizations; italic font means that it regards only public organizations; a font both italic and bold means that the gap regards both private and public organizations.

Table 4.1: Summary of literature gaps.

			INDUSTRIAL SECTOR		
			MANUFACTURING	**SERVICE**	**GENERAL**
RESEARCH FIELD	**1**	**Theoretical foundation**	**-**	***Antony (2006)***	**-**
	2	**Comparative evaluations**	Goh (2002)	Goh (2002)	Goh (2002)
	3	**Methodology tools**	***Setijono and Dahlgaard, (2007)***	***Sewall and De Yong (2003); Antony (2004); Hensley and Dobie (2005); Setijono and Dahlgaard, (2007)***	***Setijono and Dahlgaard (2007)***
	4	**Methodology implementation**	***Antony et al. (2007)***	***Antony et al. (2007)***; *Jenicke et al. (2008)*	***Antony et al. (2007)***
	5	**Actors and organizational structure**	***Hoerl (2001)***; Pandey (2007)	***Hoerl (2001)***; Pandey (2007)	***Hoerl (2001)***; Pandey (2007)
	6	**Culture and intangible assets**	Pandey (2007); Savolainen and Haikonen (2007); Antony (2006)	Pandey (2007); Savolainen and Haikonen (2007); Antony (2006)	Pandey (2007); Savolainen and Haikonen (2007)
	7	**Strategic project selection**	**-**	***Antony et al. (2006)***	**-**
	8	**Strategic choices (DMAIC vs DFSS)**	**-**	*Byrne et al. (2007)*	**-**

Over the last decade the literature on Six Sigma has steadily grown. The most frequent applications have regarded the improvement of existing processes in manufacturing and services, using its well-established method, i.e. the DMAIC model, while publications on

DFSS have been fewer. As a matter of fact, only about 20% of the Six Sigma literature deals with DFSS, however, while several have been the authors that have investigated the impact of the DFSS method to product design (Chakravorty, 2009; Bañuelas and Antony, 2004; Goel and Chen, 2008), scientific research on applications of DFSS on the NSD process is very scant.
In the table below, we have grouped the publications on Six Sigma by two different criteria: the first criteria is the purpose of application of the methodology, i.e. if the aim is improve (DMAIC) or design (or redesign) a new process (DFSS); the second criteria is the industrial sector of application, i.e. the service sector or the manufacturing sector. The data for this table regards only the papers from international journals we dealt with in the previous chapter.

Table 4.2: Distribution of papers by purpose of application and industrial sector.

		INDUSTRIAL SECTOR	
		MANUFACTURING	SERVICE
PURPOSE	IMPROVEMENT	*Six Sigma for Manufacturing* (51.39%) *	*Six Sigma for Service* (31.94%) *
	(RE-) DESIGN	*DFSS for Manufacturing* (11.11%) *	*DFSS for Service* (5.56%) *

* Percentage on the total of selected papers.

As we can see in the table, the percentage of articles dealing with the application of DFSS to service processes is only 5.56%. Beyond this, in a previous work (Campanerut and De Toni, 2010) we stated as the empirical research on applications of DFSS on the NSD process is totally lacking. Thus, these considerations helped the formulation and refinement of the three research questions of this study, that are:

1. **What are the aspects that organizations should manage to implement DFSS to design or redesign new service processes?**

2. **What are the best practices that firms must own to successfully implement DFSS to different typologies of service process?**

3. **What are the models to effectively manage the aspects of DFSS in the case of different typologies of service processes?**

The first research question focuses on conceptualizing in general the aspects, i.e. the managerial areas, that the organization must deal with, in order to successfully implement the Design For Six Sigma methodology to the design (or redesign) of new service processes.

Since there are no empirical studies on this topic in literature and theoretically there is no consensus on what are the most important aspect to deal with, we carried out an exploratory case study in order to respond to this research question. Details of this pilot case study are addressed in the next chapters.

The second research question starts dealing with the most important difference between products and services: the greatest heterogeneity of the latter. Managing the methodology in the service sector, indeed, is more difficult both for the variability resulting in the data analyzed in such processes, typically much higher than manufacturing processes, and for the heterogeneity of typologies of services existing. This latter reason, indeed, outlines that services typologies could be extremely different among them for their characteristics. They can differ for their intangibility, for their intellectual effort to be delivered, for the degree of involvement of the customer and many other reasons. In summary it is more difficult standardize a service rather than a product and consequently this makes more difficult even design a service rather than a product. This research question has been addressed in detail thanks to the cross-case analysis which helped to outline a synthesis among the different environments of service.

The third and last research question has been formulated after some considerations. In the second one, indeed, we have set our purpose in identifying some best practices, i.e. some common managerial procedures that could be transversal among the different typologies of service processes. However, the more detailed is the procedure, the more suitable tends to be for a specific service and not for general purposes. It is definitely correct try to define some general best practices, some main rules that organizations must follow in this brand new environment of application of DFSS that is the service sector, but in order to improve the benefit of the practice in the different service processes there is a need for flexible applications. The models we will expound in the next chapters represent a way to manage properly the methodology in different environments and situations, maximizing the effectiveness of the its implementation and consequently the return for the organization both in the short-medium and in the long term.

Chapter 5 -SERVICE MANAGEMENT

5.1 The service sector

The term "service" has many meanings, ranging from healthcare service to the service seen as a product, and its scope may be even wider. Any material product can indeed be turned into a customer service, if the seller tries to adapt the solution in order to meet specific customer requirements. In addition there are a number of administrative services, such as the issuing of invoices and the handling of complaints, which are actually the services rendered to the customer.
In the 60s, 70s, 80s, scholars have proposed different definitions of services. These definitions, however, were focused on the phenomenon of service and comprised almost solely of the services provided by so-called service industries. In line with this trend Gummesson (1987) proposed the following definition:

> *"A service is something you can buy and sell, but youcannot drop it on your foot"*
>
> (Gummesson, 1987)

These definition sounded like a critique rather than an attempt to find a universally shared definition, however, highlighted one of the essential characteristics of services, that are suitable to be traded, even though they often cannot experience them in a tangible way. Since the late 80s onwards, the debate on the possible definition of the services diminished, not yet reaching consensus on a shared formula. In 2002, however, Grönroos gave the following definition:

> *"A service is a process consisting of a series of more or less intangible activities that normally, but not necessarily, take place with an interaction between customer and employee and / or physical resources or products and / or systems of the service provider, that are provided as solutions to customer problems. "*
>
> (Grönroos, 2002)

This definition has highlighted the fact that usually the interactions between customers and suppliers are present and are of fundamental importance, though not all parties are fully aware. Moreover, the services are not things but processes and activities and these activities are by nature intangible.

These issues were captured perfectly by the following definition of Fitzsimmons and Fitzsimmons (2010):

> *"A service is a time-perishable, intangible experience performed for a customer acting the role of co-producer."*
>
> (Fitzsimmons and Fitzsimmons, 2010)

According to Grönroos (2002), however, is no longer necessary to continue the discussion on possible definitions of service. It could be more productive to consider the common characteristics to most of the services and come to understand its consumer nature, to serve as the starting point of developing an understanding of management and marketing services.

5.2 Common characteristics of services

In the classic literature of service, notably Grönroos (2002), Zeithami and Bitner (2000) and Fitzsimmons and Fitzsimmons (2010), named a full range of service features, which are usually compared with the physical products. The following table summarizes the characteristics of physical products and services most often cited.

Table 5.1: Differences between products and services (Grönroos, 2002).

	PRODUCTS	SERVICES
1	Tangible	Intangible
2	High variability	Very high variability
3	Production and distribution are separated by consumption	Production, distribution and consumption are simultaneous
4	An object, and item	An interaction between customer and seller
5	Customers are not involved in production	Customer participate to production
6	Can be stored	Cannot be stored
7	Transfer of property	No transfer of property

These features will be analyzed individually, in depth, in the following paragraphs. It should be clear, however, that many of these features, such as customer participation and perishability, are interrelated.

<u>Customer participation in service production</u>

The presence of the customer as a participant in the production of the service requires attention to the design of the delivery place that is not required in the traditional manufacturing sector. The presence actually implies a greater focus on physical characteristics of the service facilities that are not necessary in an classic industrial plant.

For the customer, the service is an experience that takes place in the front office environment of delivery, and quality of service is achieved if the environment itself is designed according to your perspective. Attention to interior decoration, furnishings, layout, noise, and also the color of the walls can influence the perception of the service by the customer. Some innovative services have opened the back office to the public, to promote confidence in the service, such as some restaurants provide a view of the kitchen.

An important aspect to consider in the provision of services is that the customer can take an active role in the process of service delivery. This phenomenon is called self-service. According to Fitzsimmons and Fitzsimmons (2010), this strategy is effectively illustrated by fast food, which have significantly reduced the staff to the waiters and cleaning. The customer must not only directly order their meals from a limited menu, but it should also take care of

its trash after the meal; in response of this, it is expected a faster service and cheaper meals. The service provider, however, have considerable benefits derived from this approach. First, there are fewer people in need of supervision and control. Moreover, and more important, the customer makes the necessary activities to deliver the service when required, making the service capacity directly related to demand rather than determined a priori based on the size of staff to the supplier.
Despite the self-service is growing, even taking the customer out of the delivery process is becoming more and more common, as evidenced by the exponential growth of e-commerce.

Simultaneity of production and consumption of services

The fact that services are created and consumed simultaneously and, therefore, cannot be stored is a key feature of management services. This inability to store services preclude the traditional manufacturing strategy to rely on inventory such as buffer to absorb fluctuations in demand. An inventory of finished products allows manufacturers to separate the internal planning and control from the outside. In this way, the same can be operating at a constant level of output, which allows for greater efficiency. The factory works as a closed system, with warehouses that often disconnect the production system by customer demand. Services, however, operate as open systems, with the full impact of changes in demand sent to the entire system.
Stores can also be used to separate the stages in the manufacturing process. For services, it is achieved as the waiting time for the customer. As for manufacturing warehouse management is a topic of great importance, so for the service sector must consider the queue management for customers. The problem of selecting the capacity of the service deals with customers' waiting time.
The simultaneity of production and consumption of the service also eliminates most of the techniques for preventive quality control. A product can be inspected before being delivered, but a service must rely on other measures to ensure the quality of what is delivered.

Perishability of services

Services are perishable goods, so a full utilization of production capacity becomes a challenge for management. In fact often customer demand takes considerable variation and the construction of warehouses to absorb such fluctuations is not an option.
According Fitzismmons and Fitzsimmons (2010), the manager dealing with the variability of demand and the perishable nature of the capacity has three basic options:

1. Flush the demand:

- Using reservations;
- Using price incentives;
- Discouraging customers to use the service during high demand periods.

2. Adjust the capacity of the service:

- Using part-time resources during high demand periods;

•Planning the work in order to vary the needs of the workforce in relation to demand;

• Increasing self-service.

3. Allow the customer to wait.

The last option can be seen as a passive contribution to the process of delivering the service, which accepts the risk of losing a dissatisfied customer and deliver it to its competitors. However, increasing the waiting time, there is a better use of capacity.

<u>Intangibility of services</u>

Services are ideas and concepts, while the products are usually objects or material goods. Therefore, it follows that innovations in services are rarely patentable. To ensure the benefits of the concept of a new service, the company must grow very rapidly in anticipation of the arrival of competitors. The franchise has been the vehicle to make sure the market areas and to establish its brand. The franchise allows the parent company, the franchisor, to sell their idea to a local businessman, preserving capital and reducing the financial risk.
The intangible nature of services also presents problems for customers. When buying a product, the customer can see it, feel it and test its performance before to buy. For a service, however, the customer should refer to the reputation of the supplier. For this reason, in many areas of services, governments have intervened to ensure the minimum acceptable performance. Through the use of registration, licensing and regulations, governments can ensure consumers that the training and the performance of some service companies meet certain quality standards.

<u>Heterogeneity</u>

The combination of the intangible nature of services and the fact that the customer is directly involved in the process of service delivery mainly cause variability of service.
The interaction between customer and supplier services, however, creates the possibility of a more satisfying human work experience. In services, the work is generally focused on people rather than things, although there are exceptions, e.g. in the telecommunications sector. Services characterized by limited contact with the customer show a drastic reduction of the level of work intensity, through the introduction of self-service.
The introduction of automation can enhance the personalization eliminating routine and impersonal tasks, allowing the attention of human resources to other tasks. At the same time, personal attention creates the opportunity for greater variability in services provided. This aspect is not entirely negative, however, because customers may perceive significant changes in quality. The customer expects to be treated fairly and receive the same service they receive from others. The development of standards and training of employees in the procedures is the key to achieving consistency in services provided. Monitoring the performance of each employee is rather inconvenient, so customers take a role in quality control through their feedback.
Direct contact between customer and supplier has implications also in industrial relations services. In fact, a dissatisfied employee may result in dramatic damage to the organization, as it is the only contact with the client.

5.3 The service package

Managers of services are usually difficult to describe their products. This problem is partly the result of the intangible nature of services, however, is in particular the presence of the customer in the process of service delivery that creates the greatest concern for the overall service experience.
Fitzsimmons and Fitzsimmons (2010), describe the service package as a bundle of products, services and information provided in a given environment. This bundle consists of five aspects, illustrated in the next concentric figure with the experience of the service inside.

1. Supporting facility: the physical resources are to be used first to offer a service;

2. Facilitating goods: material purchased or consumed by the buyer or the goods supplied by the customer;

3. Information: Data are available from the customer or supplier to obtain an efficient and customized;

4. Explicit services: the benefits are directly observable with the senses, consisting of the intrinsic or essential service;

5. Implicit services: the psychological benefits that the customer can perceive only vaguely or extrinsic characteristics of the service.

All these features are perceived by the customer and form the basis of his perception of the service. It is important that the service manager provides the overall customer experience, consisting of the service package.

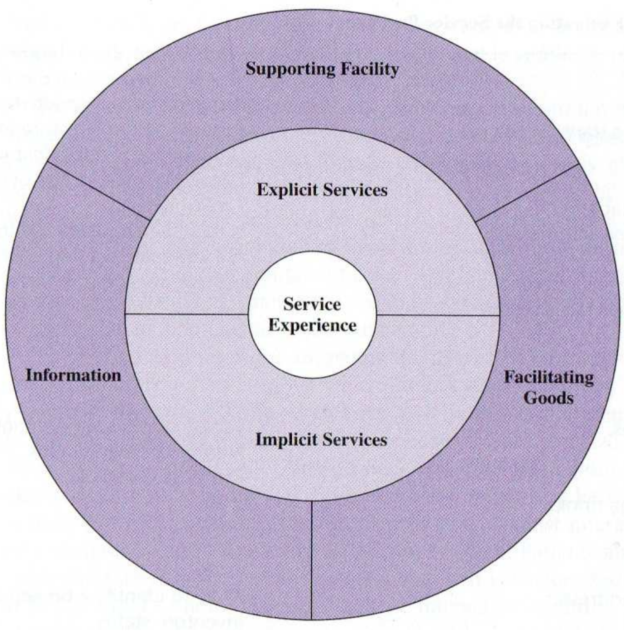

Figure 5.1: The service package (Fitzsimmons and Fitzsimmons, 2010).

The importance of facilitating goods in the service package can be used to classify services in a pure continuum in various combinations. Building a theory regarding the general management of services is difficult as the same are very diverse in their nature.
However understanding the unique environment of services is important to have a clear vision of the challenges facing managers of services.

5.4 The role of services in the modern economy

Services have a central role in the economy of any society. The infrastructure services, such as transportation and communication are the essential link between all sectors of the economy, including consumers (Fitzsimmons and Fitzsimmons, 2010).
In a complex economy, infrastructure and distribution services act as intermediaries from the operations to final consumers. In particular, infrastructure services are a prerequisite for an economy to become industrialized.
Government services play a critical role in providing a stable environment for investment and economic growth. Services like education, health, road maintenance, water system and public safety are necessary to the economy of each nation to survive and prosper.
For these reasons it is important to recognize are not secondary activities, but rather an integral part of society. Services are critical for an healthy economy and can be considered its core. Finally, the services sector not only facilitates but also makes possible the production activities of goods in the manufacturing sector.

<u>Historical development</u>

In early 1900, only 3 out of 10 workers in the United States were employed in the service sector, while the rest are involved in agriculture and industry. In 1950 the rate of employment in services comprised 50% of the workforce, whereas today the same commit about 80% of workers. During the past 90 years the society, based primarily on manufacturing has moved to one based mainly on services.
According to Fitzsimmons and Fitzsimmons (2010), the world face the greatest migration of labor since the industrial revolution. That migration, agriculture and industry to the service sector is invisible, but widespread throughout the world. The following table is shown the evolution of the rate of employment in the services sector of the major post-industrial countries.

Table 5.2: Percentage of workers in the service sector between 1965 and 2005.

COUNTRY	1965	1975	1985	1995	2005
USA	59,5%	66,4%	70,0%	74,1%	78,6%
UK	51,3%	58,3%	64,1%	71,4%	77,0%
Netherlands	52,5%	60,9%	68,3%	73,4%	76,5%
Sweden	46,5%	57,7%	66,1%	71,5%	76,3%
Canada	57,8%	65,8%	70,6%	74,8%	76,0%
Australia	54,6%	61,5%	68,4%	73,1%	75,8%
France	43,9%	51,9%	61,4%	70,0%	74,8%
Japan	44,8%	52,0%	57,0%	61,4%	68,6%
Germany	41,8%	ND	51,6%	60,8%	68,5%
Italy	36,5%	44,0%	55,3%	62,2%	65,5%

Source: http://www.bls.gov/fls/flscomparelf.htm

Most economists dealing with the study of economic growth are not surprised by these events. Clark (1957) notes that as countries become industrialized, there is an inevitable shift in employment from one sector of the economy to another.

The next figure shows the hierarchy of economic activity, which many economists have been limited to consider only the first three stages, with the tertiary sector, which included all general services. Foote and Hatt (1953) however, in the proposed model, they divided the stage of the services to create a total of five stages. Today a large number of nations are still in the early stages of development, with economies based on extraction of natural resources. Their productivity is low and their earnings depend on the price fluctuations of commodities like sugar and copper. In many parts of Africa and some in Asia, more than 70% of the workforce is employed in mining.

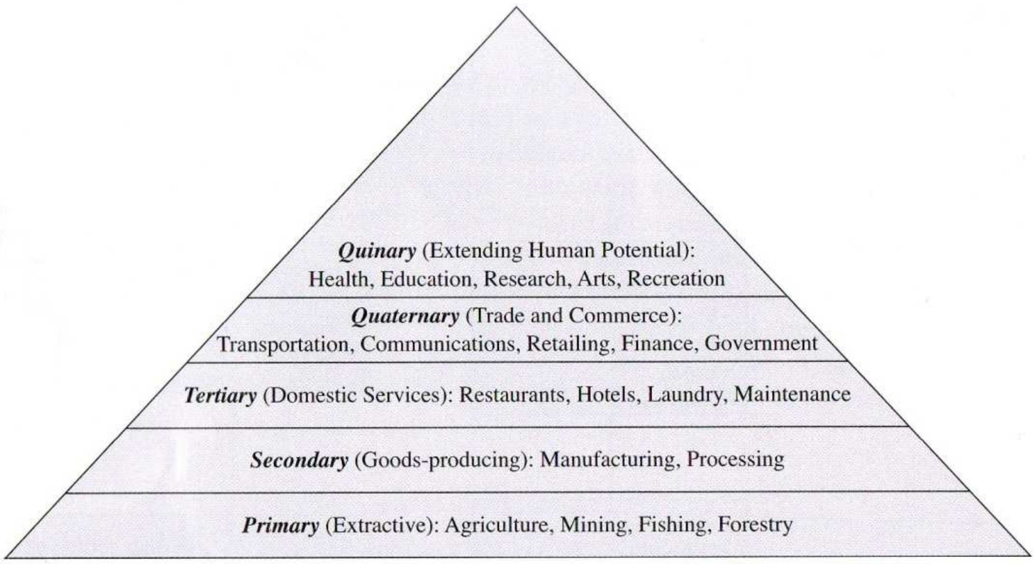

Figure 5.2: Economic sectors (Foote and Hatt, 1963).

The figure below shows the rapid growth of employment in services in the U.S. over the past 150 years, mirroring the decline of the agricultural sector. This path may be comparable to each of the nations included in the initial table.

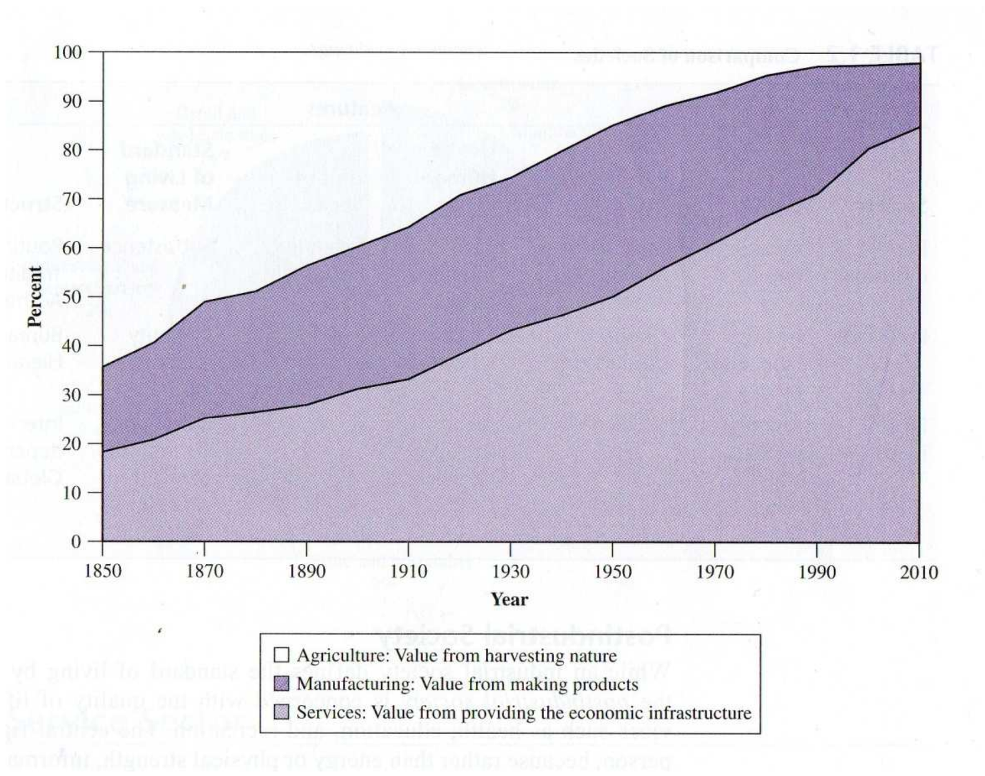

Figure 5.3: Trends of sectors in USA from 1850 to 2010 (Source: www.bls.gov/fls/flscomparelf.htm).

Emerging economies such as India, China and Brazil found rates of employment in the service sector around 50%. It may be noted that the migration to services is an evolution of the labor force expected in all countries and the economies of industrial success is built on a strong service sector. Moreover, competition in the services sector is global, consider for example the growth of call centers in India and commercial banks in Japan. However, trade in services remains a major challenge, since many countries stand up barriers to protect domestic firms.

5.5 The nature of the services sector

The growth of employment in the services sector of the last fifty years is not only related to low paid and humble tasks such as fast food jobs. Contrarily, many of the jobs in the services sector are prerogative of highly skilled workers.

The changes in the location of use will have implications on where and how people live, on the educational requirements and training and, consequently, the types of companies that will be important in our society. Industrialization has created the need for semi-skilled laborers who could be trained in a few weeks to highly automated tasks. The subsequent growth of the service sector has instead brought a shift to more specialized occupations. The website www.quintcareers.com outlined the main characteristics of this type of career:

- More career opportunities for all;
- Freedom to choose from a variety of jobs, tasks, duties;

• Greater flexibility on workplace;

• Greater control of your time;

• Greater opportunities for expression through work;

• Freedom to constantly redefine your own working life in relation to values and interests;

• More opportunities to develop different work skills in various sectors and environments;

• Open-mind pattern;

• Allows you to create situations or positions where the employee can find innovative solutions to customer needs;

• Opportunity to present themselves as independent workers or vendors with services to offer.

The growth of the service sector has resulted in less cyclical national economies. For example, during the last four recessions in the U.S., employment in services has increased, unlike that of the manufacturing sector. That statement suggests that consumers are not willing, even in periods of economic stagnation, to give up essential services such as education, telecommunications, health, banking, or security.
This partial immunity to economic crisis, according to Fitzsimmons and Fitzsimmons (2010) is due to several reasons. First, by their nature, services cannot be stored like products. Given that consumption and production occur simultaneously in services, the demand for them is more stable than that of manufactured goods and for this when the economy is stagnant, many services continue to survive. Second, during the recession, both consumers and firms delay capital investments and aim to renovate and repair existing assets. That is why they created jobs in the field of repairs and maintenance.

<u>The economy of new experiences</u>

According to Fitzsimmons and Fitzsimmons (2010) the service economy has shifted from a transactional nature to one based purely on experience. In fact, the experiences create value added by involving the client in a personal and unforgettable way.
Pine and Gilmore (1998), in this regard have proposed four types of experiences for consumers, characterized by the level of customer involvement and interaction with the environment. The entertainment (like watching a movie) is the less engaging experience level, while the escapism (like diving) involves a greater commitment by the customer.

Table 5.3: The Four Realms of an Experience.

		CUSTOMER PARTICIPATION	
		Passive	**Active**
ENVIROMENTAL RELATIONSHIP	**Absorbtion**	**ENTERTAINMENT** ***(Movie)***	**EDUCATION** ***(Language)***
	Immersion	**ESTHETICISM** ***(Tourist)***	**ESCAPISM** **(Scuba diving)**

Adapted from Pine and James (1998).

However, with respect B2B services, the value of experience is derived from the co-production or the collaborative nature of the relationship, as can be seen in relationship advice. According to Fitzsimmons and Fitzsimmons (2010), the new experiences in the field of business has three dimensions:

1. Joint creation of value:

    • The customer is co-producer of the value;

    • The customer is an input to the process of service.

2. Relationships:

    • The customer relationship is fundamental as a source of innovation and differentiation;

    •The long-term relationships facilitate the ability to develop services tailored to specific customer requirements.

3. Service capability:

    • Provide service capacity to meet fluctuations in demand while maintaining quality;

    • Service quality is measured primarily by the customer's perspective.

The fundamental experience of B2B service is to create, enable and use information in innovative ways that are not consumed in the exchange but that it remains available for further use by others.

Sources of growth in service sector

The growth of service sector is driven by progress in information technology, innovation and demographic changes that generate new demand.
About information technology, the trend toward miniaturization of IT equipment removes the need for physical proximity to service delivery and enables alternative delivery formats. A concrete example may be the home banking service, which is now provided by most banks. IT has thus affected the process of service delivery and create new value chains and new business opportunities. In this regard, Karmarkar and Apte (2007) have proposed the following three propositions:

- In the future, most of the U.S. GDP will be generated by "information chains" and not by supply chains, and many managers will be employed in the field of information;

- The management of these chains of information in IT also has a great influence on the management of economic processes behind the manufacturing sector;

- Technological developments come along and guide the business processes and value chains.

About the demographic change, in represents a very important trend that affects the growth of services. On average, the population in Italy is becoming older, and age groups above 50 years of control most domestic goods and 50% of the country's income by increasing:

- Health care.

- Recreation Services.

- Human Services.

Finally, innovation and the introduction of new product technologies often has a positive influence in service innovation. For example, the advent of Internet, developed as a network of computers connected together for scientific and military has become the source for the birth of e-commerce and all related services.
The concept for a new service often arises from the observations of personal contact, identifying the unmet needs of the customer. For example, a hotel could set up a shuttle to the airport after the concierge noted that there was a huge demand for taxis.
In addition, the service innovation can emerge from the exploitation of information available in other activities. For example, records of sales of spare parts stores can help identify specific problems in certain models of cars. Such information has value both for the producers, so they can make changes in design, and for retailers who can identify the best way to customer issues. Furthermore, the creative use of this information can be a source of new services or adding value to existing ones.
The next chapter will analyze the topic of New Service Development, in order to connect this preliminary section on services in general, to the purpose of this thesis.

Chapter 6 -NEW SERVICE DEVELOPMENT

After describing the main features of the service sector, this chapter will address the issue on the introduction and development of new services, in one word on New Service Development (NSD).

6.1 Introduction to New Service Development (NSD)

Several are the authors who defined or classified the concept of "New Service".
For Lovelock (1983), new services are defined in terms of the product or service outcomes (or offerings). The extent of change to the existing service system or based on the operational process and participants, instead, was the basis of the definition of Tax and Stuart (1997). Normally, the nature of the topic leads to consider production and delivery of service in a systemic approach, described as "service concept", i.e. the way the service offering is to be delivered (Shostack, 1984; Fitzsimmons and Fitzsimmons, 2010). Stevens and Dimitriadis (2005) specify that the modification of the service offering require the transformation of some elements of the service concept.
Some authors (Menor *et al.*, 2002) assert that changes to the service concept requiring new skills from the existing operation are considered as a new service. The same authors, considering both what service is offered, i.e. the newness of the service offering and how service is delivered, i.e. the service concept, define as new service an offering not previously available to a company's customers. Such new service results from the addition of a service offering or modifications in the service concept that allow for the service offering to be made available.
Although literature dealing with NSD is quite limited if compared to new product development (NPD) (Menor *et al.*, 2002), recently the interest on the topic has grown and several authors have studied NSD processes (Stevens and Dimitriadis, 2005; Carbonell *et al.*, 2009; Droege *et al.*, 2009).
Since the beginning, the issue whether NPD processes can be implemented to NSD has always been debated. Dolfsma (2004) is convinced that different processes are required for NPD and NSD. Nijssen *et al.* (2006) resume this argument describing two antithetical approaches in literature. The "assimilation approach" has outlined that because of their similarity, concepts developed in a product context can be implemented in a service context. On the other way, the "demarcation approach" asserts that service context is completely different from manufacturing context, hence, concepts and models must be specifically designed for services.
One of the first models on NSD process was presented by Scheuing and Johnson (1989) and consisted of two parts: service design, including service purpose and design stages and the delivery process, including testing and introduction stages. Grönroos (2002), in order to develop the offering of the service created a dynamic six-stages model, considering both organizational and customer features. The NSD model of Edgett and Jones (1991) includes 18 stages and focuses on communication with the personnel delivering the service as well as the support of the senior management during the process of service development. The model of Edvardsson and Olsson (1996) is strongly customer-focused, but it is not divided by phases. The model, indeed, distinguishes three different processes: service concept development, service system development, and service process development. Furthermore, the authors

claim that these three components have several kinds of interrelationships that depend on the type of the service development project. Another interesting model composed of seven stages was presented by Tax and Stuart (1997). The authors attempt to integrate the existing service system with the potential new service, analyzing the original firm's service system, customer's needs and the extent of change, in order to assess the effects that the new service could have on the existing service system. Finally, the NSD model of Alam and Perry (2002) consists of ten phases: strategic planning, idea generation, idea screening, business analysis, formulation of a cross-functional team, service design and process system design, personnel training, service testing and pilot run, test marketing and commercialization. The main characteristic of this model is the particular attention focused on customer integration in the service development process, topic recently discussed also by Carbonell *et al.* (2009).

6.2 Characteristics of NSD

There are many terms used in the literature to describe the ways in which services companies design new offerings, from the perspective both of the customer and organization. This definition is widely accepted and was proposed by Johnson *et al*. (2000) on the meaning of NSD:

"... The overall process of NSD is Developing new service offerings .."

(Johnson *et al*., 2000)

Also according to Cooper *et al.* (1994) NSD is a complex process that goes from the definition of the idea through to its final launch. This vision is shared by other authors, including Edvardsson *et al.* (2000), which broadened the scope of the NSD, involving corporate strategy, culture and how to implement it.

The design of services has been subject to several definitions; particularly, Zeithaml *et al.* (1990) have used the term service refers to the entire design process from concept to specification.

According to Kindström and Kowalkowski (2009) the process of NSD is generally complex and may be difficult to define and articulate. In fact, there are many unique aspects of service development that must be taken into account and do not necessarily exist in the classic NPD process used by manufacturing companies. For example, the services do not typically require the same initial investment products but require greater interaction and feedback from customers.

A service organization can deliver a service after integrating different investments in assets, processes, people and materials. As a manufactured product is made of hundreds or thousands of components, so are also the services. However, unlike products, service components are often not physical entities but rather a combination of processes, people, skills and materials that must be properly combined to obtain the service that was designed (Goldstein *et al.*, 2002).

In the design or re-design of a new service, existing managers and designers must make decisions about each component of the service, from the more significant as the location of the facility to other less important. A major challenge for service firms involves making sure that these decisions are carried out consistently, and are focused on delivery of service required by selected customers.

From this point of view, the design service means defining an appropriate mix of physical components or not. Customers however have a picture of how the service should be based on word of mouth, other sources of information or previous experiences. Before, during and after service delivery organizations define customer expectations. These expectations are linked to

the nature of the service package, as to the nature, duration and flexibility of the customer during service delivery (Goldstein *et al.*, 2002).
For the purposes of this study, a literature review on New Service Development has been carried out. This allowed to stress how the topic has recently gained importance both in the organizations and in academia. This latter area, in particular, offers several topics to be developed and show how in the last twenty years the number of scientific publications per year has constantly grown.
In the figure here below, the yearly rate of publications on NSD, from 1989 to 2010. The 2010 articles are updated to July.

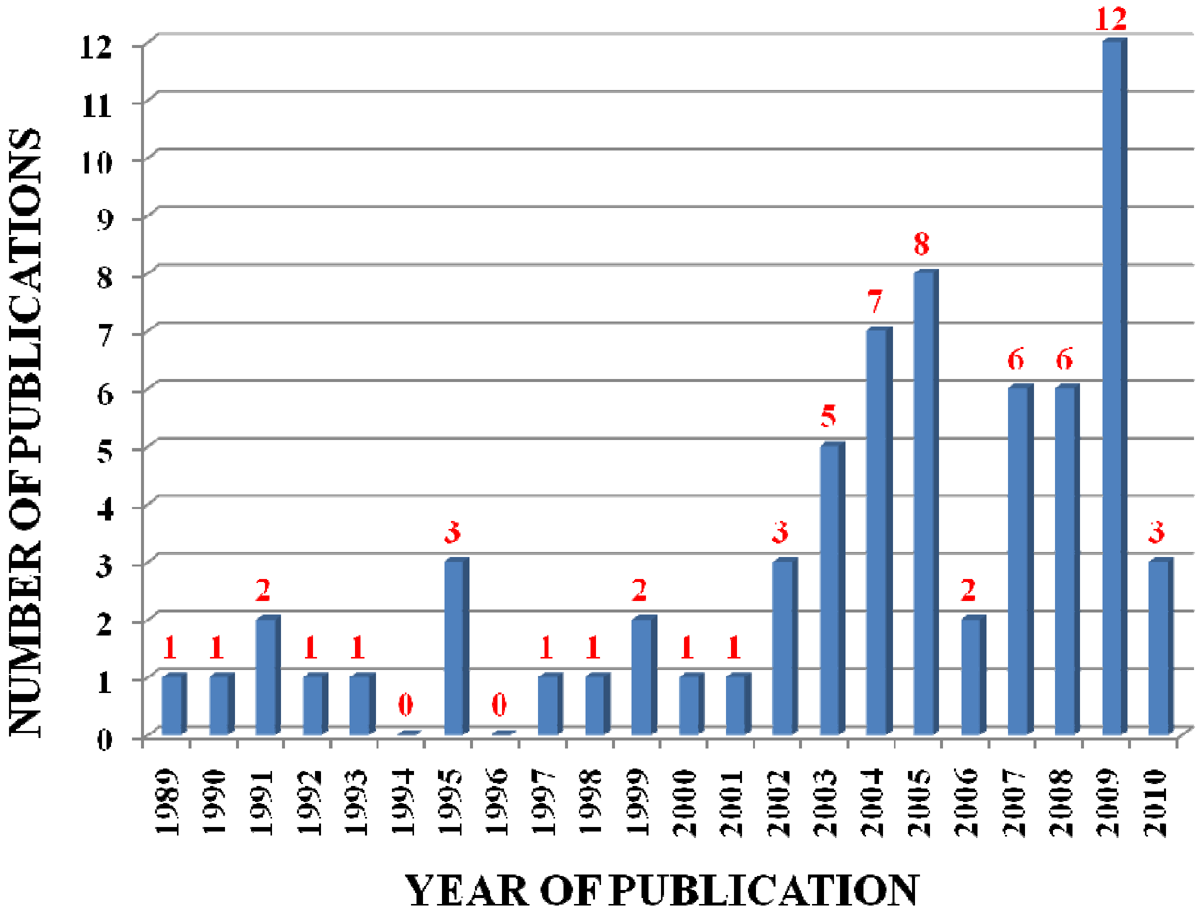

Figure 6.1: Yearly distribution of scientific papers on New Service Development.

6.3 Types of innovation in services

Lovelock (1983), has adapted an earlier classification on product innovation and described the different types of innovation services in the following table.
The two types of services described in the following table can be viewed from two different perspectives. The first is that innovation can be seen as a product or result in the abstract. The second is that innovation is seen as a process of introducing something new. This second perspective is particularly linked to the fact that an appropriate configuration of activities of design constitute the process of NSD and it is a widely recognized factor for its success.

Table 6.1: Typology of new service.

RADICAL INNOVATIONS	
New service typology	**Description**
Great innovation	New services for markets not already defined; innovations driven by technology
Start-up business	New services in a market already served by existing services
New services for existing markets	New services offered to existing customers of the organization (although they can be available in another company)
INCREMENTAL INNOVATIONS	
New service typology	**Description**
Extension of the set of services	New existing services, e.g. new dishes on a menu or new courses in a class
Service improvement	Change of characteristics of services already offered
Changes of style	The most frequent new service; minor changes that impact on perceptions and feelings of customers; only the appearances and not the functionalities are changed

Adapted from Lovelock (1983).

6.4 The NSD process cycle

Most of the literature on the process of NSD agree on a fundamental aspect: successful service organizations innovate. Roth and Van Der Velde (1992) have shown empirically that the rate and extent of the NSD characterize the leadership in the market. Beyond these considerations, however, there is no clear agreement on how service firms should innovate. Johnson *et al.* (2000) in this regard brought three points of interest:

• The existing knowledge of the NSD process is guided by the understanding of the NPD process. The prevailing feeling is that since such mechanism works in the NPD stage-gate, then it should automatically be successful in the NSD. We observe, therefore, continued references to the new service "product" development;

• The service design, service innovation and development of services are usually considered separately, and often respectively by specialists in operations, strategy and marketing. Innovation in services is the result of the development process of services. Therefore, there is still a need for a better understanding of the development process that leads to innovation, especially when the new generations of processes is required to be faster and more flexible;

• The process of development of services is in constant evolution, driven by the increasing heterogeneity of customer demands and declining returns. In addition, most research focuses on individual NSD projects, while managing a portfolio of projects or a program of NSD is neglected.

Referring to these considerations and with the assumption that the design of services and the development process are correctly integrated, Johnson *et al.* (2000) brought the NSD process cycle, shown in the figure below.

In the design phase of a new service, new ideas are skimmed, the selected concept is developed and tested for feasibility. The concepts that pass this stage are considered in the analysis phase to determine their potential as part of a profitable enterprise. After the authorization of the project, the successful concepts pass to development phase. A considerable amount of time and money are spent to design and create a new service which can be field-tested with the trained staff and through a marketing campaign focused on a city or a region. Finally, the new service is tested as a full market launch, with availability on a national or global scale.

The NSD process is guided by enabling factors: the teams that are cross-functional, the tools used, and an organizational framework that includes a culture that accepts change. The authors note how the NSD process cycle represents a progression, and in some cases, a convergence of planning and execution. The first two stages, design and analysis, are the planning stage of the NSD process cycle, when decisions on profitability of the market, internal resources and capabilities are taken. The final two stages, the final development and launch, constitute the implementation phase of the cycle. In this phase, the design of the system of service delivery, the use of enabling factors and the profusion of cross-functional efforts become key issues for managers. The ability, in each of the two phases of the cycle, is a very important aspect, however, not all projects are the result only of successful NSD skills. In the absence of a formal planning phase, a certain level of creativity may be necessary for the effective implementation of the cycle of NSD.

In the middle of the figure is all the elements of the service concept, consisting of people, systems and technology. The people element is used in both the customers, who must be recruited, trained and equipped to deliver the service. The role of the customer's needs has to be defined to increase the behavior you want from it. The systems are needed to achieve the result, and help the staff in contact with the customer in providing the service. Such systems may be located both in the front office and back office. Technological advances are often the basis for service innovation, so a service must include the monitoring of technology as an asset to protect their competitive position.

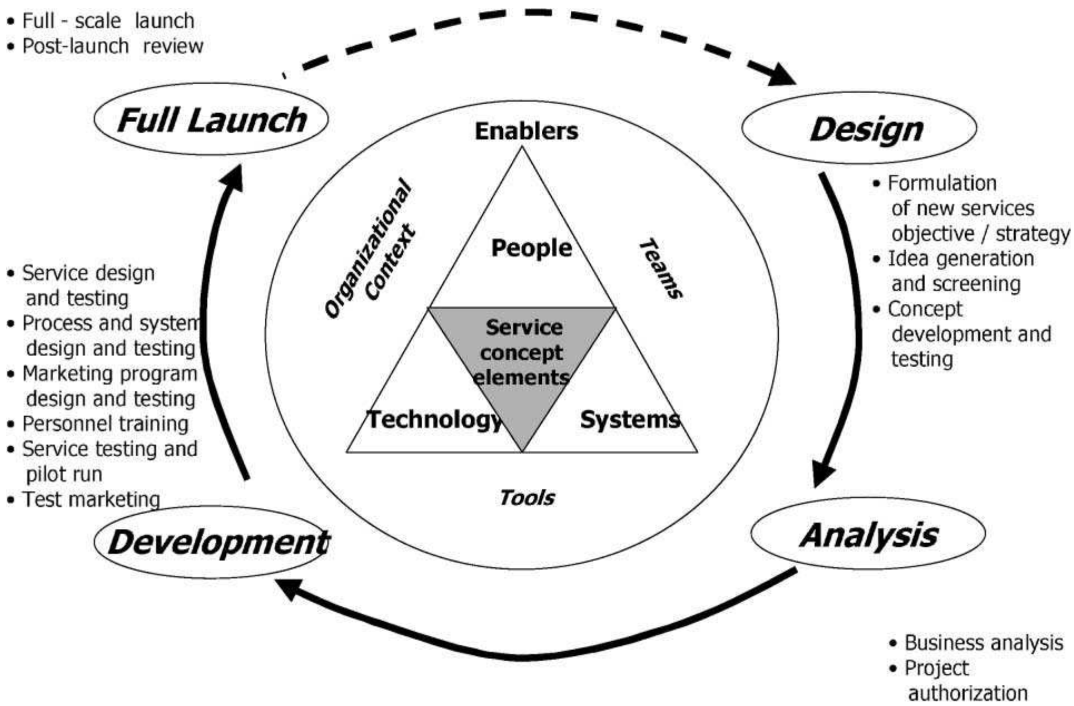

Figure 6.2: The NSD Process Cycle (Johnson et al., 2000).

6.5 The service concept

A common feature of many studies on NSD, on service design and innovation in services is the service concept topic. This is stressed by the fact that an important model as the NSD Process Cycle, shown above, put the development and testing of the concept as a fundamental activity of the design process.
Service concept is a term used frequently in the service design and literature on the NSD, but little has been written about its pivotal role in the design and development services. Most of the work encountered in the literature focus instead on presenting a definition of it. Heskett (1986) proposes the following definition:

> *"…service concept is the way in which the organization would like to have its services perceived by its customers, employees, shareholders and lenders.."*
>
> (Heskett, 1986)

Furthermore, it was also defined as the set of elements of the service package or set of customer benefits (Collier, 1994).
Edvardsson and Olsson (1996) refer to the service concept as the prototype of the service and define it as:

> *"…detailed description of what i sto be done for the customer and how this is to be achieved…"*
>
> (Edvardsson and Olsson, 1996)

The authors focus on the development of the service concept and consider it critical in the design of the service. This includes understanding customer needs and alignment with the general strategy of the organization and its competitive purposes.

Edvardsson *et al.* (2000) define the service concept as a detailed description of the customer's needs be met, and how to fulfill what should be done for the client to achieve this goal. Johnston and Clark (2001), also called the service concept as:

- *Service production*: the way in which the service is provided;
- *Service experience*: the direct experience of customer service;
- *Service outcome*: the benefits and results of customer service;
- *Service value*: the benefits that the customer perceives as being related to the service, compared to its cost.

Deconstruct a service into its components allows designers to identify the various elements that constitute it, comparing them with the customer's needs and then design and deliver those items.
The service concept is therefore a key role in the development and design of the service, not only as an element of the design process but as a means to realize the nature of the service. The service concept not only defines the "*how*" and "*what*" of service design, but also ensures the integration between them. Furthermore, the same can also help mediate between the needs of the customer and the organization's strategic intent. In fact, one reason for a poorly perceived service is the separation between what the organization wishes to provide (its strategic intent) and what its customers may require or expect (the customer's needs). This gap can be avoided by turning in the design phase, ensuring that the focus is on the same meeting the needs of clients (Goldstein *et al.*, 2002).
In this regard it is noted the proposed structure in the model below:

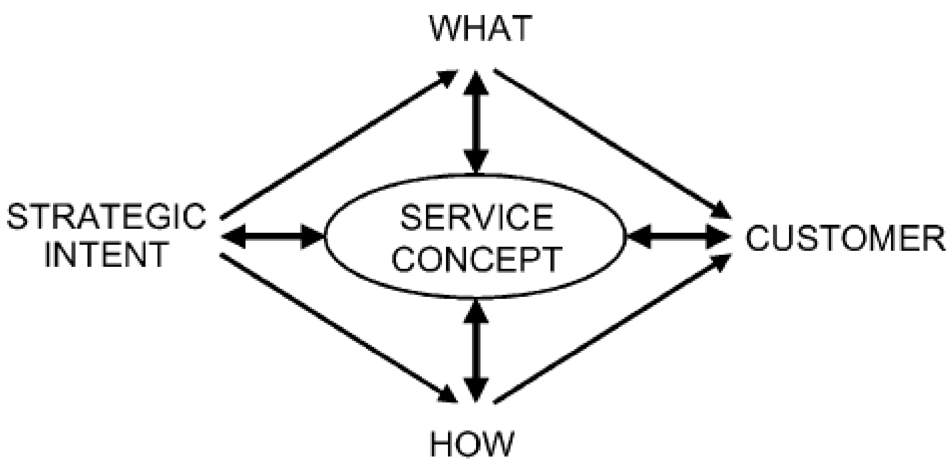

Figure 6.3: Basic structure of service concept (Goldstein et al., 2002).

The study of the service concept helps to begin to understand how customers and service providers see the services as the sum of components (processes, facilities, etc. ..) or as a result of a single process. In this sense, the service concept should be seen as expectations of the

customer and the supplier on how it should be the service. Furthermore, the same helps to understand as the needs and desires of the customer be satisfied by its perception of the service experience.
The service concept leads the strategic planning within the design. The system of service delivery includes the structure, infrastructure and processes necessary to deliver the service. In addition, the system of service delivery should facilitate the strategic intent of the company, including market position and the type of relationship with clients to pursue.

6.6 The service blueprint

When a building is designed, its design is captured in some architectural drawings called blueprint, because reproduction is printed on special paper, creating the blue lines. These blueprints show how the product should be included and all the specifications required for its production. Shostack (1984) has proposed that the delivery system can be captured in a visual diagram, called a service blueprint, which we show in the figure later.
First, a blueprint is a map or a flowchart with all the transactions that constitute the process of service delivery, including the potential points where an error could occur (fail-points) At the highest point are the "physical evidence" that customers will see and try. The activities in the first row above the "line of interaction" are step, decisions and interactions that the customer makes in the purchase process, energy consumption and evaluation of the service. Each flow line crossing the vertical line represents a direct interaction between the customer and the organization.
Parallel to the actions of the customers there are two areas of contact with staff. Above the "line of sight" there are actions in full view of the customer, while below this line, there are backstage activities that are not seen by the customer. The main questions regarding this area concern the selection of the appropriate number of staff from backstage to avoid unnecessary delays in the front end.
Under the "line of internal interaction" are the support processes that generate questions about the capacity requirements of the back office system.
Finally, the position of the line of sight in a service blueprint can immediately report the level of customer involvement in the process of service delivery.
According to Fitzsimmons and Fitzsimmons (2010), a blueprint is a precise definition of a service delivery system that enables management to test the concept of service that on paper before any final commitment is made. In addition, the blueprint facilitates problem solving and creative thinking in identifying potential points of failure and emphasizing the opportunities to meet customer perceptions on the service.

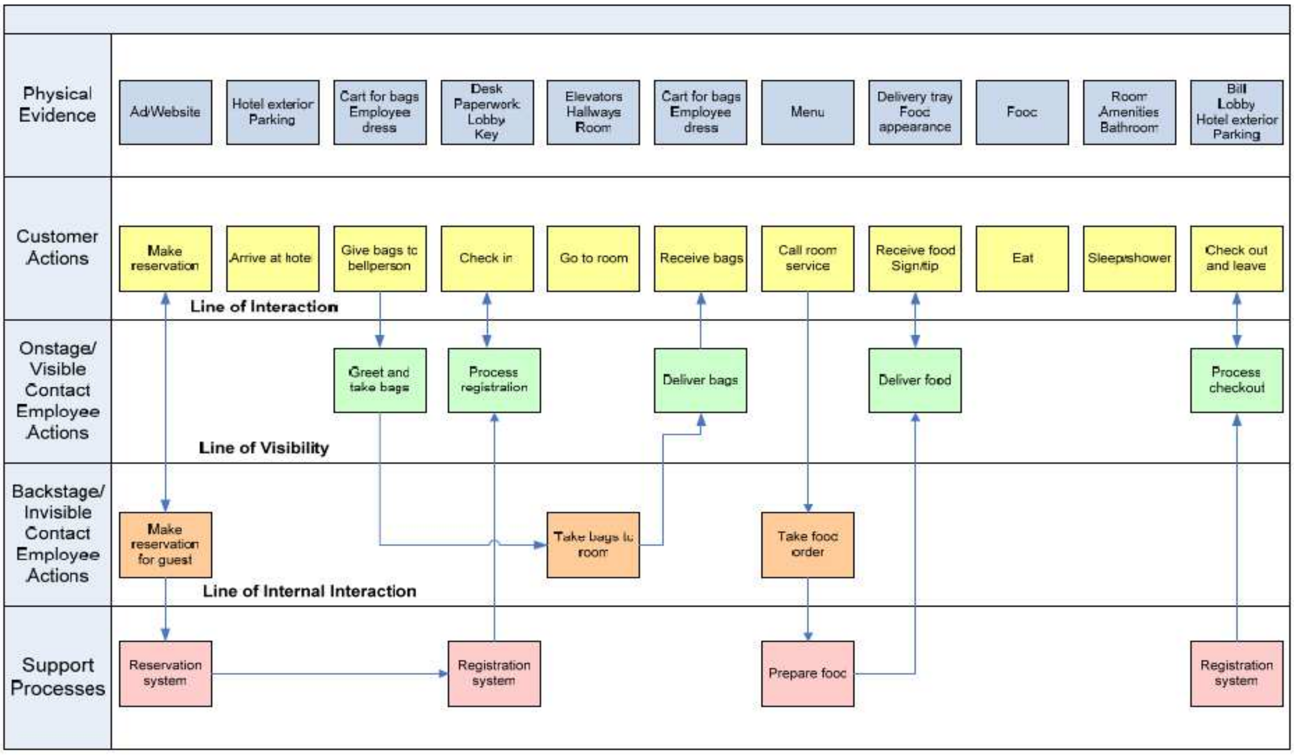

Figure 6.4: Example of service blueprint (Source: www.digiservices.wordpress.com) .

6.7 The design of services

6.7.1 Characteristics of the design of services

The design of the system of service delivery is a creative process that begins by defining the service concept and strategy to provide a service that differs from that of competitors. The various alternatives for achieving these objectives must be identified and analyzed before making any decisions. Design a service system involves issues such as location, design the facility, the layout for efficient work flow, quality, selection of equipment and definition of capacity. The design process never ends, once the service becomes operational, organizations may introduce changes in the delivery system to ensure operating conditions.
Fitzsimmons and Fitzsimmons (2010) have listed the elements of the design of services which are divided into structural and managerial.
With regard to the structural elements are considered:

- Delivery System;
- Design of facility;
- Location;
- Capacity Planning;

As for the managerial factors the authors claim:

- Information;
- Quality;
- The period of interaction with the customer service, i.e. the contact time;
- Capacity and demand management.

These elements must be designed to create a service offering that allows to achieve significant strategic vision that the company seeks. The elements of the design of the service thus become a template that informs customers and employees, respectively, what they can expect and what they have to provide to the service.

6.7.2 Influence of the common features of the design

As noted in the chapter on services, the theme of the differences between them and the property has been treated with particular emphasis in the literature on service marketing. Focusing specifically on the factors that distinguish services from physical products, the researchers offered different ideas on how intangibility, inseparability, variability and perishability affect the design of services.
In particular, De Brentani (1991), offered a comprehensive overview, analyzing in depth the influences brought by each feature in the design of a new service.

<u>Intangibility</u>

Although the services are often associated with certain physical elements, for most customers it is a risk buying a result or an experience that cannot physically evaluate.
Therefore, to effectively sell a new service, particularly if characterized by a strong innovation, the company must pay particular attention to helping clients conceptualize and evaluate the service. The best solution to this problem leads to provide a tangible service to make it less abstract for buyers. Companies should incorporate physical objects such as brochures, in the design of the service.
Further implications of intangibility is that the new services are usually developed more easily and quickly than products. Designing and launching a new service on the market generally does not involve physical prototypes or major investments in raw materials, plant or equipment. This is why the NSD for many companies becomes a relatively informal process in which new services tend to evolve over time in response to changes in customer needs and market opportunities.
This ease of development, however, has its negative aspects, primarily the fact that the lack of patentability of the services and little need for investment, making them easily imitated. This often leads to the proliferation of services very similar, with the consequent difficulty of achieving acceptable returns. A second negative effect of the apparent ease in the development of new services is that companies can use a too casual approach in the development process, and this could lead to bad results. Even the simplest of services is characterized by a very complex process that involves many activities, experiences, results, and perceptions of consumers. Companies that act quickly too often are faced with not

thoroughly defined concept of service, a process of random design, a poor planning and inadequate testing of the actual launch.

Simultaneity

Direct contact with the consumer of the service process implies that consumer satisfaction is linked to both the outcome of the service and the process by which it is produced and delivered. For this reason, in the service sector, the production and delivery become critical components for effective planning. Therefore, as with the intangibility, also the characteristic of simultaneity has certain implications in the development of new services.
First, the effective design of a new service requires the active involvement of expertise from different business functions. Second, as production and supply essential to the success of a service, companies might ignore the needs of the market, focusing exclusively on the operational aspects of the development process.
The inseparability of production and consumption, however, lead to regular contact with the customer, which could make the service companies more aware of its problems and its needs.

Variability

The services are influenced by input from the staff of the company during the delivery; therefore the final result of the process and experience of the consumer varies time after time. This aspect can have positive and negative implications. First, customers often require personal service, for which the variability can be seen as an opportunity to develop services that better meet the different needs of customers.
Variability, however, can even lead to a lack of consistency or poor quality of service. The services not in line with customer expectations could be perceived as bad quality. In cases where the reduction of uncertainty of the customer is essential for success, companies should then focus on providing more standardized services.

Perishability

Services cannot be produced in advance and stored, therefore often the demand is fluctuating during different business cycles. For these reasons, companies can incur high costs associated with the excess of capabilities during periods of falling demand, and at the same time they may lose profit when they are not able to respond to high demand levels of the same. The implications in the development of new services are related to the addition of product lines that allow new operational systems during periods of lower demand. During periods of peak instead should offer alternative versions of the service usually proposed in order to allow the company to overcome the limited capacity.

6.7.3 The different approaches to the design of services

In the chapter on services, the service package is defined as a set of attributes consisting of five features: supporting facilities, facilitating goods, information, explicit services, implicit services. In a well-designed service system these features are harmoniously coordinated in order to obtain the desired service package. Consequently, the definition of the service package is the key to designing the service system itself. Fitzsimmons and Fitzsimmons (2010) consider that the design of services can follow different approaches.

The production line approach

The routine services can be delivered through an approach similar to the production line. Through this way, services are delivered in a controlled environment to ensure the quality and efficiency in its delivery, trying to transfer a success concept from manufacturing to the service sector.
The standardization and quality are the trademarks of a production line. In standardized service, the performance is evaluated in accordance very positively by consumers. For this service the customer expects the same in any different franchising company. If you want a more personalized service, it becomes more appropriate a more flexible staff.
The production line approach suggests that the overall work is divided into groups of simple activities, which allows the specialization of job skills. In addition, the division of labor allows companies to pay employees in relation to the skills that are required to implement the tasks assigned. This has led to the emergence of many low quality jobs in the service sector characterized by low wages.
The systematic replacement of people with equipment was a source of progress in the manufacturing sector. This approach can then be used also in the services sector, as noted in the banking sector, with the proliferation of ATMs, instead of employees.

The approach of the customer as co-producer

Another approach is to encourage the active participation of consumers in the process. Allowing the consumer to take an active role in the service process can bring many benefits for both the supplier and the consumer.
The consumer, instead to stay in the audience, could create opportunities to increase productivity by taking up certain activities of the service. In addition, the participation of the consumer may increase the degree of customization. Therefore, customer involvement in the process of service can support a competitive strategy of cost leadership, with a partial customization if the same is focused towards customers who want to provide by their own. In relation to the degree of involvement, there is a broad spectrum of service delivery systems, from self service to full dependence on the service provider.
The self-service leads to get through the work of the client, a highly personalized service, and is the highest level of co-production. Customers are becoming the modern co-producers, receiving benefits in terms of convenience, a significant percentage of consumers also appreciate the control aspects arising from self-service. Finally, co-production identifies the problem of matching supply with demand, because the customer provides the extra capacity when needed.
A second approach to the level of demand for the service has always been characterized by great variability that can be influenced by time of day, day of week or season. To implement a strategy for flushing demand, customers act as passive co-producers, adjusting the timing of their application to fit the availability of the service. A typical example is related to the use of appointments and reservations, which should allow the customer avoid waiting time for service. The customer also may wish to purchase the service during off-peak hours by means of price incentives.
If the attempt fails to flush the demand, high capacity utilization can be achieved by requiring customers to wait for the service. So waiting customers give a positive contribution to productivity, through better capacity utilization. The client may need to be convinced to take a more independent role as an active participant in the service process. This educational role for

the provider is a new concept in services, because traditionally the supplier kept the consumer in a state of ignorance, and therefore of greater dependence.
Finally, the Internet has opened new opportunities for co-production of the customer, through the true generation of content used by other customers. One example in this regard to Wikipedia.com.

The approach of the customer contact

An intermediate approach leads to divide the service activities in high and low contact time activities. This allows low-contact activities be designed technically by a team isolated from the customer, improving their efficiency.
The low-contact activities, in the back office, are carried out in analogy to what happens in a manufacturing plant, sometimes even with a high content of technology. This separation of activity can lead to a perception of customized service by the customer, while at the same time might be derived economies of scale due to high volumes processed. The success of this approach depends on the amount of contact with the customer to create the service and the ability to isolate the technical core activities to design.
In high contact services, the customer determines the timing of the application and the nature of the service by participating directly in the process. The perceived quality of service is determined largely by the experience of the customer. However, even if a service falls into the category of high-contact services, it may be possible to isolate some activities, and applying to it the same way as low-contact services.
When the service systems are separated into high-and low-contact activities, each area can be designed separately to achieve better performance. It should be emphasized that the activities require high-touch employee with excellent interpersonal skills. Service objectives and operational levels in these activities are uncertain, because the customers dictate the timing of the application and, in some cases, the services themselves.
There is always a trade-off between the efficiency of activities and sales opportunities, or the measure of the likelihood of increasing sales and therefore the returns generated by each customer contact. The highly personalized and high contact services require highly trained employees, but there is a great opportunity to develop loyal relationships with customers.

The approach of information empowerment

The many advances made in the field of information technology have guided the approach of information empowerment. No service today can survive without the use of IT, and the successful manager observed that it offers more than just a convenient way to store data. A business can have a computerized database with customer names and their addresses, and may have a similar one for the main suppliers of goods and services. The development of relational databases, however, changed everything. Relational database, or integrated, means that information from all relevant activities can be used by anyone. An employee may request in the warehouse without going through the purchasing department. Today, in fact employees of an organization can interact with each other through functional links, and also with those from other organizations.
Even customers can benefit directly from IT. Internet, connecting people from all over the world is an example of a very powerful tool. In this way, customers are no longer dependent entirely on local service providers.
In conclusion we can say that our everyday life will be increasingly influenced by IT, and their impact will be measured over a time horizon getting shorter.

In this characterization of service sector and NSD, next chapter will focus on the different models of classification of services, in order to define a comprehensive distinction among service processes and reach the purposes of this thesis.

Chapter 7 - THEORY ON SERVICE CLASSIFICATION

In this section we propose a historical overview of the main models of classification of services, which have led to the one used in this thesis, for managing the five aspects of the methodology for NSD.

7.1 Overview of the main models

Society has always provided and consumed services, however the formal aspects of matters have been considered only in recent decades. The Harvard Business School, for example, was the first to have a course in service operations in 1972, creating the way for a series of publications that approached the subject using methods and different perspectives.
Sasser *et al.* (1978) were the first to propose the following classification, based on the level of customization, and derived from the models applied to the Operations management:

- **Project**: consultant and professional services;
- **Jobbing**: design and installation of a computer system, a management of development program;
- **Batch**: computer bureau;
- **Line**: preliminary steps in a fast food restaurant.
- **Continuous process**: not used in service operations.

At one extreme there are the project activities defined as highly customized and that can be as complex as the management advice in general or all professional services, which takes the name “project”. Moving to the other extreme, service typologies are progressively less personalized and more repetitive, like in the jobbing, batch and line. The continuous process is not used in service operations, but only the Operations management.
This classification met considerable criticism in the literature on service operations, based on the fact that it was inadequate and incomplete because it did not take into account the variability generated by the customer on the service delivery system.
For this reason some authors in the field of service management have proposed some additional dimensions in order to classify it more deeply and completely the different types of service. The following dimensions of services have been widely recognized for their value and used frequently in the literature of service management:

Table 7.1: Summary of service dimensions.

SERVICE DIMENSION		AUTHORS
1	**Focus on technology/people**	Thomas (1975), Kotler (1980)
2	**Extension of contact time**	Chase (1981)
3	**Degree of customization**	Lovelock (1983), Maister (1982, 1983), Johnston and Morris (1985)
4	**How customer relationship influences customer satisfaction**	Lovelock (1983)
5	**Front office and back office as source of value**	Maister (1983)
6	**Focus on product/focus on process**	Johnston and Morris (1985)

Thomas (1975) and Kotler (1980) made a distinction between services based on equipment and services based on people. Examples of services based on including aviation equipment and vending machines, while for the people-based services was referred to the repair of equipment or business advice. These publications were an attempt to shift the strategic thinking of managers from the focus on products and services to the characteristics that make them unique.

7.1.1 The customer contact model

The nature of the services created a field of research almost qualitative; furthermore, there was a lack of models that try to represent the phenomenon in an analytical way. The first attempt to fill this gap was made by Chase (1981), with the proposal of the Customer Contact Model.

$$Potential\ efficiency = f(1 - \frac{Customer\ Contact\ Time}{Service\ Creation\ Time})$$

Formula 7-1: Potential efficiency in the Customer Contact Model (Chase, 1981).

According to the basic premise of the model, the efficiency of the service is a function of contact time with the client, which is variable, and time of creation of the service, which tends to be relatively constant. Therefore, in order to improve the efficiency of the service, the contact time should be reduced, so that the second term of the function is lower.

By definition, the Customer Contact Model, does not consider the utility to the consumer, organizational performance or marketing factors. The model identifies a functional relationship between efficiency, contact time and the time of creation of the service, however, fails without considering other factors in addition to the evaluation time. For example, an ATM can reduce the time of customer contact with the service delivery system in about a minute, unlike desk clerk with whom the contact time is about five minutes. However, customers may prefer the tellers for the personal attention and the ability to customize and interactively discuss the transaction. Thus, using the ATM would improve the time efficiency, but the effectiveness of delivery of the service might be affected.

7.1.2 Use of technology and customization

A general approach for increasing productivity in services was proposed by Fitzsimmons and Sullivan (1982), and can be summarized in three key areas:

1. Transfer of technology by manufacturing;
2. Use computers to automate;
3. Increase customer participation in the process of service delivery.

These three points seemed to be fit for purpose, however, Blois (1984) suggested to focus on changing the customer's participation in the service rather than on increasing the same. In addition, Collier (1985) introduced the need for selective application of automation, to preserve the perception of delivery by the customer.

Berry *et al.* (1985), claim that the output of the service is closely linked to customer satisfaction, partly created by the expectations and perceptions of the service delivery process. The concepts introduced thus asserted that the service provider should use the technology, considering the effect of that on the service perceived by the customer.

Maister and Lovelock (1983) added a measure of customization of service to the concept of extension of the contact introduced by Chase. Activities with high level of customization involves a personalized service to each client, e.g. a project carried out by a consulting firm. On the other side, extreme standardized activities need processes characterized by low variability: although there may be different paths and choices, their availability is always predetermined. For example, a public transportation system provides the customer a wide choice of routes between different destinations, but the service cannot be customized to meet the needs of each customer. The figure below shows how the customization is developed along two dimensions: first, the service features that allow customization, the other the possibility of personal contacts to influence and change the service.

Table 7.2: Classification of service typologies by degree of customization and how customer relationship influences customer satisfaction

		DEGREE OF CUSTOMIZATION	
		High	**Low**
HOW CUSTOMER RELATIONSHIP INFLUENCES CUSTOMER SATISFACTION	**High**	•Surgery; •Taxi drivers; •Restatutants; •Consulting services	•Schools; •Health programs; •Family restaurant
	Low	•Phone services; •Hotel services; •Bank services; •Bar	•Public transportation; •Cinema; •Dining halls

Source: Lovelock (1983).

7.1.3 The nature of service and the recipient

Lovelock proposed different classifications of types of services in order to understand all the possible strategic dimensions, which go beyond a vision bounded to a single sector.

The following figure presents a classification based on two dimensions: who or what is the direct recipient of service and the tangible nature of the service. This classification scheme raises questions about the traditional way in which the services were provided, e.g., the need for the physical presence of the customer during service delivery. These observations have significant implications in the design of service-scape and interactions with the personal contact, in fact, the impressions will influence this perception of customer service.

Table 7.3: Classification of service typologies by recipient of service and nature of service.

		RECIPIENT OF SERVICE	
		People	**Properties**
NATURE OF SERVICE	**Tangible**	**People's body** •Healthcare; •Trasportations; •Beauty farms; •Restaurants	**Tangible property** •Freight trasportation; •Manteinance; •Laundry
	Intangible	**People's mind** •Schools; •Media; •Theater; •Museums	**Intangible assets** •Banks; •Lawyers; •Accountants; •Insurances

Source: Lovelock (1983).

7.1.4 Influence of the demand on the classification

Another classification proposed by Lovelock considers the nature of demand for the service and the ability to respond to it by the organization. The perishability of services creates many difficulties for managers, given the impossibility of storing and selling later. In the previous figure, however, the extent to which demand exceeds capacity varies depending on the type of services covered.

Table 7.4: Classification of service typologies by extent of demand fluctuation and extent to which demand exceeds capacity.

		EXTENT OF DEMAND FLUCTUATION OVER TIME	
		Wide	**Narrow**
EXTENT TO WHICH DEMAND EXCEEDS CAPACITY	**Peak demand met without major delays**	•Electricity; •Phone; •Hospital maternity unit; •Police emergencies	•Insurance •Legal services •Banks; •Laundry
	Peak demand regularly exceeds capacity	•Tax preparation; •Passenger transportation; •Hotels	•Fast food; •Movie theater; •Gas station

Source: Lovelock (1983).

7.1.5 The Service Process Matrix

Starting from some of the limitations listed above about the Customer Contact Model, Schmenner (1986) proposed the Service Process Matrix.

In this matrix, the vertical axis measures the degree of work intensity, defined as the ratio between the cost of labor and capital costs. For example, capital-intensive services such as airlines or hospitals are characterized by considerable investments in relation to labor costs. Conversely, labor-intensive services such as schools or assistance office are characterized by relatively high labor costs if commensurate to capital investment required. In the horizontal axis measures the degree of interaction and customization, a marketing variable that describes the customer's power to directly influence the service provided. It is necessary only a small interaction between the customer and the supplier when the service is standardized rather than customized, e.g. in any canteen. Conversely, there is a strong interaction, for example, between doctor and patient or between a hairdresser and a customer. However, the interaction due to a high level of customization creates potential problems in managing the process of service delivery and design.

Table 7.5: Service classification, the Schmenner's Service Process matrix.

<table>
<tr><td colspan="2"></td><td colspan="2">DEGREE OF INTERACTION AND CUSTOMIZATION</td></tr>
<tr><td colspan="2"></td><td>LOW</td><td>HIGH</td></tr>
<tr><td rowspan="2">DEGREE OF LABOUR INTENSITY</td><td>LOW</td><td>SERVICE FACTORY
• Airlines
• Trucking
• Hotels</td><td>SERVICE SHOP
• Hospitals
• Auto-repair
• Other repair services</td></tr>
<tr><td>HIGH</td><td>MASS SERVICE
• Retailing
• Banking
• Schools</td><td>PROFESSIONAL SERVICE
• Doctors
• Lawyers
• Architets</td></tr>
</table>

Source: Schmenner (1986).

The four quadrants of the Service Process Matrix have names, as defined by the two dimensions to describe the nature of the services which illustrated. The Service Factory quadrant provides a standardized service, characterized by a high capital investment, similar to the production line of a manufacturing facility. The service shop quadrant allows greater customization of the service, but only in an environment characterized by a capital intensive. Mass Service customers receive a service in an undifferentiated type of labor-intensive, while those who turn to a Professional Service receives individual attention from highly trained specialists.

Miozzo and Soete (1989) argue that, in general, services can be meaningfully grouped according to the technological activities within the enterprise services. The authors divide the services between technology users and producers of technology. More specifically the services are divided into three subgroups, called science-based, scale-intensive and supplier-dominated services. The type of science-based services such as technical advice are seen as producers of technology, while the supplier-dominated services such as restaurants and hotels, are considered as users of technology. The type of scale-intensive services are finally considered in terms of their ambivalent relationship with technology.

7.1.6 The Service Transaction Analysis Model

Haynes (1990) has combined the dimensions proposed by Schmenner, offering an array with the following axes: degree of operational complexity and degree to which the interface is organic or mechanistic.

Regarding the reference to the interface board, the term implies mechanistic hierarchical control and communication, a precise definition of functional processes and, generally, a system of production governed by the rules. This definition suggests that the consumer may

interface with some electronic device during the delivery of service. The term organic instead considers the interactions between actors, the delivery of information in advance rather than decisions. It also implies the ability to adjust during the delivery process to compensate for functional limitations related to the presence of staff.
In the axis referred to the technology, the words simple and complex usually include the content in terms of cost, sophistication and information technology aspects of the service.

Table 7.6: Service Transaction Analysis Model.

		TECHNOLOGY	
		Simple	**Complex**
INTERFACE	**Mechanistic**	**PRODUCT**	**PROJECT**
	Organic	**PERSONAL**	**PROFESSIONAL**

Source: Haynes (1990).

7.1.7 Other models

Silvestro *et al.* (1992), proposed a classification of services from the concept of extension of the contact time, introduced by Chase and the six dimensions found in the literature on service operations, as described at the beginning of this historical pattern.
In particular, the authors state that there are three types of service processes: professional, service shops and mass. Each type of service is characterized by reference to the six dimensions defined above. Based on evidence derived from case studies, the authors argue that the dimensions are correlated with the volume of customers processed by a production unit on a daily basis. As in production, the volume is the unifying mechanism in the definition of the reference model, it seems that the same can be used to integrate disparate types of services.
Thus, specifically, the authors define three types of service:

- **Professional services**: they are organizations with a low number of transactions, highly customized, with a relatively long contact time, with most of the value added in the front office, where flexibility is important in order to meet the needs of customers;

- **Mass services**: the case of organizations where there are many customer transactions, involving limited contact time and a little customization. The offer is primarily product oriented, with most of the value added by the back office and low flexibility of the front office;

• **Service shops**: a typology of organizations that falls between professional and mass services.

The more the customers processed by a unit, we find the following comments in relation to six key dimensions: the focus shifts from people to an orientation on the equipment; contact time decreases;, the degree of customization decreases; the level of employee flexibility decreases;, the added value moves from the front office to back office; the focus shifts from an orientation on process towards one on product.
Advances in ICT are having a profound effect on the ways in which customers interface with service providers. In this regard Froehle and Roth (2004), propose five ways in which technology helps service delivery.
Referring to the figure below, the method A is called technology-free service encounter, in which the customer is in physical proximity and interacts with a human service provider. This mode is the traditional high-contact service, where technology does not play a direct role. The B-mode is called technology assisted service encounter, as only the service provider has access to technology to facilitate the delivery of services face to face. The C-mode is called technology Facilitated service encounter, in which the customer and the service provider have access to the same technology. From D mode, called the technology-mediated service encounter, the customer and the supplier of the services are not located in the same place, so that service delivery is no longer the traditional type of face to face. The communication is usually enabled through a telephone, such as booking a restaurant or aid to remote call centers. In E-mode, called technology generated service encounter, the provider of human service is entirely replaced by technology that allows the customer to use alone. This mode is becoming more common as companies attempt to reduce the cost of providing the service.

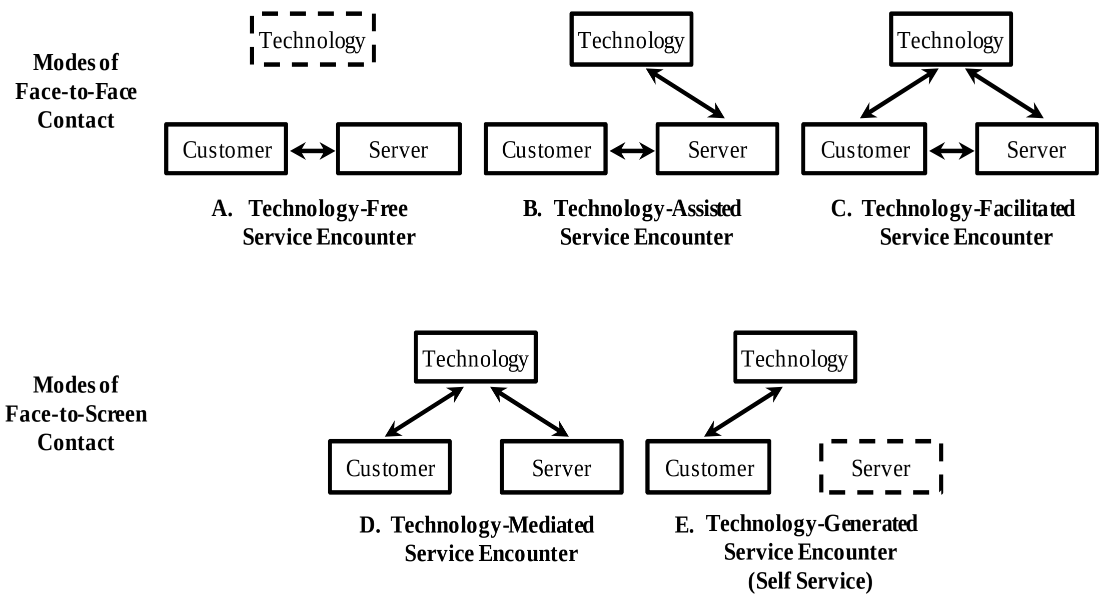

Figure 7.1: Classification of services of Froehle and Roth (2004).

7.2 Summary and evaluation of the models

Below we summarize a table with the classification models of services described above.

Table 7.7: Pros and cons of the different classifications of service in literature.

	MODEL	PROS	CONS
1	**Sasser *et al.* (1978): first classification based on customization**	Customization is a simple concept and is taken from manufacturing	Basic classification and not considering customers
2	**Thomas (1975), Kotler (1980): difference between technology and people base services**	New valid dimensions like technology and people	It does not care of the extension of contact
3	**Chase (1981): Customer Contact Model**	It introduces the extension of contact	Too much focused of time dimensione of contact
4	**Fitzsimmons and Sullivan (1982): bond between productivity of service, customization level and technology**	Simple and it has several interesting dimensions	Basic and not very structured
5	**Maister and Lovelock (1983): Classification on customization, contact with customers, nature of demand and recipients of service**	Different point of view	It does not consider enough technology
6	**Schmenner (1986): Service Process Matrix**	Classification widely recognized in literature	It does not consider enough technology
7	**Soete and Miozzo (1989, 2001): classification on technology**	It considers technology for service delivery	Too much focused on technology
8	**Haynes (1990): Service Transaction Analysis Model**	Different interfaces for service delivery and it considers technology	It does not consider enough role and impact of the extension of contact with customer
9	**Silvestro *et al.* (1992): Characteristics on the basis of contact time**	Evolution of Chase (1981), it considers different sectors and dimensions	It does not consider enough the impact of technology
10	**Frohele and Roth (2004):contribution of technology to service delivery**	Overview of the different effects of technology on service delivery	Too much focused on the technological aspects of service

On the next page presents an evaluation of the dimensions of the classification of services in the models described above. The evaluation was performed by assigning a score from 1 to 5, on the basis of previous literature and comments of authors. The purpose is selecting the best dimensions to classify service processes in the context of New Service Development, i.e. those which present some characteristics that, if modified, they can impact on design process.

Table 7.8: Evaluation of the dimensions of the classification models in literature.

	DIMENSION	AUTHORS	EVALUATION
1	**Interface (Mechanistic/Organic)**	Thomas (1975), Kotler (1980), Silvestro *et al.* (1992)	**5**
2	**Extension of contact time**	Chase (1981), Silvestro *et al.* (1992)	**5**
3	**Degree of customization**	Sasser *et al.* (1978), Lovelock (1983), Maister (1982, 1983), Schmenner (1986), Silvestro *et al.* (1992)	**4**
4	**How customer relationship influences customer satisfaction**	Lovelock (1983), Maister (1983), Silvestro *et al.* (1992)	**3**
5	**Recipient of service**	Lovelock (1983)	**3**
6	**Nature of service**	Lovelock (1983)	**2**
7	**Extent Of Demand Fluctuation Over Time**	Lovelock (1983)	**2**
8	**Extent To Which Demand Exceeds Capacity**	Lovelock (1983)	**2**
9	**Degree of labour intensity**	Schmenner (1986)	**3**
10	**Technological activities**	Soete and Miozzo (1989, 2001)	**2**
11	**Technological complexity**	Haynes (1990)	**2**
12	**Kind of interface**	Haynes (1990)	**5**
13	**Volume of customers**	Silvestro *et al.* (1992)	**3**
14	**Influence of technology on service delivery**	Frohele and Roth (2004)	**3**

7.3 Conclusion and proposal of a model of classification for NSD

As outlined in literature, it is possible to classify services in different ways. One of the objectives of this thesis is related to the identification of DFSS approaches more suitable to be applied in each specific situation of service process, and with this purpose, we have tried to identify the dimensions most suitable for the classification.

One of the dimensions used in most models encountered in literature is surely the degree of customization of the service, referred to by various authors such as Sasser *et al.* (1978), Maister and Lovelock (1983), Schmenner (1986), Silvestro *et al.* (1992). Furthermore, Maister and Lovelock (1983) have also proposed other classifications, referring to the nature of the request and its relationship with the company's capacity, or the nature of the service and the recipients. However, these dimensions appear to be relatively unsuitable as a reference for designing the service, as most appropriate to provide taxonomic suggestions rather than operational ones. The same limit appears to be found in Schmenner's Service Process Matrix (1986), a classification model universally recognized in the literature, but provides little insight and tips for planning.

Haynes (1990), Miozzo and Soete (1989, 2001) and more recently Froehle and Roth (2004), have focused much on the technological dimension and the influence of technology in the service delivery. This dimension provides a number of interesting points, however, is incomplete as it ignores the possible presence of personal interactions in the environment where the service is deployed.

For the design of the service is however important to consider the complexity, the number and type of interactions that occur between the customer and the service provider. The more the environment will consist of supply and unpredictable in fact, the more difficult will be the design and service operations.

Therefore, for the purposes of research, it seems more appropriate to classify organizations based on two fundamental questions:

- **Where** the services are provided?
- **How** the services are provided?

From the first point of view, services can be classified according to the *extension of the contact* during service delivery. This allows to overcome the fact that research in the often too qualitative and does not provide good metrics to measure them (Haynes, 1990). Contact is to be understood as the physical presence of the customer at the point of service delivery. The extension of the contact is instead defined as the percentage of time spent by the customer in service delivery compared with the time of delivery. As we saw earlier, this concept has emerged about thirty years ago, with the first studies in this field led by Chase (1981) and that led to the definition of the Customer Contact Model. Afterwards, even Schmenner (1986), starting from the Chase model, used the concept of extension of the contact, to define, combined with customization dimension, the Service Process Matrix. In addition, Silvestro *et al.* (1992), based on the concept of extension of the contact, they proposed a model that also considered the daily volume of transactions.

In terms of how the service is delivered, the interface of delivery can be classified as being based mainly on people or on machinery and technology. Also in reference to this categorization, the literature provides references from different periods, starting in the '60s and '70s until today. In particular, from the analysis carried out previously, we refer to the work of Thomas (1975), Kotler (1982), Schmenner (1986), Haynes (1990), Miozzo and Soete (1989), Silvestro *et al.* (1992), and more recently Froehle and Roth (2004), although the latter is typically focused on the ways in which technology affects the service delivery.

Combining the two dimensions above described, there are four possible typologies of service process, which give rise to the model shown below:

Table 7.9: Proposed model for classification of service processes.

		How is the service deployed?	
		People	**Technology**
Extension of contact	**High**		
	Low		

The proposed classification raises a number of aspects:

- There is a continuum rather than a pigeonhole of organization into any one of the four classes;

- The specific organizations involved in service deployment can offer services classifiable in different typologies.

These considerations are interesting from the perspective of service design, if organizations want to develop a strategy to move from one type of service to another since the early stages of design.
From the model above defined, we will proceed in the empirical part of this thesis to the specification of the same for each of the five aspects identified for the application of DFSS to service processes.

PART II – EMPIRICAL STUDY

Chapter 8 -RESEARCH METHODS

This chapter presents an overview of the methodology of the research. The first two sections describe in general the methods used in this thesis and offer an overview of the methodological phases; afterwards, since the systematic literature review has been already explained in detail in the previous chapter, it deeply outlines the empirical research design based on the research questions and theoretical models hypothesized in this study. The choice for the case study method will be explained and commented, deepening all the aspects of data gathering and data analysis, e.g. the choice of our unit of analysis, i.e. the organization itself, the research protocol and research instruments. A specific section for explaining the choice of the single case studies is presented and the use of cross-case analysis is introduced. A last section on the confirmative literature review and how the research has been concluded, is presented in the final part of this chapter.

8.1 Preliminary concepts

For conducting empirical research, basically there are two methods of data gathering, i.e. qualitative and quantitative. Every method, obviously, has its strengths and weaknesses. The qualitative method allows researchers studying selected issues in detail and depth. It also permits to approach fieldwork without being constrained by predetermined categories of analysis contributes to the depth, openness, and detail of qualitative inquiry. On the other hand, the quantitative method requires the use of standardized tools so that the different perspectives and experiences of people can fit a limited number of predetermined response categories, to which numbers are assigned. A quantitative method permits to measure the reactions of a great many people to a limited set of questions, thus facilitating comparison and statistical aggregation of the data and this represents its main advantage. This gives a wide and general set of findings presented succinctly and in few elements. On the other hand, a qualitative method typically produces a huge amount of detailed information about a much smaller number of people and cases. This increases understanding of the cases and situations studied but it makes difficult to generalize them (Patton, 1990).

8.2 Research overview

Mainly, the research process in this thesis consisted of four main phases, in which both literature and empirical reality played important roles. Our choice to carry out a case study research was suitable, as this empirical method is particularly appropriate for studying and presenting various phenomena in their real-life environments (Yin, 2005). We could observe and understand this phenomenon as the basis for generating relevant theory (Meredith, 1998). In the table here below the four main phases of the research have been represented.

Table 8.1: Methodological steps of the research.

PHASE	METHOD	PURPOSE
1	**Systematic literature review**	Develop a holistic framework of the research fields in literature, outline gaps, define research questions
2	**Exploratory case study**	Identify the main variables to focus for the application of the DFSS to service processes and analyze the characteristics of a big organization implementing such methodology to this kind of processes
3	**Multiple case studies**	Separately analyze in-depth four different organizations that apply the methodology to service processes and then compare the data with a cross-case analysis
4	**Confirmative literature review**	Consolidate the results obtained from the organizations and the cross-case analysis with new theoretical insights found in literature, in order to generalize the findings as possible

The purpose of the first phase, i.e. the systematic literature review we have already described in the previous chapter, was to explore the research domain in order to define and outline the state of the art of the studies on Six Sigma. Using the insights and the results generated by the literature review, we developed an holistic and preliminary conceptual model on the researches on this topic. Furthermore, this allowed outlining the gaps in the literature and formalizing the research questions for this thesis.

In the second phase, we launched an exploratory case study in order to address the research questions. This pilot suggested to analyze five specific aspects of the methodology, corresponding to five of the eight research fields of the literature. These five aspects belong to the strategic, organizational and operational macro-fields, i.e. the three decision levels, i.e., three of the four dimensions mentioned before.

This theoretical framework, i.e. the five aspects above mentioned, and the findings obtained from the exploratory case study needed more empirical evidence, thus the third phase was designed: the multiple case study research. On the basis of this conceptual framework and taxonomy, we developed a research protocol that we used in four different organizations. We made first an in-case analysis, studying and discussing the data in each company separately, and then a cross-case analysis to compare findings and results among the four different cases.

In the fourth and final phase of this study, our goal was to consolidate the findings of the four cases with another literature review, in order to discuss and verify our results. We compared the findings of the four cases to the theoretical insights we had obtained, in order to consolidate our conclusions.

In the next section, *empirical research design*, the second and the third phase of the research, i.e. the phases representing the empirical part of the thesis, will be described and commented, explaining the pattern we have followed in order to respond to the research questions.

8.3 Methodological protocol

Develop the research design is necessary in order to connect the research questions to the data gathered. Research design must follow from the questions and fit them with data. The design is the basic plan for a piece of empirical research, and includes main idea, the choice of the case studies, and the tools and procedures to be used for collecting and analyzing empirical data (Voss *et al.*, 2002). In this thesis the empirical research is represented by phase two and three of the previous table.
Scientific research can be conducted through different ways, including experiments, surveys, analysis of archival records and obviously the case study. Each strategy has advantages and disadvantages, which according to Yin (2005) depend on three conditions:

- The type of search problem;
- The researcher's control on actual behaviors;
- The focus on the contemporary rather than historical phenomena.

Furthermore, according to Yin (2005), case studies are the best strategy when the questions "*how*" and "*why* " are placed, when the researcher has little control over events and when the focus is on a contemporary phenomenon in a context of real life.
Eisenhardt (1989) highlights how the case study research strategy is focused on understanding the dynamics present within single settings, and he claims that may involve both single and multiple cases, as well as several levels of analysis.
At this point, Voss *et al.* (2002), confirm that it is possible to use different cases from the same company to study different issues or to seek the same field in different contexts in the same company. Also the case of research provides the means to study the emerging practices, such as those studied in this thesis.
The following definition, proposed by Leonard-Barton (1990) seems to sum up perfectly the aspects previously considered:

> *"A case study is a history of a past or current phenomenon, drawn from multiple sources of evidence. It can include data from direct observation and systematic interviewing as well as from public and private archives. In fact, any relevant to the stream of events describing the phenomenon is a potential datum in a case study, since context is important"*
>
> (Leonard-Barton, 1990)

Eisenhardt (1989), also considered aspects of strength and weakness of using this methodology in research, in particular for the exploration and construction of new theories. A first good point to the ability of generating new theories could be the overlapping of contradictory or paradoxical evidence. The attempt to reconcile evidence from different cases, different data, different investigators and literature, increases the probability of proposing a new theoretical vision. A second good aspect is the emergence of theories that are testable with constructs that can be immediately measurable, because they are evaluated during the process of theory building. A third aspect to consider is that the resulting theory will most likely be valid from an empirical point of view. The probability of a valid theory is high because the process of theory building is closely connected with the evidence from empirical observation.
However, with respect to the aspects of weakness, the intensive use of empirical evidence can produce quite complex theories. A trademark of a good theory is the synthesis, but the huge

volume of data available with this methodology can lead to construct theories that seek to capture all the issues raised by them. The result could be a theory very rich in detail, but lacking of simplicity and a general perspective. A second point of weakness is that the construction of theories through case studies can produce results limited and contradictory. It is in fact a bottom-up approach, which attempts to generalize a theory based on specific data. The risks are related to the fact that the researcher is unable to raise the level of generality of the proposed theory.
As illustrated by Voss *et al.* (2002) case studies can be used for different research purposes:

• **Exploration**: in the early stages of many research programs, the exploration is needed to develop research ideas and questions. Many doctoral thesis start with one or more case studies to generate a list of research questions deserve to be investigated;

• **Theory building**: one particular area where the use of cases is very strong is precisely the construction of theories. A theory can be made up of four components: the definition of terms or variables, a domain, a set of reports and specific predictions. The same can be seen as a system of constructs and variables in which the constructs are related to each other by propositions and the variables from hypotheses. The case studies are particularly useful when there is uncertainty in the definition of the constructs;

• **Theory testing**: despite its limited use for testing theories, research on the case study was used to test the Operations management issues as complicated as the implementation of the strategy. When the same is used in this context is typically used in conjunction with research based on surveys, in order to achieve data triangulation;

• **Theory refinement**: the case studies can be used as a follow-up research-based survey in an attempt to more deeply examine and validate previous empirical results.

Our research questions and purposes indicate that our research has an explorative character. This is not surprising given the limited research available about this topic at the present moment (Campanerut and De Toni, 2010). This will thus have two consequences: the construction of a theory and testing it in practice. Several authors claim that case study is not only useful as explorative tool and assert that it introduces procedures that offer the opportunity to carry out high quality research (Eisenhardt, 1989; Yin, 2005).
Many researchers emphasize that the importance of theory cannot be overstated. Right use of theory will provide a better focus for data collection and give weight to the data. Moreover, if the investigation has a strong theoretical foundation, there is more latitude for the validity of the results across the context in which the theory has been tested.
In addition to a sound theoretical basis, a good case study protocol is fundamental. Yin (2005) underlines the importance of the case under study matching the conditions of the theory and he proposed a number of rules and data-collection strategies to increase the quality of the research. Thus, he defined a series of criteria for testing the quality of research designs:

- *Construct validity*: establishing good operational measures for the concepts being studied;

- *Internal validity*: establish causal relationship;

- *External validity*: establish the domain to which a study's findings can be generalized;

- *Reliability*: demonstrate that the operations under examination – such as data collection – can be repeated with the same results.

8.4 The empirical research design

In this research, considerable emphasis has been placed on the theoretical foundation, as Yin's principles being applied where possible, and the quality judged on the basis of the above criteria.
In summary*, the five steps for the empirical research* we followed in this study are:

1. *Selection of case*s: identification of cases suitable for investigating the research questions defined in the previous phase;

2. *Data collection*: it uses several tools and sources, quantitative and qualitative, to gather data to analyze;

3. *Data analysis*: Data collected are analyzed by focusing on a single case that cross-case analysis;

4. *Formulation of hypotheses*: it is based on the results of the analysis, passing through an iterative process, reaching the definition of hypotheses.

8.4.1 Selection of cases

One of the key decisions in planning a research using the method of the case study is about how many cases to carry out.
Starting from a given set of resources available, the less the case studies, the greater the opportunity to comment in depth. Voss *et al.* (2002), emphasize that single case studies have weaknesses. First, there are limits to the external validity of the conclusions, models or theories developed from a single case study. Also there is the risk of incorrectly judging a single event, or to overestimate the significance of the available data. These risks exist in all research with case studies, however, are sometimes mitigated when the events and the data are compared between the cases. The multiple case studies may instead reduce the depth of the study when resources are constrained, but may increase the external validity, reducing the bias.
Carrying out multiple case studies, a key issue deals with the selection. Eisenhardt (1989) emphasizes that the concept of population is crucial, given that it defines the set of entities to which the research sample is constructed. In addition, the selection of an appropriate population controls extraneous variation and helps define the limits for generalizing findings.
However, the sampling of cases from a chosen population is unusual when the aim is building a theory using the same ones. Cases may be chosen to replicate previous cases, extend emergent theory, or simply they can be chosen to complete theoretical categories and provide examples of polar types. The cases could be chosen randomly, but this practice is not necessary, nor advisable.
As noted by Pettigrew (1988), given the limited number of cases which can usually be studied, it strongly does make sense to choose cases belonging to extreme situations and polar types in which the process of interest is transparently observable. There polar cases are

typically presenting some common features and some contrast features among them, in order to increase the external validity of the study.

8.4.2 Data gathering

The researchers, applying the methodology of the case study, typically use multiple methods of data collection from a variety of sources.
Yin (2005), analyzed in this regard the six main sources of evidence used in the typical case study: documentation, archival records, interviews, direct observations, participant observation and physical objects. It should be noted that no single source could prevail in a clear manner on the other, which are considered as complementary. Therefore, in order to make a good case study, it is necessary to use as many as possible. In fact, through the triangulation of data collected, it is possible to build stronger constructs and hypotheses.

1) Documentation

This type of source can take many different forms:

- Letters, notes and other information;
- Agendas, announcements and summary records of meetings and other written reports of events;
- Administrative documents, proposals descriptions of progress and other internal documents;
- Formal studies or evaluations of the same site in question;
- Newspaper clippings and other items that appear in the media.

In the case study, the use of this source is most important to appreciate and support the evidence from other sources. The documents are useful to verify the correct spellings or names of the organizations mentioned in interviews. In addition, documents may also provide more details on the information from other sources. Finally, documents can be explored to draw any conclusions, however, through other types of information.

2) Archival data

In some case studies, archival records can be important. They are divided into:

- Archives of service: highlight the number of customers served in a given period of time;
- Archives of organization: organizational projects and budgets covering a period of time;
- Maps and charts of the geography of a place;
- Lists of names and other relevant data;
- Survey data: official documents previously collected about the site;
- Verbal personal diaries, calendars and lists of telephone numbers.

The usefulness of this source varies from case to case, for some cases of official acts may be so great as to become the only object of retrieval and analysis, some cases may have been only partially.

3) Interviews

One of the most important sources of information in the case studies are interviews, which may be of different kinds.
The first type is that of open interviews in which respondents may be asked to speak to you of the facts of an event or to submit their opinion on it. Sometimes the interviewee to propose his opinions about certain events, which can be used as a basis for further investigation. A second type is the structured interview, where an individual is interviewed for a short period of time. In these cases, in conducting the interview, it is more useful to follow a certain order of questions derived from the protocol of the case study. The most common purpose of this type is usually to confirm certain facts that are thought to have already been verified. In this situation, specific questions must be carefully formulated, to be simple and without any prejudice towards the subject, allowing the interviewee to provide a spontaneous comment about it.
A third type of interview provides semi-structured questions, along the lines of a formal investigation. While a structured interview has a formalized, limited set questions, a semi-structured interview is flexible, allowing new questions to be brought up during the interview as a result of what the interviewee says. The interviewer in a semi-structured interview generally has a framework of themes to be explored.
However, the specific topic or topics that the interviewer wants to explore during the interview should usually be thought about well in advance (especially during interviews for research projects). It is generally beneficial for interviewers to have an interview guide prepared, which is an informal group of topics and questions that the interviewer can ask in different ways and different times of the interview.
The interviews are an essential source of evidence in a case study in how often respondents are subject to well-informed and can provide important views within a situation. They can also provide shortcuts to trace the historical roots of this situation, helping to identify other relevant sources of evidence. It should be noted that it is reasonable to confirm the validity of data collected in the interview with information from other sources. A common problem concerning the recording of interviews on the use of the recorder: the use of this tool is basically a subjective matter. The tapes provide a more accurate method than any other interview. It should be emphasized that the researcher cannot believe, however, that the tape is a substitute for "listen" more deeply during the interview.

4) Direct observation

The opportunity to make direct observations are created during the making of a field visit or site of the case study, including the occasions when we collect other evidence, such as those derived from interviews. For example, the conditions of buildings or areas of work may suggest something about the climate or the culture of an organization, and likewise, the interior layout of a respondent may be an indicator of the status of the latter within an organization.
Some specific behaviors or environmental conditions may be observable, and such comments will be an additional source of evidence of the case study. This source, involves a data collection activity both formal and casual.

5) Participant observation

Participant observation is a way of looking where they were not simply passive. In fact the

researcher can take on different roles in the study of a case, and can truly participate in the events under observation.
Participant observation allows access to life events or groups that would otherwise be inaccessible to scientific research. In fact, for some topics, there can be no other way to gather evidence only through participant observation. In addition, this type of source allows us perceiving reality from the perspective of someone "inside" of the case study rather than external to it, that it a valuable perspective to delineate the accurate profile of a phenomenon of the case study.
However, in these cases, it is likely that the researcher take positions or roles for taking care of the situation and such conduct is contrary to the interests of good scientific practice. In addition, the role of participant may require too much attention to the role of the observer. Participant observation may not have sufficient time to take notes or ask questions about events seen from different perspectives.

6) Physical objects

A final source of evidence is the physical or cultural artifact: it may be a technological device, a tool, a work of art or other physical evidence. These objects can be collected or observed as part of a field visit and are usually used in anthropological research. This type of source is generally less important in the study of the classical case.

<u>Qualitative evidence and quantitative evidence</u>

Eisenhardt (1989) suggests the need of combining qualitative and quantitative evidence. Although the term qualitative and case study are often used interchangeably, case study research can involve qualitative data only, quantitative data only, or both (Yin, 2005). Furthermore, the combination of different types of data can be highly synergistic. Qualitative data are useful to understand the logic or theory behind relationships revealed by quantitative data, or could suggest theories that could be directly supported by quantitative data. This synergy has been described by Minzberg (1979), as follows:

> *"For while systematic data create the foundation for our theories, it is the anecdotal data that enable us to do the building. Theory building seems to require rich description, the richness that comes from anecdote. We uncover all kinds of relationships in our hard data, but it is only through the use of this soft data that we are able to explain them"*
>
> (Minzberg, 1979)

<u>Multiple investigators</u>

Eisehardt (1989) also points out how very useful the use of multiple investigators, who have two key advantages. The first is that trigger the creative potential of the study. In fact, members of the research team often have additional insights that add richness to the data collected, in addition to their different perspectives increases the opportunity to capitalize each new suggestion that may emerge from the data. Secondly, the convergence of the observations of multiple investigators enhances confidence in the findings. Increase perceptions of converging empirical foundation of the case, while preserving the conflicting perceptions of the team to premature closure.
Pettigrew (1988), states that a strategy for employing multiple investigators is to visit the sites of the case study team. This allows cases to be viewed from different perspectives of multiple observers. A variation on this strategy is to give researchers the unique role of the team,

raising the possibility that investigators see evidence of the case in different ways. For example, the interviews could be conducted by teams of two people, a researcher asks questions while the second recording notes and observations. The interviewer has perception of personal interactions with the interviewee, while the registrant holds a different perspective, as distant as possible (Eisenhardt, 1989).

Additional Indications

Glaser and Strauss (1967), suggesting an overlap of stages of data collection and data analysis, a practice that is partly used by many researchers durations searches. This practice increases the flexibility of the process of formation of the emergent theory, the benefits associated with it.
A further adjustment to the tools used for data collection is the addition of questionnaires to the normal protocol interviews. Such adjustments allow the researcher to explore the emerging issues and to take advantage of opportunities that may be present in given situations.
The use of these adjustments is suitable, since investigators seek to understand each case individually, and with the highest level of detail possible.

8.4.3 Data analysis

In this phase of the methodology, collected data are analyzed by focusing on both the individual case that cross-case analysis. Data analysis is the central part of the methodology that aims to build theories from case studies, however, is the most difficult and least codified the entire process.

Data analysis of individual case

Data analysis of each case is characterized by the huge volume of data. Pettigrew (1988) has described this aspect of emphasizing that there is always the risk of "*death by data asphyxiation*". Furthermore, the fact that the research problem is often undefined and constantly evolving, makes all more complicated. In this sense, the analysis of the case can help to address this cluster of information.
This type of analysis typically involves in detail every single paper written down during each visit on the field performed for the case study. These documents are often simple descriptions, but are essential for the generation of hypotheses, because they help researchers to deal with the first stages of analysis. However, there is a standard format for this type of analysis.
Eisenhardt (1989), suggests to get familiar with each case, as if it were a stand-alone unit. This process allows the unique paths of each case to emerge before the researchers are encouraged to generalize paths through the various cases. In addition, it gives investigators a certain knowledge of each case that accelerates the next phase of comparison between different cases, i.e. the cross-case analysis.

Cross-case analysis

The cross-case analysis is used after the data analysis on the individual cases. The basic concept for this kind of activity is the fact that people are limited in processing information; they reach their conclusions based on limited data, they are severely affected by the clarity of

authoritative managers and key actors. Often these data are actually inconsistent with the basic statistical properties and sometimes it can happen that, by mistake, some evidence to refute a theory are overlooked. The risk is that researchers come to premature conclusions, or even false, as a result of bias in processing information. The key to avoiding this occurrence is, therefore, to observe the data through different perspectives.
Eisenhardt (1989) suggests to select categories or dimensions for classifying cases in groups, and then note the similarities within the same group and differences between different groups. The size may be suggested by the problems of research or literature exists or can be the researcher to choose just the same. An extension of this strategy is to use 2x2 matrices to compare several categories at once, or to move on a continuous scale of measurement that allows a graphical representation.
A second strategy is to select pairs of cases and then to list similarities and differences between each pair. This practice forces the researchers to look for subtle similarities and differences between the cases themselves. The juxtaposition of seemingly similar cases by an investigator of the research focused on the differences can break too simplistic hypotheses. Similarly, the search for similarities in seemingly different pairs can lead to a deeper understanding.
Finally, a third strategy is to divide the data according to the source of origin. For example, a researcher can sift through the data derived from observations, while a second review the interviews and much more work on the evidence derived from questionnaires.
Overall, the idea behind cross-case analysis is to force researchers to move beyond their initial impressions, especially through the use of different points of view as you approach to data collection. These strategies increase the probability to outline theories as accurate and credible as possible, like those with a close relationship with experimental data. Furthermore, searching through the cases raises the possibility that investigators catch new evidence hidden in the data.

8.4.4 Formulation of Hypotheses

From the analysis of the data begin to emerge possible scenarios, concepts, and relationships between variables. The next step in this highly iterative process is to compare systematically the emergent structures with evidence of each case in order to assess its compatibility with experimental data. The central idea is that researchers may compare theory and data constantly, so as to arrive iteratively at a theory that is suitable to them. A close match is important in building a good theory because it allows you to produce a valid result empirically.
Eisenhardt (1989), suggests that a first step in the formulation of hypotheses is the refinement of the constructs. This is a two-part process that involves the conceptualization of the construct and the construction of tests that measure the construct in each case. This is achieved through a constant comparison between the data and constructs themselves, in order to accumulate evidence from different sources to converge on a single well-defined construct.
A second step in the formation of the hypotheses is to verify that the emerging relationships between constructs fit together with the evidence in each case. Sometimes a relationship is confirmed by evidence in the case, sometimes it is not confirmed or abandoned for lack of evidence. Thus, the rationale is to replicate, i.e. treating a number experiments in each case, using each case to confirm or refute the hypotheses. In the logic of replication, cases that confirm the reports increase confidence in the validity of the report; cases which deny the report can often provide an opportunity to redefine or extend the theory.

In this process, qualitative data are particularly useful for understanding the reasons for keeping or not the emerging reports. When a relationship is supported, qualitative data often provide a good understanding of the dynamics underlying the report. This aspect is crucial in the establishment of the internal validity.
In summary, the formulation of hypothesis for theory building involves measuring constructs and verifying relationships. In carrying out this task, the research team must judge the strength and consistency of relationships within the case and between cases and show in detail the procedures when the findings are published, so that readers can apply these discovered standards.

8.4.5 The confirmative literature review and the conclusion of the study

An essential step of the methodology appears to be the comparison of emerging concepts, theories, or hypotheses with the existing literature. This involves identifying the similarities, contradictions and the reasons behind them. A key to this process is to consider a wide range of literature (Eisenhardt, 1989).
The literature that conflicts with the emergent theory is important for two reasons. First, if the researcher ignores the conflicting evidence, then the credibility of the findings is reduced. Second, and perhaps more importantly, the literature on conflict is an opportunity. The juxtaposition of conflicting results forces the researchers to a more creative way of thinking of what could normally reach. The result can lead to deeper insights and refine the limits of the external validity of the research.
The literature review confirms the findings is important as it links the same way and emphasizes similarities in phenomena normally not associated with another one. The result is often a theory with greater internal and external validity and much more conceptual level. This practice is crucial in this methodology because the research findings often are based on a limited number of cases. In this situation any further improvement of the internal or external validity is a major improvement and allows reaching the final conclusions of the research.

8.5 Considerations about the conclusion of the research

Two aspects are important in order to arrive at the conclusion of the study: when to stop adding cases and when to stop iterating between theory and data.
In the first case, ideally, researchers should stop adding cases when theoretical saturation is reached. The theoretical saturation is simply the point at which incremental learning is minimal because the researchers are observing a phenomenon seen before (Glaser and Strauss, 1967). The theoretical saturation often has practical implications determination of time and money once you have finished the collection of cases. Often the researchers plan the number of cases in advance. This type of planning may be necessary because the time constraints and availability of resources forced the researchers to develop cases in parallel. Finally, although there is no ideal number of cases, an amount usually between 4 and 10 appears to fit. With fewer than 4 cases, it is often difficult to generate more complex theories, and empirical foundations may be weak.
The second aspect to be considered, regards when to stop iterating between theory and data and the saturation is still the key concept that addresses this decision. Specifically, the iteration process ends when the incremental improvement to the theory is minimal.
At best, the final result of research can result in concepts, conceptual frame work, propositions or possible middle theories. In the worst, the result may be disappointing,

leading to solutions that simply replicate previous theories or they fail to provide clear paths between the data presented.

Chapter 9 -EXPLORATORY CASE STUDY

In the previous chapter we already commented that the exploratory nature of this study suggests in the beginning the use of a qualitative methodological approach, and in particular an exploratory case study, which will represent out pilot for the following multiple case studies. Research through exploratory case studies is a useful tool to understand the complex nature of design and quality management, and it is recommended by several authors, e.g. Voss *et al.* (2002), Eisenhardt (1989) and Yin (2005).
The pilot case study in object is focused on the study of **Motorola Inc.**, an American lead company operating in the telecommunications industry based in Schaumburg, Illinois. Motorola is a multinational organization and we decided to carry out our analysis in the branch located in Plantation (Florida, USA). This organization was firstly chosen due to its historical use of Six Sigma methodology.

9.1 Methodological notes

To acquire a deep understanding of the dynamics involved in Motorola, multiple data collection methods were adopted. These are references to official company's documents (website and archival documents), press review and interviews.
The aim was twofold: to increase information basis and to diversify data, in order to reduce biases (Eisenhardt, 1989; Patton, 2002; Yin, 2005).
Documentation proved exact and broad coverage, allowing the researchers to review details of events (Yin, 2005, p. 86) and to triangulate information with the interviews.
Multiple respondents were considered in order to reduce subjectivity and biases of single informants (Voss *et al.*, 2002, p. 205). The respondents were two Six Sigma Master Black Belt dealing with new products and new services development and a Master Black Belt who had just moved to another company and was in charge of the same activities in Motorola.
At the beginning the interviews were open, in order to deepen the background of the interviewees. Afterwards, the protocol has scheduled semi-structured interviews (Yin, 2005), in that a previously prepared list of questions was used as guideline. However, the list was used in a way that let the respondents feel as free as possible to talk about the overall subject, sharing their own ideas and feelings to ensure that no important arguments were left out. All interviews were carried out by conference call (due to geographical distance of the company). They were taped and transcribed accordingly, to better find conflicting answers and review their contents. The transcriptions were analyzed by the authors and then compared with previous documentation. The analysis refers to a period from September 2009 to January 2010.

9.2 Firm description

Motorola organization was born in Chicago, Illinois as Galvin Manufacturing Corporation in 1928. Its first product being a battery eliminator. Paul Galvin acquired the patents to the automotive radio and acquired the rights to the trade name Motorola from William Lear. The name Motorola was adopted in 1930, and the word has been used as a trademark since the 1930s (Motorola.com).

Many of Motorola's products regarded radio, starting with a battery eliminator for radios, through the first walkie-talkie in the world in 1940, defense electronics, cellular infrastructure equipment, and mobile phone manufacturing. In the same year, the company built its Research and Development program with Dan Noble, an expert in FM radio and technology of semiconductors. Dan Noble joined the company as director of R&D.

In 1943, Motorola went public and quoted in the stock market. In 1947, the name changed to the present name. The present logo (see figure here below) was introduced in 1955, it was designed by Zeke Ziner in late 1954. At this time, Motorola's main business was producing and selling televisions and radios.

Figure 9.1: Motorola logo (Motorola.com).

In 1952, Motorola opened its first international subsidiary in Toronto (Canada), to produce radios and televisions.

Nowadays, its core business is represented by wireless telephone handsets. Furthermore, it designs and sells wireless network infrastructure equipment such as cellular transmission base stations and signal amplifiers.

Today, Motorola is mainly organized into two business units:

The *Mobile Devices and Home* business is set to lead in the convergence of mobility, Internet and new media. Products' portfolio includes mobile converged devices and smart-phones, digital entertainment devices in the home, and end-to-end video, voice and data solutions enabling to provide advanced mobile media solutions and multi-screen experiences. Currently the company is working with network operator partners in order to create new advanced personalized services to leverage the capability of expanding wireless and wire-line broadband availability.

The *Enterprise Mobility Solutions and Networks* business comprehends an end-to-end portfolio of products and solutions, e.g. mobile computers, rugged two-way radios, secure public safety systems, barcode scanning and wireless network infrastructure to enterprises and governments, as well as 4G broadband infrastructure, devices and services to network operators globally.

Furthermore, Motorola offers several kind of services, such as:

- Application services (e.g. Design Services, Application Engineering Services, End-to-End Solutions);
- Integration services (e.g. Equipment Installation Services, Hardware Upgrade Services, Network Migration Services);
- Strategic Mobility Services (e.g. Planning Services, Consulting Services, System Readiness Analysis Services, Logistics Optimization Services);

- Support services (e.g. Remote Monitoring, Preventative/Corrective Maintenance, Software Maintenance, Hardware Support).

In the figure here below a representation of different applications, products and services offered by the company.

Figure 9.2: Different applications, services and products offered by Motorola Inc. (Motorola.com).

The rapid convergence of fixed and mobile broadband Internet and the growing demand for next-generation mobile communication solutions, allowed the company to refine the mission and to lead the next wave of innovative products and services for meeting the expanding needs of the customers around the world. The trends towards ubiquitous connectivity, media mobility and wireless flexibility, joined with mobile lifestyles and business, keep on expanding.

Today, Motorola is considered a big multinational, comprehending approximately 66 thousand employees, most of them working in the North-American area.

The Motorola 2009 net sales were about US$ 22 billion. United States take the lead with the 54% of the total net sales, followed by Asia (excluding China) and Latin America (11%), Europa (9%) and China (6%). A block of several other countries represent the remaining 9% of the net sales.

In Motorola the drive for innovation is noteworthy. The 2009 R&D expenditures were US$ 3.2 billion, while from 1928 the number of patents granted in the company was 23019 (worldwide). This big effort towards communications and electronics industry innovation joined to massive R&D expenditures brought to many technological breakthroughs, e.g. the world's first commercial high-power transistor, the world's first commercial portable cellular phone, the world's first GPRS cellular system. In the figure here below all the great inventions and innovations brought to the market by Motorola during these decades.

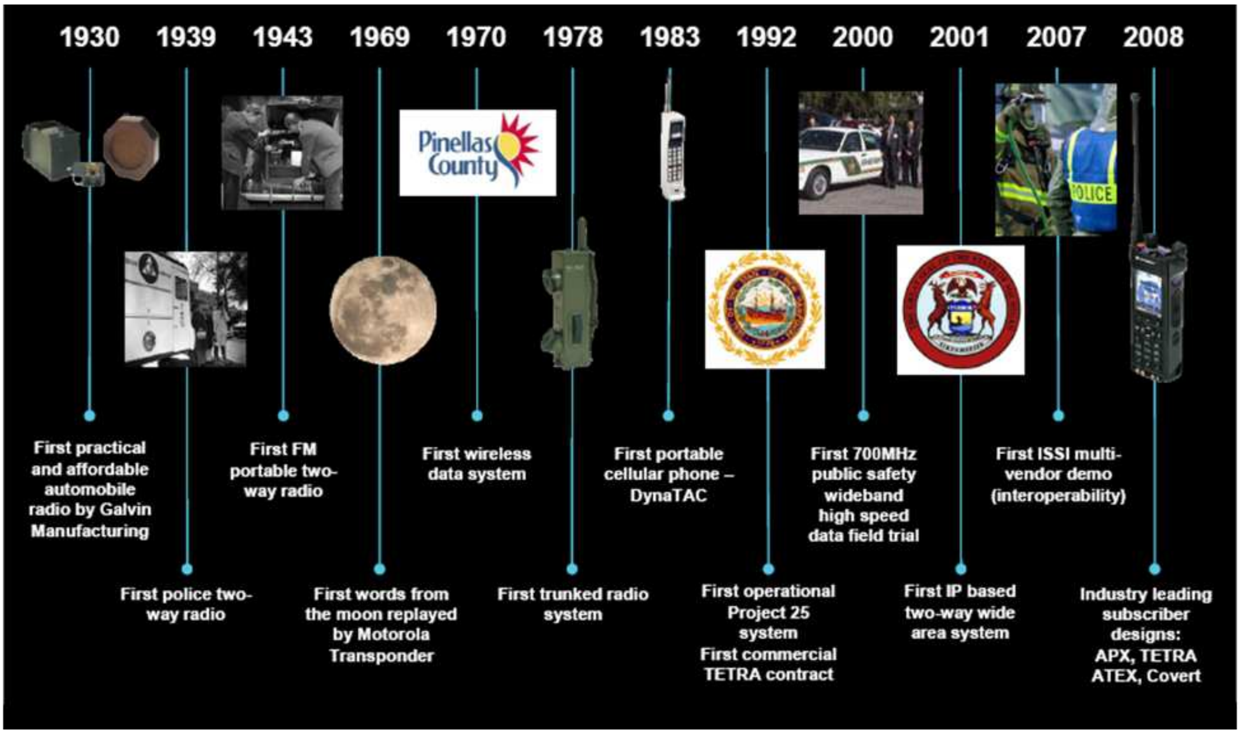

Figure 9.3: Innovations of Motorola (Motorola.com).

9.3 The role of Six Sigma in Motorola

Nowadays Six Sigma and Lean Sigma are widely-upheld methodologies and tools used to reduce variation in a business process by using a statistical process control to measure variance and standard deviation (Näslund, 2008).
Six Sigma methodology originated in manufacturing as a set of practices designed to improve processes and eliminate defects, but its application was subsequently extended to other types of business processes as well. In Six Sigma, a defect is defined as any output of the process that does not meet specifications, or that could lead to creating an output that does not meet specifications.
The Six Sigma methodology was first developed at Motorola even though it became much more famous thanks to General Electric. It was created by engineer Bill Smith, under the direction of Bob Galvin, i.e. the son of founder Paul Galvin, when he was running the company.
Bill Smith first formulated the particulars of the methodology at Motorola in 1986. Six Sigma was heavily inspired by six preceding decades of quality improvement methodologies such as quality control, TQM, and Zero Defects, based on the work of quality Gurus such as Shewhart, Taguchi, Deming, Juran, Ishikawa and others.
During the last decades, implementing the Six Sigma methodology, Motorola Inc. has realized several significant developments, becoming a pioneer for technology innovations.
Many organizations agree with the misconception that generating random ideas is essential to developing revolutionary offerings. Contrarily, the company has placed greater emphasis on

the actual process surrounding the identification of opportunities. Innovations are considered those inventions that reach the market (Joh and Mayfield, 2009) and represent a big business. However, they demand considerable investment in finance, time and personnel.
Contrary to common expectations, the search for new business opportunities is often stimulated by periods of uncertainty or even crisis. In this context, since Motorola's available resources were often limited, this factor forced us to identify company's priorities. The company, in fact, had the possibility to choose among several quality improvement initiatives. Since these initiatives were extended to different functional areas of the company, the company had to base its choice on the positive financial impact that the project would bring, but also on the strategic implications in the long term.
Over the years, the verification of the applicability of Six Sigma outside of manufacturing has led to the gradual evolution of the methodology and to the reinforcement of a shared quality culture.
Conventional thinking says that firms must sacrifice quality to achieve quantity or low cost. Motorola and other companies that implemented Six Sigma showed that the opposite is true. In the first five years of implementation the results obtained were astonishing:

- The employee productivity increased 100 per cent;
- Almost US$ 1 billion manufacturing cost savings;
- The defect rate declined from 6000 to 30 DPMO (Defect Per Million Opportunities);
- Cumulative cost savings were in excess of US$ 3 billion;
- 5 per cent added to profit levels;
- Sales increased from US$ 5.9 billion to US$ 13.3 billion.

Due to great results of the first years, Six Sigma methodology continued to evolve in Motorola, showing massive financial returns. In 2000 the company began to implement Design For Six Sigma (DFSS), a methodology for driving breakthrough performance in new product development.
In Motorola, the need for a brand new process comes when occurs at least one of these conditions:

- None of the ways to produce an output is completely accurate;
- No process exists to produce a product or service to satisfy a new customer need;
- The process is considered completely optimized but customer's needs are still not satisfied.

The evolution of Six Sigma in Motorola also dealt with taxonomy. What was called "Six Sigma" in 1986, in 2005 finally evolved into "Digital Six Sigma." Digital Six Sigma (DSS) is a management system with a business improvement methodology that focuses on customer requirements, process alignment, timely execution, etc. using applied statistical tools derived from Six Sigma. The current DSS program in Motorola integrates principles of traditional "Six Sigma" with "Lean Tools."
There are two main branches of DSS at Motorola today, namely, Six Sigma Process Improvement (SSPI) and Six Sigma Product Development (SSPD). SSPI's focus is on eliminating waste and variation in business processes that already exist, using the DMAIC model. SSPD's focus, instead, is about designing new concepts utilizing the Voice of the Customer. These concepts will be mainly used for robust new product development.

9.4 Towards the DFSS for service processes

At the beginning of Six Sigma implementation, Motorola applied the DMAIC model only to manufacturing processes, representing its core-business. Gradually, the company started to broaden the methodology’s application area to internal services, since they can be definitely considered processes. Afterwards, given the excellent results obtained, Motorola began to implement the methodology’s principles to design robust products and processes, opening the way for the DFSS to develop new services, eventually. The application of DFSS to NSD in Motorola does not correspond to a specific name or acronym in the organization. Hereafter in this paper we refer to this activity as Six Sigma Service Development (SSSD).
Figure here below provides a clear summary of the Six Sigma applications in Motorola.

Table 9.1: Six Sigma applications in Motorola.

		PURPOSE	
		IMPROVEMENT	**DESIGN**
PROCESS FOCUS	**PRODUCT**	***SSPI***	***SSPD***
	SERVICE	***SSPI***	**SSSD**

Applying the methodology in service processes represents in Motorola a further opportunity for increasing profit levels. Research showed that most of the service processes perform at less than 3.5 sigma quality level with a defect rate of over 23000 DPMO (Yilmaz and Chatterjee, 2000).
Motorola overcame the prejudice still conforming to the notion that Six Sigma is relative only to manufacturing mainly implementing and developing the methodology through the three basic principles quoted by Antony (2006):

1. All work occurs in a system of interconnected processes;
2. All processes exhibit variability;
3. All processes create data and it is responsibility of the company to identify the sources of variability and implement effective strategies to reduce or eliminate such variability.

Applying DFSS methodologies for designing and developing new services and in general new processes has definitely led to several benefits in Motorola:

- Market share has increased;
- Customer satisfaction has improved;
- Service operational costs (compared to similar services) have been reduced;
- Variability of the main service processes have been reduced;
- Defect rate in service processes has been reduced;
- Improved culture due to a better attitude to quality improvement;
- Process cycle time (compared to similar services) have been reduced.

In order to obtain these benefits and successfully implement DFSS to NSD, Motorola has concentrated its efforts towards three main aspects: strategic, organizational and operational.
The strategic aspect mainly deals with the ability of the company to choose the best opportunity for a new service and to translate this opportunity in a Six Sigma project. Beyond to satisfy the needs of the customer, indeed, Six Sigma projects must be accurately chosen in order to fit with the company's strategic priorities.
The organizational aspect deals with the Six Sigma human resources put side by side to the organizational structure of the firm. Furthermore it deals with the company's culture and all the other intangible aspects.
Finally, the operational aspect deals both to the implementation of the methodology in the company and the choice of the best tools to be used in the specific phases during a Six Sigma project.

9.4.1 Introduction to the strategic aspect

When Six Sigma was born in Motorola, the international competition among American companies was quickly increasing. Nowadays, because of this competition, most companies try to do more with fewer resources. Service development methodologies such as SSSD is allowing Motorola to launch new services sooner, at lowest cost for the company and with less variation, while satisfying customers. In Motorola, the use of DSS is directed to a better comprehension of customers' value and needs. As a matter of fact, the final purpose of the methodology is a business delivering value for its customers (internal or external) and stakeholders in a perfect value stream. The only possibility to achieve this goal is seeking continuous improvement in every process of the company: from strategic planning to service delivery.
Unlike other quality methodologies, a distinctive characteristic of Six Sigma is the project-based implementation. Six Sigma projects are the vehicle that leads to improvement but among thousand good ideas representing potential improvement opportunities, the company has to select some to be implemented.
Bañuelas and Antony (2002) assert that Six Sigma project must have a direct impact on both financial and operations goals and a clear effect on the whole business. On this basis, in every single project Motorola tries to identify the link between the project and the business strategy, demonstrating its benefits and how it will sustain the business strategy, not only in financial terms.

Actually in Motorola, the Six Sigma projects selection process is extremely important, as it represents the connection between business strategy and the needs of those customers who might receive the service that the company design.
In our opinion, as Goldstein *et al.* (2002) linked the needs of customers and the strategic intentions of the organization with the design of the service (see fig.), Six Sigma projects selection could represent the missing managerial link between corporate strategy and customers' satisfaction.

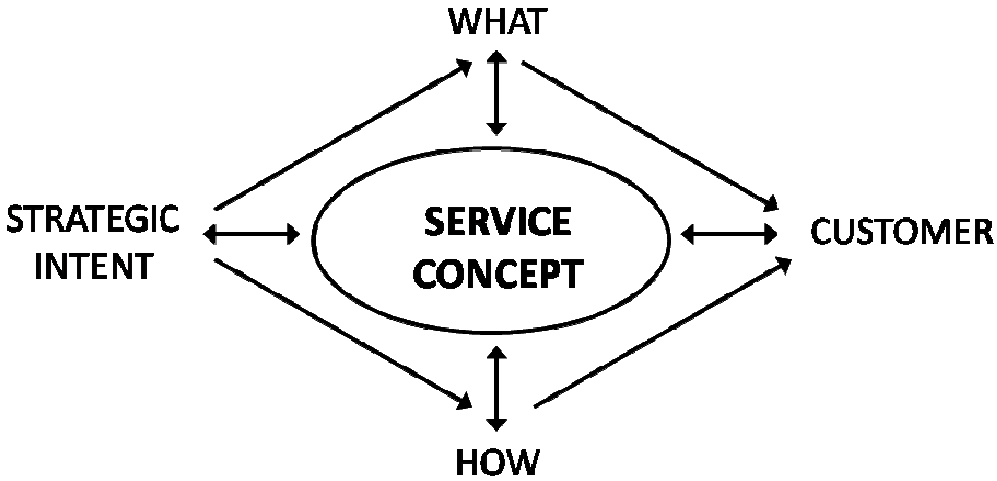

Figure 9.4: The proposed link with service design (Goldstein et al.*, 2002).*

Motorola, in order to generate service concepts that fit with this purpose, has considered Six Sigma project selection as a strategic process. The aim of this process is selecting only the NSD projects which are aligned to the firm's business strategy and for this Motorola is creating formal procedures for the selection process of NSD projects.
Top management in Motorola is convinced that NSD projects prioritization should have its basis overall on objective factors. These factors are mainly based on three analysis: a full risk analysis for the NSD projects, a detailed financial analysis and a wide market analysis. The market analysis comprehend a formal study of the market to monitor changes in customer demand, a clear segmentation and the identification of a complete set of customer requirements and actual needs.

9.4.2 Introduction to the organizational aspect

Since the beginning of its experience with Six Sigma methodology, Motorola has used a people-centered approach to drive fundamental changes. This approach required several elements to move towards a new corporate culture.

- The development of new reward and recognition systems based on return on net assets from each major sector (and some smaller groups) of the company;
- Uniform quality measurement and goals through the introduction of the DPMO (Defect Per Million Opportunities) concept in the company;
- The communication of new quality rules to the organization;
- The training of skilled and prepared people;
- Nurturing and supporting facilitators;

- Commitment of senior executives.

In the company, some of these elements have been considered fundamental also for the implementation of DFSS to services. Others evolved in order to better fit the NSD processes. Finally, the introduction of novel procedures made much easier the evolution of the company's culture towards this new approach.
Motorola still has a people-centered system in the firm, indeed, the purpose is that top managers have long term commitment to NSD and senior managements show strong support for this process.
The company has substantially increased the amount of money spent on training, applying a structured training approach for the employees involved in NSD. Basic training is available to all firm employees via short periodical classes, while Green Belt and Black Belt certification programs involve a strict nomination and review process. The training program is administered internally and includes companywide a DSS education for practitioners. Any employee of Motorola can register for class and achieve basic Six Sigma certifications, named first White and then Yellow belt. Earned these certifications, employees have to be nominated and register for certification programs to continue learning. The following Six Sigma programs will take them through rigorous Green, Black and Master Black Belt certifications. These programs include intensive classroom education in Six Sigma tools and methodologies followed by projects participation.
For the future, the company is planning also to train part of the customer contact personnel on the service delivery procedures before the service launch, in order to improve the effectiveness of the delivery process.
Employees who are involved in NSD are qualified in process design and optimization. Whenever a Six Sigma project has been launched, a NSD team formed by Green and Black belts is formed. This NSD team must have high skills in using Six Sigma tools and techniques for quality improvement and process design.
Furthermore, the company encourages the use of multifunctional teams i.e. teams which comprise experts from different functional areas. These areas should have good coordination and communication during the NSD process.
Finally, Motorola has also developed leadership and change management classes. The final purpose is to extend its training to customers and suppliers so that the Six Sigma values might spread along the entire value chain.

9.4.3 Introduction to the operational aspect

Typically, the application of Six Sigma for quality improvement of existing processes refers to the well-established DMAIC model. Contrary to this, DFSS does not have a unique model, and the literature on the topic offers several models, depending also on the characteristics of the process. Some of the most famous are the DMADV model (Define, Measure, Analyze, Design, Verify), the IDOV model (Identify, Design, Optimize, Validate) and the DMEDI model (Define, Measure, Explore, Develop, Implement).
The operational aspect is the third main aspect that Motorola has considered in order to successfully implement DFSS to NSD. This aspect deals both to the implementation of the methodology in the company and the choice of the best tools to be used in the specific phases during a DFSS project.
The company considered the use of formal procedures the basis for effectiveness in the activity of SSSD. The model that the firm has developed to implement DFSS to the process of NSD is the CDOV model.

The CDOV model (Concept, Design, Optimize, Verify) was created in Motorola as a derivation from IDOV in 2005. Basically, the main difference consists in the major emphasis on the Concept phase, as the identification of a good service concept has a significant impact on the following service quality and customer satisfaction.
The *Concept Phase* is probably the most important among the four phases. It mainly refers to capturing the Voice of the Customer (VOC) in order to develop services that fit with their needs. To perform this activity, the company makes extensive use both of survey researches and face to face interviews, using questionnaires. Here below this first phase is described in detail, in the case of face to face interviews. It is composed by a set of 9 steps:

1. Identify the SAM (Served/Serviceable Available Market), i.e. all the potential customers;
2. Comprehend the market strategy;
3. Identify the interview team;
4. Develop the questionnaire using KJ analysis, i.e. a tool for qualitative analysis;
5. Perform the interviews;
6. Translate the VOC in a process using a worksheet (define the service concept);
7. Send the statements on the service back to the customers (to validate and score);
8. Prioritize the customer needs;
9. Find the critical parameters for the service.

In the *Design Phase* the organization's development team clearly defines a set of Critical to Quality factors (CTQ) for the service. Customer needs and inputs are carefully documented in order to successfully break down the service in sub-processes that can be provided without errors. This activity contributes to a high-quality design, improving service quality and customer satisfaction while the service is delivered.
In the *Optimize Phase* critical parameters are tracked and improved and the development team conducts a series of pre-launch tests to ensure success to the project before the actual launch. Both in the Design and in the Optimize phases, periodical reports are used in order to better monitor the situation.
Finally, in the *Verify Phase* the company conducts the post launch review and documentation after the new service launch. The post launch review could take a long time if the interface between service customer and service supplier is mainly human-based. In this case, indeed, although the process has been carefully designed, service providers could take additional time to learn the new procedures.
The purpose of the organization in this phase is finding a clear set of key performance indicators (KPI) to monitor the post launch performance of the service. More in general, another aim is seeking out appropriate performance measures to evaluate the effectiveness of NSD.
The firm, in order to hear the VOC and implement DFSS to its services, uses several tools and techniques. Project management tools and skills, for example, are widely used in the projects. Furthermore, management tools such as the balance scorecard are used and obviously the firm employs tools from quality management and statistics, like Pareto charts and regression. Actually, statistical techniques are not widely used in NSD Six Sigma projects and Motorola prefers to use more qualitative tools like benchmarking, or even integrate tools from Lean Management.
The last part of this section represents in table X the classification of tools that Motorola uses for DFSS projects. Each tool has been included in one or more phases, depending on those it is usually applied.

Table 9.2: Classification of tools used in Motorola.

	TOOLS	PHASES			
		Concept	***Design***	***Optimize***	***Verify***
1	Benchmarking		✓		
2	CTQ analysis	✓	✓		
3	DOE		✓	✓	
4	FMEA	✓	✓	✓	✓
5	Focus group	✓			
6	Internet focus group	✓			
7	Interview	✓			
8	Kano analysis		✓		
9	KJ analysis	✓			
10	Monte Carlo simulation	✓	✓	✓	
11	MSA		✓	✓	✓
12	Pareto analysis		✓		
13	Process mapping		✓		
14	Project management tools	✓	✓	✓	✓
15	Pugh matrix	✓			
16	QFD	✓			
17	Regression analysis		✓	✓	
18	Survey	✓			✓

To summarize all these concepts, the main procedures and preliminary best practices for the implementation of DFSS to NSD emerged in the Motorola case study have been gathered and translated into statements. These statements, listed and grouped by strategic, organizational and operational aspect in table 9.3, has represented the basis for further in-depth studies on this topic.

Table 9.3: Statements for the implementation of DFSS to NSD.

ASPECTS	STATEMENTS	
STRATEGIC	1	Use of formal procedures for NSD projects selection
	2	NSD projects prioritization based on objective factors
	3	Exhaustive risk analysis for the NSD projects
	4	The firm conducts periodical and detailed formal study of the market
	5	The firm clearly draws a set of customer needs and requirements before service design
	6	NSD projects selection is clearly linked to the corporate strategy
	7	Detailed financial analysis for the NSD projects
ORGANIZATIONAL	1	Top managers have long term commitment to NSD
	2	Strong support for NSD given by senior managements
	3	Structured training approach for employees involved in NSD
	4	Use of experts from different functional areas in NSD teams
	5	NSD teams skilled in using six sigma tools for quality improvement and process design
	6	Good communication and coordination among functional areas in NSD
	7	The firm trains some of the customer contact personnel on the service delivery procedures before the service launch
	8	The firm spends a conspicuous amount of money on training
	9	The firm extends its training to suppliers and customers
OPERATIONAL	1	Use of formal procedures in NSD
	2	Use of periodical reports during NSD
	3	The firm conducts a long post launch review and documentation after the new service launch
	4	Use of project management tools and skills
	5	The firm carefully collects customer needs and inputs during NSD
	6	Pre-launch tests for NSD before actual launch are performed
	7	Use of tools for the Voice of the Customer analysis
	8	The firm evaluates the effectiveness of NSD using reliable performance measures
	9	The firm monitors service performance using a clear set of Key Performance Indicators
	10	Use of balance scorecard and other management tools
	11	Greater use of qualitative tools rather than statistical and quantitative tools

9.5 Discussion of the pilot

In summary, this pilot led to gather the data and translate it into statements belonging to the three macro-fields identified in literature (Campanerut and De Toni, 2010):

A. The *strategic aspect*, dealing with the ability of the company to translate the best opportunity of improvement in a Six Sigma project whose purpose is connected both with customer needs and corporate strategy;

B. The *organizational aspect*, mainly dealing with the Six Sigma human resources employed in the company and with the training system adopted in the organization;

C. The *operational aspect*, dealing with the model that the company has implemented to apply DFSS to NSD (i.e. the CDOV model) and with the several tools used in this model (e.g. benchmarking and project management tools).

Afterwards, joining that with the study of the literature allowed considering such procedures not only belonging to such macro-fields, but even to five specific aspects of the methodology associated to research fields, mentioned in the previous chapters:

1. *Strategic project selection*, dealing with the ability of the company to connect corporate strategy to Six Sigma project selection (Strategic macro-field);

2. *Culture and intangible assets*, dealing with values, knowledge and Six Sigma training throughout the company (Organizational macro-field);

3. *Actors and organizational structure*, dealing with the meso-structure of Six Sigma organization and the people involved in the project teams (Organizational macro-field);

4. *Methodology implementation*, dealing with the models that organizations can use to apply the methodology and the procedures for its application (Operational macro-field);

5. *Methodology tools*, dealing with the best tools that organizations can use in the model to improve its implementation (Operational macro-field).

The remaining three research fields, i.e. *Theoretical foundations*, *Comparative evaluations* and *Strategic choices*, previously emerged in the literature review, have not gathered enough empirical evidence to be considered highly important for our purposes.
Empirical results have showed that the implementation of DFSS to services has led to various performances improvement in Motorola, e.g. reduction of service operational costs and customer satisfaction enhancement. Furthermore, beyond the previous results, comparing the strategic, operational and organizational aspects with the literature, has given the possibility to consider them not only as aspects, but even as *decision levels*, where the different managerial practices identified can be placed in perspective. Actually, to conclude the “big picture”, a fourth decision level should be considered: the *inter-organizational* decision level.
In the table here below we summarize the four decision levels above mentioned:

Table 9.4: Decision levels.

		DECISION IMMEDIACY	
		LOW	HIGH
DECISION EFFECT	INTERNAL AND EXTERNAL	Inter-Organizational	**Strategic**
	INTERNAL	**Organizational**	**Operational**

- - - -➤ Increment of complexity

The validation of this model is designed to explain the categorization of the procedures in the different five aspects or decision levels.
Bañuelas and Antony highlight the impact of methodology on corporate culture and organization (organizational decision level), and stress the importance of aligning the objectives of LSS projects to corporate strategy (strategic decision level).
In order to effectively introduce the LSS methodology within the organization need to change values and culture: Six Sigma was developed in an open and secure environment, where the defects are seen as an opportunity for improvement; this is in contrast with the classical culture of companies, based on non-acceptance of the error and that make employees to hide the flaws in the system. Hence the need to change the corporate culture and the importance of identifying best practices to serve as a guide.
In addition to cultural aspects, the adoption of the LSS methodology requires substantial changes in the organizational structure and infrastructure as they are essential to the communication within the company (e.g. personal involvement in order to overcome the internal resistance), the focus on long-term strategy, teamwork and the availability of resources dedicated to the implementation of the methodology.
Using the LSS methodology must ultimately be aligned with corporate strategy through a clear link of the projects and other activities with the business: customers, core processes and competitiveness (Pande *et al.*, 2000).
The macro-areas described above are essential in order to introduce and implement the methodology effectively, but not enough to describe it thoroughly.
Schroeder *et al.* (2008) define Six Sigma as:

> *"An organized structure to reduce variation in processes of the organization through the use of specialists for improvement, a structured approach and metrics for performance evaluation, in order to achieve strategic objectives."*
>
> (Schroeder *et al.*, 2008)

This definition highlights the third area considered in this analysis: the operational decision level; it contains a description of practices and tools to improve existing processes and to create new services in DFSS.
The Inter-Organizational decision level has not been used for the classification of the best practices in our analysis, because was not possible to identify specific and detailed procedures

in that level. However, regarding the culture and intangible assets aspect, Motorola has expressed the purpose of extending the culture for the LSS methodology along the supply chain, providing a starting point for future analysis of this level.

The absence of this field among the case studies can be easily justified because it is more difficult for the organization to control the external environment rather than the internal one: the organization tends to concentrate its efforts for the application of Six Sigma inside.

Analyzing in greater detail the organizational level, its importance lies in the function of promoting the cultural change of people and the creation of those conditions required the effective use of the methodology.

Hannah and Freeman (1984) argue that the inertial factors of the organization cause the slowdown not only against external threats but also opportunities. The authors classify the inertial factors differentiating between internal and external to the organization. As regards the implementation of the Six Sigma methodology it makes sense to highlight only the internal factors such as the difficulty in finding the resources, to change the skills of employees, the investments made in existing structures, the presence of myths, cultures and beliefs hinder the creation of the new organizational structure.

Inertial factors cause delays in adopting the new methodology and therefore the effects of decisions at the organizational level are far from immediate; Bañuelas and Antony affirm the importance of communication to engage employees and overcome internal resistance. They also claim that to keep people interested in Six Sigma can be used quick wins early in the introduction of the methodology, although the benefits of Six Sigma are oriented to the long term.

Using the Six Sigma methodology at strategic level passes through the selection and alignment of projects with the corporate strategy: even if the improvement efforts are focused on problems of operating environment, it must be clear impact on the entire business. It 'must be clear how projects and other activities are connected to the client, core processes and competitiveness (Pande *et al.*, 2000).

For these reasons, the selection of Six Sigma projects has an impact on both internal (core processes, internal customers) and external (external customer, competitiveness).

Hannah and Freeman (1984) classify the strategic and structural organization whose relevance to affect the use of resources. This perspective allows us to identify hierarchical core issues in a organization, which are:

1. *Objectives*: the foundations on which legitimacy is based on the distribution of resources;

2. *Forms of authority and communication* within the organization (e.g. organizational structure and infrastructure);

3. *Core Technology*: that includes capital investment, infrastructure and skills of employees;

4. *Strategy*: generally defined as the choice of target customers and the way atrarre resources from the environment.

Hanna and Freeman (1984) assert in their analysis that these four elements are arranged in a hierarchical manner, where the targets are subject to stronger constraints and strategy to weaker ones.

Consequently, the easiness of change declines moving up the hierarchy. Six Sigma also follows a top-down approach in which the support and direction provided by top management are key components for the application of this methodology; the change of organizational culture is subordinated to the will of change of top management.
For these reasons, it is reasonable to consider that the immediacy of change at strategic level is much faster than the organizational level.
The operational level contains useful tools and practices to implement correctly and efficiently improvement processes and creating new services. Through a structured training and the involvement of staff is possible to distribute a basic knowledge of statistical tools and lean across the company relatively quickly.
Derived from the extension of the methodology also the operational impact will be rapid:

> *"In some cases you can get recommendations from the team immediate and rapid improvement, such as the elimination of non value added steps to clear or remove the causes of unwanted variability"*
>
> (Woodball and Montgomery, 2008)

In summary, these four decision levels are based on the decision effect, i.e. the context that the procedures can affect; and the decision immediacy, i.e. how fast managerial choices can affect the context.
At organizational level, for example, changing the values or the organizational structure of a firm will require time and big efforts, while modifying the corporate strategy could be simply a change of direction in the high-level choices.
Normally, broadening the decision effect and lowering the decision immediacy, increase the managerial complexity of the environment. Consequently in our study, operational procedures represent a minimum level of complexity and strategic ones the highest. Organizational procedures, instead, represent a middle level of complexity. From the pilot and the following multiple case study, we could not find any inter-organizational procedure, so the paper was focused only on strategic, organizational and operational ones. This absence can easily be explained with the fact that external context is much more difficult to control and firms tend to concentrate the efforts to apply Six Sigma overall on their own organization.

9.6 Conclusion of the pilot case study

In the previous paragraphs, it has been showed that the implementation of DFSS methodologies to NSD has meant considerable improvements within the organization, both regarding the financial benefits (e.g. service operational costs) and the customer satisfaction in the services. In summary, Motorola has considered three main aspects in order to implement the methodology and obtain these results and we have asserted that such main aspects can be considered as decision levels.
The strategic decision level is the first considered, and it is represented by only one aspect: the Six Sigma project selection. In Motorola, the Six Sigma projects selection represents the connection between business strategy and the needs of those customers who might receive the service that the company design. The statement of this link both has managerial importance, since it suggests a strategic view for Six Sigma methodology, and fills a gap in service literature. Goldstein *et al.* (2002), indeed, assert that literature on NSD has not successfully brought strategic service issues into service design. Some scholars have proposed concepts such as strategic project selection (Schroeder *et al.*, 2008; Zhang *et al.*, 2008), claiming that is

a process affecting the whole organization. However, these studies were general and not specifically focused on service design process in a company using DFSS methodologies.

As regards the organizational decision level, it groups first the actors and organizational structure aspect and second the culture and intangible assets aspect. In such decision level, the remarkable importance of training has emerged in the organization. Bañuelas and Antony (2002) have formerly asserted that training is an important factor in the successful implementation of Six Sigma projects and the company spends a conspicuous amount of money on this activity. Part of this money could be used to train some of the customer contact personnel on the service delivery procedures before the service launch, in order to improve the effectiveness of the delivery process. Besides to training, the importance of top management commitment has been confirmed, like in other Six Sigma studies (Schroeder *et al.*, 2008; Antony *et al.*, 2007), as well as the primary role of communication (Bañuelas and Antony, 2002). Furthermore, the use of experts from different functional areas in NSD teams has been highlighted as best practice by the firm for the implementation of the methodology.

Finally, the operational decision level groups two different aspects: the methodology implementation and the methodology tools. About this decision level, it has been gathered that the post launch review and documentation (i.e. the Verify phase) tend to be longer in services rather than manufacturing. This issue could be explained quoting Antony *et al.* (2007), who assert that service processes in general are much more dependent on human and organizational change than manufacturing, hence, increasing the complexity of the whole project. Furthermore, during the application of the methodology, it has been highlighted the importance of the pre-launch test for NSD and the use of periodical reports as the project evolves. Lastly, Motorola employs several tools in the CDOV model, e.g. quality and project management tools. However, even if Bañuelas and Antony (2002) claim that DFSS methodologies have strong bases in the use of statistics, statistical techniques are not widely used in NSD Six Sigma projects and more qualitative tools are preferred by project teams in the field of services.

Chapter 10 -MULTIPLE CASE STUDY

In chapter 9 the exploratory case study we carried out has been expounded. As we said, this pilot outlined five specific aspects of the methodology to be managed in order to effectively implement DFSS to service processes:

6. *Methodology implementation*, dealing with the models that organizations can use to apply the methodology and the procedures for its application (Operational level);
7. *Methodology tools*, dealing with the best tools that organizations can use in the model to improve its implementation (Operational level);
8. *Culture and intangible assets*, dealing with values, knowledge and Six Sigma training throughout the company (Organizational level);
9. *Actors and organizational structure*, dealing with the meso-structure of Six Sigma organization and the people involved in the project teams (Organizational level);
10. *Strategic project selection*, dealing with the ability of the company to connect corporate strategy to Six Sigma project selection (Strategic level).

Even if from this pilot some preliminary managerial procedures have emerged, it was absolutely necessary to process more empirical research on this topic. Thus, to respond to the research questions and find the best practices among different kinds of services, a multiple case study has been launched, comparing the results in four different organizations that have applied the Six Sigma methodology in order to design or redesign their service processes.
We decided to analyze several case studies, given the limited external validity of a single case results (Yin, 1981; Yin, 2005). We selected organizations operating in different service contexts that are innovative in introducing new services and products (which in turn would require new services). We used the method of retrospective analysis. We selected examples of Best Practice in order to analyze the critical factors of success (Voss *et al.*, 2002).
As discussed previously the case, multiple projects have advantages and disadvantages when compared to projects of individual cases. Evidence from multiple cases is often considered more reliable and the whole study is, therefore, considered more rigorous. At the same time, the reasons for carrying out an individual case study usually do not fit with multiple case study projects. The rare or unusual case, as well as the critical or the revealing case, by definition need of individual cases. Furthermore, conducting a case study may require too much time and resources for a student or independent researcher (Yin, 2005). For the reasons mentioned above, the decision to undertake a study of multiple cases must be considered very seriously.
Before to proceed with the selection of the sample of cases, we have identified what the best population for our purposes was. For this aim, we performed an analysis of the past case studies in the service sector using the articles obtained from the literature review.

10.1 The choice of the case studies

10.1.1 Analysis of case study research in service sector in the literature of Six Sigma

In this review we have considered all the articles from international journals and conferences containing case studies whose context is the service sector and whose object of study is the development, design or redesign of new service processes. All the case studies in the manufacturing sector have been excluded, as well as those discussing an improvement of existing processes.
The number of case studies in the database satisfying these criteria is 36, approximately 30% of total case studies analyzed in this thesis. We have included also two action research, for some aspects a research method similar to those case studies using particular data gathering through participant observation (Yin, 2005).
The first classification of cases this proposal refers to Schmenner's Service Process Matrix (1986) described below, in which services categorization is based by the degree of intensity of work and the degree of interaction and customization. In brackets the number of cases in literature.

Table 10.1: Schmenner's Service Process matrix.

		DEGREE OF INTERACTION AND CUSTOMIZATION	
		LOW	**HIGH**
DEGREE OF LABOUR INTENSITY	**LOW**	**SERVICE FACTORY (14)** • Airlines • Trucking • Hotels	**SERVICE SHOP (8)** • Hospitals • Auto-repair • Other repair services
	HIGH	**MASS SERVICE (14)** • Retailing • Banking • Schools	**PROFESSIONAL SERVICE (0)** • Doctors • Lawyers • Architets

Source: Schmenner (1986).

Most of the cases lie in the category "*Service Factory*" and "*Mass Service*", which together represent about 80% of cases (28 out of 36). A smaller number of cases, however, significant, falls into the category "*Service Shop*", by their less suitable characteristics for the application of the methodology. It should be noted that the cases found in this latter typology are specifically more recent than those belonging to other types and are by far concentrated in the

health sector and hospital, which seems to be one great recent trend in the use of the methodology. There are no cases of *Professional Service*. In the following pages some reports with the classification of cases according to the type of service.
From the last table, the chart here below, and considering the characteristics of such services, we can make the hypothesis that the number of case studies found in literature could even represent the applicability of the methodology to such kind of services. In this way, the Service Factory and Mass Service typologies would represent a high applicability context for the methodology, while the Service Shop context a lower one. It seems extremely difficult implement the methodology to professional services, obviously.

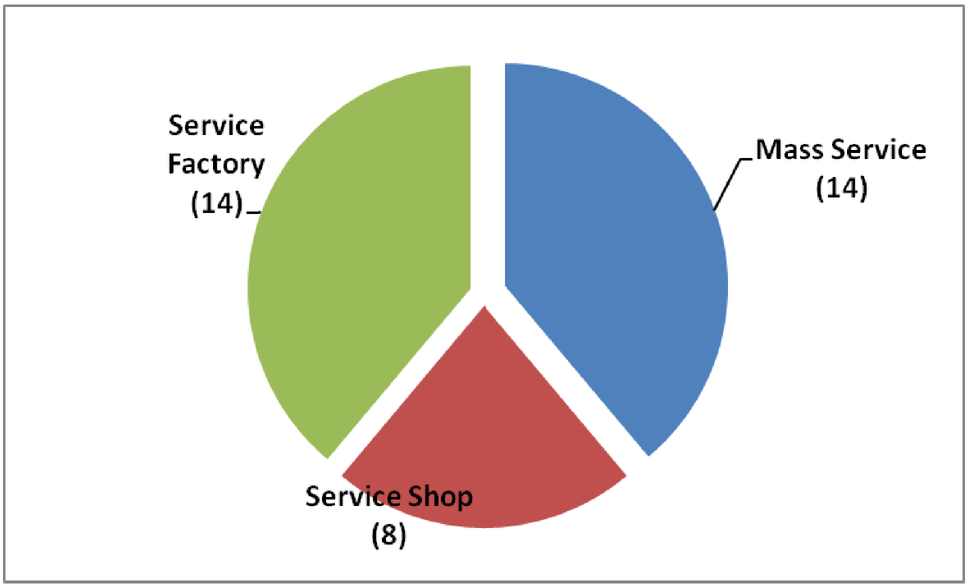

Figure 10.1: Distribution of case studies by typology of service.

Table 10.2: Summary of case studies of Mass Service typology.

	MASS SERVICE CASE STUDIES (14)				
	Title of paper	**Authors**	**Year**	**Kind of company**	**Country**
1	Customer-orientated Six Sigma in call centre performance	Mc Adam *et al.*	2009	Call Center	United Kingdom
2	Eliciting success factors of applying Six Sigma in an academic library. A case study	Dong-Suk	2010	Education	South Korea
3	The implementation of Lean Six Sigma in financial services organizations	Delgado *et al.*	2010	Financial	Portugal
4	Measuring performance in multi-stage service operations: An application of cause selecting control charts	Sulek *et al.*	2005	Commercial	USA
5	Reducing the delivery lead time in a food distribution SME through the implementation of six sigma methodology	Nabhani and Shokri	2009	Food industry	United Kingdom
6	Strategically focused training in Six Sigma way: a case study	Pandey	2007	Financial	India
7	Improving self service the Six Sigma way at Newcastle University Library	Kumi and Morrow	2006	Education	United Kingdom
8	Lean Six Sigma in financial service	De Koning *et al.*	2008	Financial	Netherlands
9	Using Six Sigma DMAIC to improve credit initiation process in a financial services operation	Kumar *et al.*	2008	Financial	USA
10	Information Technology Strategy for Six Sigma Projects in a Thai University	Chookittikul and Chookittikul	2008	Education	Thailand
11	Improving retention of minority freshmen in engineering by applying the Six Sigma methodology	Burge *et al.*	2004	Education	USA
12	Implementing lean six sigma in a front office customer service centre identification of managerial challenges	Smith *et al.*	2010	Financial	United Kingdom
13	Lean Six Sigma applied to a Customer Services Process within a Commercial Finance Organization	Fraser and Fraser	2009	Financial	United Kingdom
14	Reducing employees' turnover in transactional services: a Lean Six Sigma case study	Laureani and Antony,	2010	Auto rental	Ireland

Table 10.3: Summary of case studies of Service Shop typology.

	SERVICE SHOP CASE STUDIES (8)				
	Title of paper	**Authors**	**Year**	**Kind of company**	**Country**
1	Managing outsourcing process: applying six sigma	Agarwal and Bajaj	2008	Software	India
2	Lessons for Lean in Healthcare from Using Six Sigma in the NHS	Proudlove, Moxham and Boaden	2008	Hospital	United Kingdom
3	An application of Six Sigma methodology to turnover intentions in health care	Taner and Sezen	2009	Healthcare	Turkey
4	Time-based analysis of total cost of patient episodes. A case study of hip replacement	Peltokorpi and Kujala	2006	Hospital	Finland
5	Using Six Sigma and Lean Methodologies to Improve OR Throughput	Fairbanks	2007	Hospital	USA
6	An overview of six sigma applications in healthcare industry	Taner *et al.*	2007	Healthcare	Turkey
7	Using the Six Sigma Process to Implement the Centers for Disease Control and Prevention Guideline for Hand Hygiene in 4 Intensive Care Units	Eldrige *et al.*	2006	Healthcare	USA
8	DFSS in Healthcare; the medication process *	Gremyr *et al.*	2010	Healthcare	Sweden

* Action research

Table 10.4: Summary of case studies of Service Factory typology.

	SERVICE FACTORY CASE STUDIES (14)				
	Title of paper	**Authors**	**Year**	**Kind of company**	**Country**
1	Using a Lean Six Sigma approach to drive innovation	Byrne, Lubowe and Blitz	2007	Construction	USA
2	Integrating the global enterprise using Six Sigma: Business process reengineering at General Electric Wind Energy	Goel and Chen	2008	Energy	USA
3	Six Sigma programs : an implementation model	Chakravorty	2009	Information Communication Technology	USA
4	Can business process reengineering lead to security vulnerabilities: analyzing the reengineered process	Goel and Chen	2008	Energy	USA
5	Remember, the (Internet) applet doesn't fall far from the tree	Nellis and Harrington	2003	Information Communication Technology	USA
6	Assessing readiness for Six Sigma in a service setting	Hensley and Dobie	2005	Public transportation	USA
7	Clinical research the six sigma way	Liu	2006	Pharmaceutical	USA
8	Case Study Analysis of Six Sigma in Singapore Service Organizations	Chakrabarty and Tan	2008	Construction	Singapore
9	An Application of Six Sigma with Lean Production Practices for Identifying Common Causes of Software Process Variability	Tonini *et al.*	2007	Software	Brasile
10	Six Sigma Approach in Software Quality Improvement	Redzic and Baik	2006	Information Comunication Technology	USA
11	Research on the Application of Six Sigma Method in Logistic Corporation	Zang *et al.*	2007	Logistics	Cina
12	Implementing Lean Sigma in pharmaceutical research and development: a review by practitioners *	Carleysmith *et al* .	2009	Pharmaceutical	United Kingdom
13	Examining the application of six sigma in the service exchange	Noone, Namasivayam and Tomlinson	2010	Hotel	USA
14	Six Sigma Roles in Innovation	Kai X.	2006	Commercial	USA

* Action research

The trend of the publications regarding these case studies is growing, with a slope in the 2008. This is coherent with the results obtained by the general literature review expounded in the previous chapters.

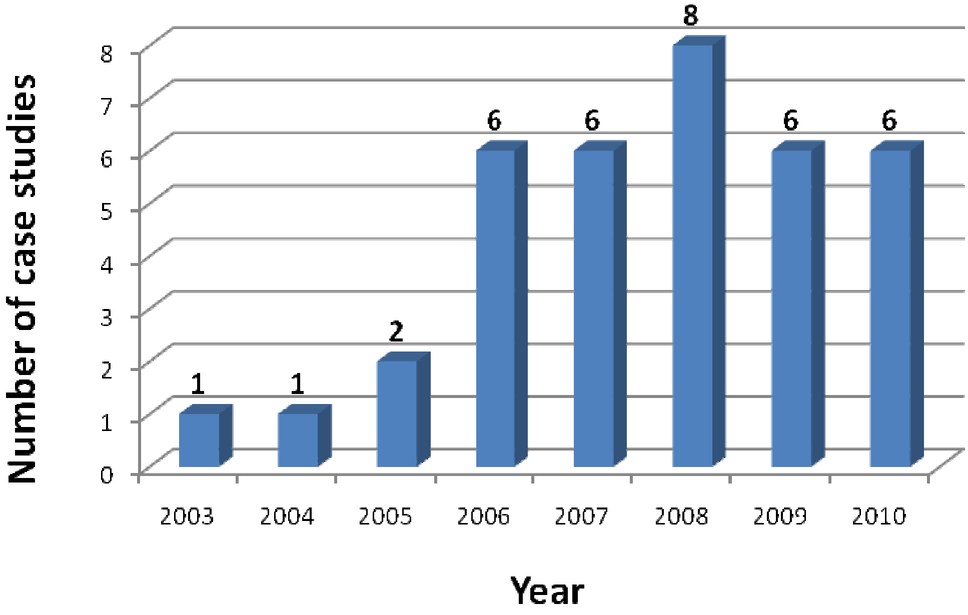

Figure 10.2: Distribution of case studies by year.

Analyzing the kind of company involved in the case studies, we notice as most of them are hospitals of just in the financial area. Data show overall that most of the cases from this kind of companies are published from 2007 to 2010, meaning that the academic interest for this topic is definitely current.

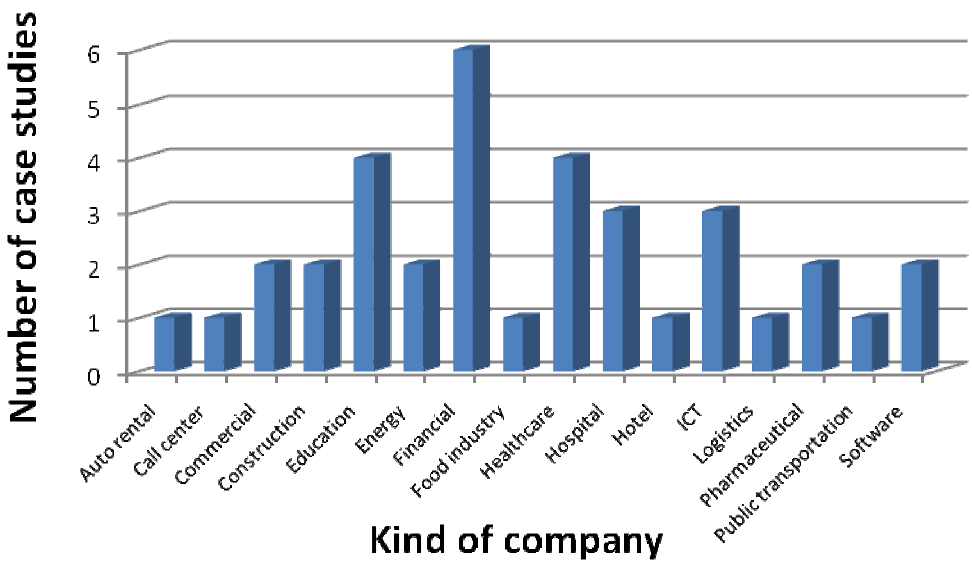

Figure 10.3: Distribution of case studies by kind of company.

The geographical area of the case studies shows that most of them are from Europe and America, in particular from USA and United Kingdom.

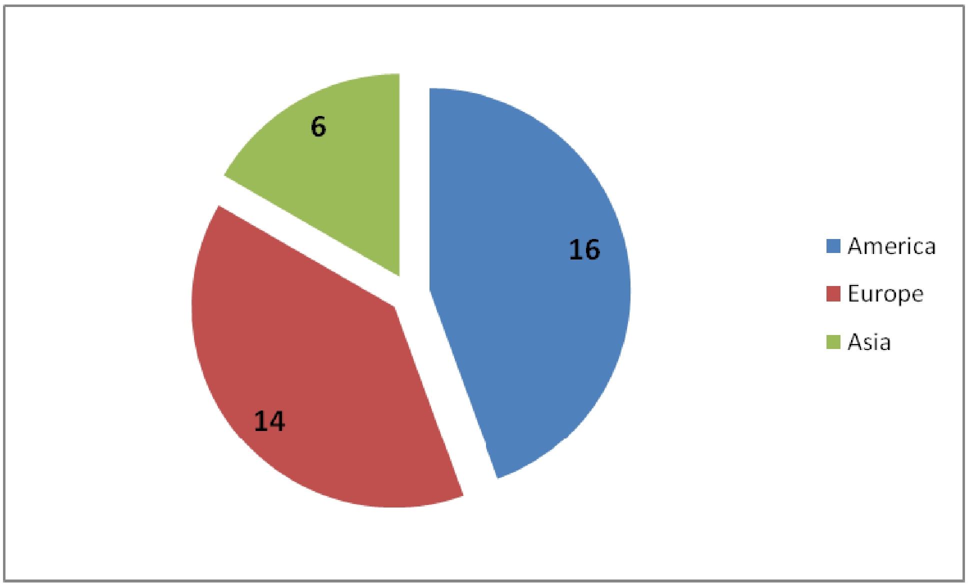

Figure 10.4: Distribution of case studies by geographical area of the company.

10.1.2 Case selection

In pursuing a strategy of multiple case study for research, one of the most important step is the selection of case studies or sampling. Miles and Huberman (1994), argue that the selection process involves two stages. The first concerns the determination of the boundaries of the object of study and the connecting it to the research questions. The second involves the creation of a sample frame to help uncover, confirm or qualify the basic processes or constructs that are the basis of the study.
The traditional way of selecting the cases is to identify a population and then select a random or stratified from such population. According to Yin (2005), in building theories from case studies a logical replication rather than sampling logic should be used. From this point of view, each case should be selected for:

- Providing similar results;
- or providing contrasting results but for predictable reasons.

Huberman and Miles (1994), identifies three types of case selection in the case study research. The first type covers cases typical or representative of the phenomenon in question. The second category concerns cases negative or refuting the hypotheses that are confirmed. The third category concerns the discrepant or exceptional cases. These cases allow the researcher classifying their findings and to specify the differences in the relationship observed.
At this point, Eisenhardt (1989), suggests that cases can be chosen to replicate previous cases or extend emergent theory; furthermore they can be chosen to complete theoretical categories and provide examples of polar types. Cases could be chosen randomly, but this practice is not necessary, nor advisable.

As noted earlier, Pettigrew (1988), suggests that, given the limited number of cases which can usually be studied, it makes sense to choose cases belonging to extreme situations and polar types in which the process of interest is transparently observable.
The object of study of this thesis concerns the identification of common practices for the successful implementation of DFSS for different types of services. Thus, to increase the external validity of the results, we followed the indications of Miles and Huberman (1994) and Voss *et al.* (2002); we designed four polar case studies outlining common and contrasting characteristics. There are some common characteristics: all the four case studies are designed in big multinational private organizations that use Six Sigma for the development of new services. Furthermore, it seemed appropriate to identify companies with high experience in the use of Six Sigma methodology; all the case studies are represented by companies which used Six Sigma methodology since the early ‘90s.
In order to comply with conditions of general applicability, about the contrasting characteristics we chose:

- The application of the methodology to Business to Customer services;

- The nature of service processes, i.e. what kind of customers new service processes are normally directed to.

Organizations of Case 1 and Case 2 are respectively a telecommunications company, Motorola, and a technology equipment company, General Electric Oil & Gas. Such companies apply the methodology mainly to complementary service processes, i.e. to those associated to products or other processes related to the company core business; moreover such service processes are addressed to internal customers and they are not B2C.
Contrarily, organizations in Case 3 and Case 4, respectively General Electric Capital and UniCredit Group, deliver pure financial services and apply Six Sigma to service processes addressed both to B2B and B2C customers. Beyond to this, referring to the previous paragraphs, we can consider Motorola and GE Oil & Gas as Service Factory companies, GE Capital and UniCredit Group as Mass Service companies.
For the purposes of this study, we outline that although GE Oil & Gas and GE Capital represent two organization in the same huge group, they can be analyzed separately and considered two different elements of the sample (Yin, 2005).
In summary, our choice is summarized in the following matrix, where the cases are classified with reference to the two dimensions described above. In the last matrix we have also classified the four case studies on the basis of the Service Process Matrix of Schmenner (1969); for the theory expounded before, we outline as all the four organizations represent a context of high applicability for the Six Sigma methodology.

Table 10.5: Classification of selected case studies by nature of service and application to B2C.

		NATURE OF SERVICE	
		Complementary service	Pure service
APPLICATION TO B2C	No	MOTOROLA intelligence everywhere; GE OIL & GAS	
	Yes		GE CAPITAL; UniCredit

Table 10.6: Classification of selected case studies by the Service Process Matrix dimensions.

		Degree of interaction and customization	
		LOW	HIGH
Degree of labour intensity	LOW	SERVICE FACTORY MOTOROLA intelligence everywhere GE OIL & GAS	SERVICE SHOP • Hospitals • Auto-repair • Other repair services
	HIGH	MASS SERVICE GE CAPITAL UniCredit	PROFESSIONAL SERVICE • Doctors • Lawyers • Architets

10.2 Methodological notes on the case studies

On the basis of the conceptual frame work obtained from the pilot case study, i.e. the five different aspects outlined for managing the DFSS for the service processes, we carried out four relevant case studies. We analyzed and discussed the data from each of the four organizations separately, in order to perform a detailed in-depth analysis of the company, and provide as more data as possible for the following cross-case analysis.

In order to perform a high quality in-case analysis, in every case study the data relating the same phenomenon was collected through different methods and tools, e.g. archival data, documents and interviews. This allowed us performing data triangulation (Voss *et al.*, 2002) and increase the internal and external validity (Yin, 2005). The main source of information was the same in every case, however, there was some difference due to some constraints.

The Motorola case study was even the pilot case study launched for this research. During this in-depth analysis following the exploratory case study, a new semi-structured interview was performed and some questionnaires were sent to the company. The data obtained, joined to the bunch of information already gathered and analyzed previously in the pilot, allowed carrying out a high quality case study (Yin, 2005). Since the preliminary information about the Motorola company have already been expounded in the previous chapter, the next section will be limited to outline and summarize the new concepts of the topic object of the study. Such concepts will be used in the following cross-case analysis.

In both the GE Oil & Gas case study and the GE Capital case study we have collected evidence through interviews, documents, archival data as well as in Motorola. However, in these two organizations was even possible to gather more information through direct observations, since the interviews were carried out in the plant of Florence for the former and in the main office of Rome for the latter.

Finally, the UniCredit Group case was the most complete in terms of sources of data, because beyond to interviews, documentation, archival data and direct observation, it was even possible to perform participant observation; a project, indeed, with object the application of DFSS methodologies to the redesign of a service process was launched and successfully completed at the Quality Department of the main office of Milan. Such project allowed participating first as auditor and then as analyst, gathering a huge amount of new data on the topic.

In tables 10.7 and 10.8 we summarize the different sources of evidence used in the case studies and a focus on the interviews and questionnaires used.

Table 10.7: Summary of sources of evidence.

SOURCE OF EVIDENCE		CASE STUDY			
		Motorola	GE Capital	GE Oil&Gas	UniCredit
1	*DOCUMENTATION*	✓	✓	✓	✓
2	*ARCHIVAL RECORDS*	✓	✓	✓	✓
3	*INTERVIEWS*	✓	✓	✓	✓
4	*DIRECT OBSERVATION*	-	✓	✓	✓
5	*PARTICIPANT OBSERVATION*	-	-	-	✓
6	*PHYSICAL ARTIFACTS*	-	-	-	-

✓Available and gathered
- Not available

Table 10.8: Summary of interviews and questionnaires.

	CASE STUDY			
	Motorola	**GE Capital**	**GE Oil&Gas**	**UniCredit**
Number of interviews	**3 (Conference call)**	**2**	**4**	**4**
Tipologia interviste	**Open and semi-structured**	**Open and semi-structured**	**Open and semi-structured**	**Open and semi-structured**
Role of interwees	**❑ Master Black Belt (3).**	**❑ Leasing & Lending Leader (1); ❑ Black Belt (1).**	**❑ Master Black Belt area IT (1); ❑ Black Belt area NP&SD (2); ❑ Black Belt area Global Services (1).**	**❑ Chief Quality Officer (2); ❑ Black Belt (1); ❑ Green Belt (1).**
Ex-post questionnaires	**Yes**	**Yes**	**Yes**	**Yes**

10.3 Motorola Inc.

The first organization in our in-case analysis is even the same of the pilot case study: Motorola Inc. However, questionnaires and new sources of data have been added to the bunch of information, allowing new considerations.
For this reason, we will only outline a brief description of the company, once again, and a commentary of the aspects of the methodology in the Motorola context.

10.3.1 General description

Motorola Inc. provides integrated communications and embedded electronic solutions worldwide. Solution areas include: software-enhanced wireless telephone and messaging; two-way radio products; systems, networking, and Internet-access products; end-to-end systems for the delivery of interactive digital video, voice, and high-speed data solutions; embedded semiconductors solutions for wireless communications, networking, and transportation markets; and integrated electronic systems for automotive, telematics, industrial, telecommunications, computing, and portable energy systems markets.
The headquarters of Motorola are in Schaumburg, Illinois (USA), with its global WAN maintained in Phoenix, Arizona.
Here below we have a few numbers about Motorola in 2010:

- Market cap: $ 12.93 billion;
- Revenues: $ 21.07 billion;
- Number of employees: 53000;
- Revenue/employee: $ 397600;
- Net income: $ 482 million;
- R&D expenditures: CA 3.2 billion.

(Source: Wolfram-Alpha.com, 2011)

Motorola appears in the 2010 Fortune 500 company listing. Every year Fortune the American business magazine compiles, ranks and publishes a list of the top 500 U.S. public corporations based on their gross revenue. The Top Fortune 500 Company list provides Fortune magazine readers with facts and information about the top companies and their contributions to the American economy. Companies eligible for inclusion in the Top Fortune 500 Company list are those incorporated in the United States and whose revenues are publicly available.
The main source of information for this caser study was interviews by conference call and the main interviewee was Dr. Lara Martin.

<u>General information about Dr. Lara Martin</u>

Dr. Lara Martin got her Bachelor of Science at the Georgia Institute of Technology, attending from 1990 to 1995.
Later, after some work experience, she starts to work for Motorola Inc. and in 2001 she received her Black Belt. In 2003 she received her Master Black Belt.
The next year she starts a Ph.D. at the Georgia Institute of Technology; her topic included (but was not limited to) the Six Sigma approach taken to develop a new material. She got her Ph.D. in 2008.

At Motorola, during her Six Sigma work in business improvement methodologies and statistics, she has worked with DMAIC methods, Lean methods, Design for Six Sigma (DFSS), Six Sigma for Product Development (SSPD), and PMFSS (Product Marketing for Six Sigma). Dr. Martin worked directly in an engineering development organization for 3 years for application of DFSS. Dr. Martin, during the last year, has been working with Product Management from several different businesses for application of PMFSS to new products and new services development.

Six Sigma in Motorola

Since the Six Sigma methodology has been created in Motorola in the Eighties, the company has changed a lot its structure and it has introduced several innovations.
Most of the people think that quality can exist only through the incremental improvement of the processes, however Motorola immediately understood that quality comes through changes and changes come through resources. In this sense it is necessary find new ideas and new opportunities to be introduced, i.e. even new processes.
Crisis like the one we have been living recently, can push for new business opportunities, but there must be enough and the right resources, to develop the company's priorities. Motorola has made several efforts to identify the right priorities for the organization.
Over the years such priorities have changed and at the same time the methodology was changing. Once Motorola verified the applicability of Six Sigma outside manufacturing context, the organization extended all its initiatives to different functional areas of the company and for different purposes, cause the aim was to consider even the strategic implications of such choices in the long term.
Motorola, with the Six Sigma methodology, showed in fact that was possible to improve quality and financial results at the same time and for this even at the theoretical level the methodology kept on evolving.
In 2000 the company began to implement Design For Six Sigma (DFSS), a methodology for driving breakthrough performance in new product development. The same innovations were made applying the continuous improvements to the service processes. The last step was to merge DFSS and the service field, in order to design or redesign defective service processes.
In summary, at the beginning of Six Sigma implementation, Motorola applied the DMAIC model only to manufacturing processes, representing its core-business. Gradually, the company started to broaden the methodology's application area to internal services, since they can be definitely considered processes. Afterwards, given the excellent results obtained, Motorola began to implement the methodology's principles to design robust products and processes, opening the way for the DFSS to develop new services, eventually.

The evolution of the methodology

The evolution of Six Sigma in Motorola passed through manufacturing towards service processes. Moreover, the DFSS came later the classic DMAIC cycle. Recently they invented the term "Digital Six Sigma", to define the new methodology used in the company environment.
Digital Six Sigma (DSS) is a management system with a business improvement methodology that focuses on customer requirements, process alignment, timely execution, etc. using applied statistical tools derived from Six Sigma. The current DSS program in Motorola integrates principles of traditional "Six Sigma" with "Lean Tools."

There are two main branches of DSS at Motorola today, namely, Six Sigma Process Improvement (SSPI) and Six Sigma Product Development (SSPD). SSPI's focus is on eliminating waste and variation in business processes that already exist, using the DMAIC model.
SSPD's focus, instead, is about designing new concepts utilizing the Voice of the Customer. These concepts will be mainly used for robust new product development.
The application of DFSS to service processes does not have still any different name in Motorola, so we called it SSSD, i.e. Six Sigma for Service Development.
In summary, in Motorola the need for a brand new process comes when occurs at least one of these conditions:

- None of the ways to produce an output is completely accurate;
- No process exists to produce a product or service to satisfy a new customer need;
- The process is considered completely optimized but customer's needs are still not satisfied.

<u>The influence of Lean in Motorola</u>

In Motorola there is a clear connection between lean management and Six Sigma methodology. The joint between these two philosophies allow reaching better results in general.
Basically, Six Sigma has the purpose to eliminate errors and defects in a step of a process, Lean to eliminate the wrong step itself. A step of the process is considered wrong if it does not add value to the customer. Then in a process that goes from supplier to customer, Six Sigma action to remove errors in the step, the Lean works to remove the steps themselves or to reduce the time from one step to another.
In Motorola, Lean tends to reduce the cycle time of the process, and sometimes between one step and another may be necessary approvals and inspections, procedures that sometimes require days, even weeks, and Lean seeks to intervene even to reduce these losses in terms of time. Contrarily, Six Sigma, acts to reduce the variance within a certain step of the process.
Consequently, from the analysis between Six Sigma and Lean, particularly in the transactional aspects, its boundaries are not well defined and there are overlaps.
In the vision of Motorola, many could be the methods that have influenced the Six Sigma application in the company, i.e. Triz, Total Quality Management, the Theory Of Constraints, however the most important results the Lean Management, without doubt.

10.3.2 Operational aspect

<u>Methodology implementation</u>

The application of Six Sigma for quality improvement of already existing processes refers to the DMAIC cycle, normally. Contrarily, DFSS does not have only one cycle available, and the literature on the topic offers several ones, depending also on the characteristics of the process. Among the most famous cycles we can quote the DMADV cycle, i.e. Define, Measure, Analyze, Design, Verify; the IDOV cycle, i.e. Identify, Design, Optimize, Validate; and the DMEDI cycle, i.e. Define, Measure, Explore, Develop, Implement.
The company considered the use of formal procedures the basis for effectiveness in the activity of New Service Development. The model that the firm has developed to implement DFSS to the process of NSD is the CDOV cycle, or model.

The CDOV model, i.e. Concept, Design, Optimize, Verify, was created in Motorola as a derivation from IDOV in 2005. Basically, the main difference consists in the major emphasis on the Concept phase, as the identification of a good service concept has a significant impact on the following service quality and customer satisfaction.
In the figure here below the scheme of this cycle:

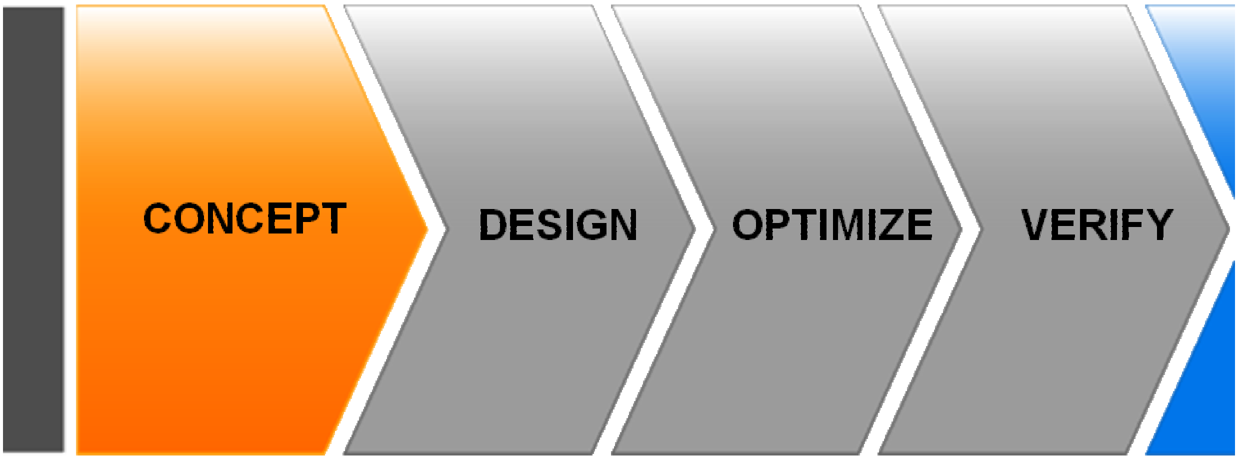

Figure 10.5: Scheme of the CDOV cycle.

The *Concept Phase* is probably the most important among the four phases. It mainly refers to capturing the Voice of the Customer (VOC) in order to develop services that fit with their needs. To perform this activity, the company makes extensive use both of survey researches and face to face interviews, using questionnaires.
In the *Design Phase* the organization's development team clearly defines a set of Critical to Quality factors (CTQ) for the service. Customer needs and inputs are carefully documented in order to successfully break down the service in sub-processes that can be provided without errors. This activity contributes to a high-quality design, improving service quality and customer satisfaction while the service is delivered.
In the *Optimize Phase* critical parameters are tracked and improved and the development team conducts a series of pre-launch tests to ensure success to the project before the actual launch. Both in the Design and in the Optimize phases, periodical reports are used in order to better monitor the situation.
Finally, in the *Verify Phase* the company conducts the post launch review and documentation after the new service launch. The post launch review could take a long time if the interface between service customer and service supplier is mainly human-based. In this case, indeed, although the process has been carefully designed, service providers could take additional time to learn the new procedures.

<u>Methodology tools</u>

Motorola utilizes in the Six Sigma projects a large number of different tools, coming from various areas of the organizations.
One important tool is the set of key performance indicators (KPI). KPI allow monitoring the post launch performance of the service. More in general, another aim is seeking out appropriate performance measures to evaluate the effectiveness of NSD.

The firm, in order to hear the VOC and implement DFSS to its services, uses several tools and techniques even from the project management area. For example, they are widely used in the projects the Gantt charts. A Gantt chart is a type of bar chart that illustrates a project schedule. It illustrates the start and finish dates of the terminal elements and summary elements of a project.
Furthermore, management tools such as the balance scorecard (BSC) are used. The balanced scorecard is a strategic performance management tool, a semi-standard structured report supported by proven design methods and automation tools that normally can be used by managers to keep track of the execution of company's activities by staff within their control and monitor the consequences of these actions.
Beyond this, there have been used quality management and statistical tools like simple or multivariate regression and Pareto chart. A Pareto chart, named after Vilfredo Pareto (1848-1923), is a type of chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line.
Actually, statistical techniques are not widely used in NSD Six Sigma projects and Motorola prefers to use more qualitative tools like benchmarking, or even integrate tools from Lean Management.
Some of the tools used in Motorola during Six Sigma projects are (but not limited to) listed here below:

- Benchmarking;
- Crtitical To Quality analysis;
- Design Of Experiments;
- Failure Mode Effect Analysis;
- Focus group;
- Internet Focus Group;
- Interview;
- Kano analysis;
- KJ analysis;
- Monte Carlo simulation;
- Measurement System Assessment;
- Pareto analysis;
- Process mapping;
- Project management tools;
- Pugh matrix;
- Quality Function Deployment;
- Regression analysis;
- Survey.

10.3.3 Organizational aspect

<u>Culture and intangible assets</u>

Since the first years of its experience with Six Sigma methodology, Motorola has used a people-centered approach to drive fundamental changes. This approach required several elements to move towards a new corporate culture.

About this aspect, the most important evidence found in Motorola are represented by the great support given by the senior managers and the top managers. Besides, Motorola definitely cares about all its intangible assets like the brand, the strategy and the values. The slogan, the Vision statement and the Mission statement are the most important ones.
About the Motorola slogan, it is a short, memorable catch phrase, tagline or motto used to to identify a product or company in advertisements. The advertising slogan, or business slogan most associated with Motorola, is: "*Hello Moto*".
Mission Statements and Vision Statements, instead, are written for customers and employees of corporations. A Mission Statement can be defined as a sentence or short paragraph written by a company or business which reflects its core purpose, identity, values and principle business aims. The definition for a Vision Statement is a sentence or short paragraph providing a broad, inspirational image of the future.
Motorola **Mission Statement**:

> "*We are a global communications leader powered by a passion to invent and an unceasing commitment to advance the way the world connects. Our communication solutions allow people, businesses and governments to be more connected and more mobile.*"

Motorola **Vision Statement**:

> "*Our history is rich. Our future is dynamic. We are Motorola and the spirit of invention is what drives us.*"

Beyond the commitment of senior managers, Motorola has always considered as fundamental the communication of new quality rules to the organization, in particular all the principles that the Six Sigma philosophy can suggest.
Furthermore, the introduction of novel procedures made much easier the evolution of the company's culture towards this new approach.
Last but not least, Motorola has also developed leadership and change management classes. The final purpose is to extend its training to customers and suppliers so that the Six Sigma values might spread along the entire value chain.

Actors and organizational structure

In the organization, some elements have been considered very important also for the implementation of DFSS to services, e.g. the training of skilled and prepared people, nurturing supporting facilitators and the development of new reward and recognition systems based on return on net assets from each major sector (and some smaller groups) of the company. Others evolved in order to better fit the NSD processes.
Motorola still has a people-centered system in the firm, indeed, the purpose is that top managers have long term commitment to DFSS and senior management shows strong support for this methodology.
The company has dramatically increased the amount of financial resources spent on training, applying a structured training approach for the employees involved in Six Sigma and NSD. Basic training is available to all firm employees via short periodical classes, while Green Belt and Black Belt certification programs involve a strict nomination and severe review process. The training program is administered internally and includes companywide a Digital Six Sigma (see previous chapters) education for practitioners. Any employee of Motorola can

register for class and achieve basic Six Sigma certifications, named first White and then Yellow belt, i.e. a kind of basic awareness. Earned these certifications, employees have to be nominated and register for certification programs to continue learning. The following Six Sigma programs will take them through Green, Black and Master Black Belt rigorous certifications. These programs include intensive classroom education in Six Sigma tools and methodologies followed by projects participation. The Master Black Belt certification, instead, in on the basis on the results obtained in the various Six Sigma project the candidate has carried out so far.
For the future, the company is planning also to train part of the customer contact personnel on the service delivery procedures before the service launch, in order to improve the effectiveness of the delivery process.
Employees who are involved in NSD are qualified in process design and optimization. Whenever a Six Sigma project has been launched, a NSD team formed by Green and Black belts is formed. This NSD and Six Sigma team must have high skills in using Six Sigma tools and techniques for quality improvement and process design.
Furthermore, the company encourages the use of multifunctional teams i.e. teams which comprise experts from different functional areas. These areas should have good coordination and communication during the process of designing new services.
About learnign and training in Motorola, we can outline the creation of the Motorola University, globally recognized as a leader in corporate Six Sigma education. The university provides prospective clients with the assurance of consistent, high-quality services.
Motorola is the globally recognized creator of Six Sigma, and despite the abuse of the trademark in the marketplace, it actually holds the registered trademark. This provides prospective clients with the assurance that the services are based upon first-hand experience and have not been diluted as the methodology might be if presented by third parties.
Motorola University is one of the most professional organizations capable of providing recognized and respected Six Sigma certification of Green Belts and Black Belts.
In this environment, candidate practice the abilities requested for real Six Sigma projects in Motorola and the university continues to update materials with lessons learned and best practices.

10.3.4 Strategic aspect

Strategic project selection

In Motorola, the use of Six Sigma has the main purpose a better comprehension of customers' values and expectations. As a matter of fact, the final purpose of the methodology is a business delivering value for its customers (internal or external) and stakeholders in a perfect value stream. The only possibility to achieve this goal is seeking continuous improvement in every process of the company: from strategic planning to service delivery.
Unlike other quality methodologies, a distinctive characteristic of Six Sigma is the project-based implementation. Six Sigma projects are the vehicle that leads to improvement but among thousand good ideas representing potential improvement opportunities, the company has to select some to be implemented.
In Motorola, like in other Six Sigma organizations, the Six Sigma projects selection process is definitely important, as it represents the connection between business strategy and the needs of those customers who might receive the service that the company design.

Motorola, in order to generate service concepts that fit with this purpose, has considered Six Sigma project selection as a strategic process. The aim of this process is selecting only the projects for design or redesign new service processes which are aligned to the firm's business strategy and for this Motorola is creating formal procedures for the selection process of NSD projects.
Top management in Motorola is convinced that Six Sigma projects prioritization should have its basis overall on objective factors. These factors are mainly based on three analysis:

- A full risk analysis for the NSD projects;
- A detailed financial analysis and;
- A wide market analysis.

The market analysis comprehend a formal study of the market to monitor changes in customer demand, a clear segmentation and the identification of a complete set of customer requirements and actual needs.

10.4 The General Electric Company

The General Electric Company, also known as GE, is a huge American multinational company. Its headquarters are placed in Fairfield, Connecticut (USA). GE deals with four different macro-areas: Energy Infrastructure, Technology Infrastructure, NBC Universal (TV network) and Capital. In 2010, Forbes[9] ranked GE as the second largest company in the world, based on a formula that compares the total sales, profits, assets and market value of several multinationals.
The company has about 305,000 employees around the world and, as shown in the figure below, in 2009 reported sales for $157 billion and profits for $11.2 billion.

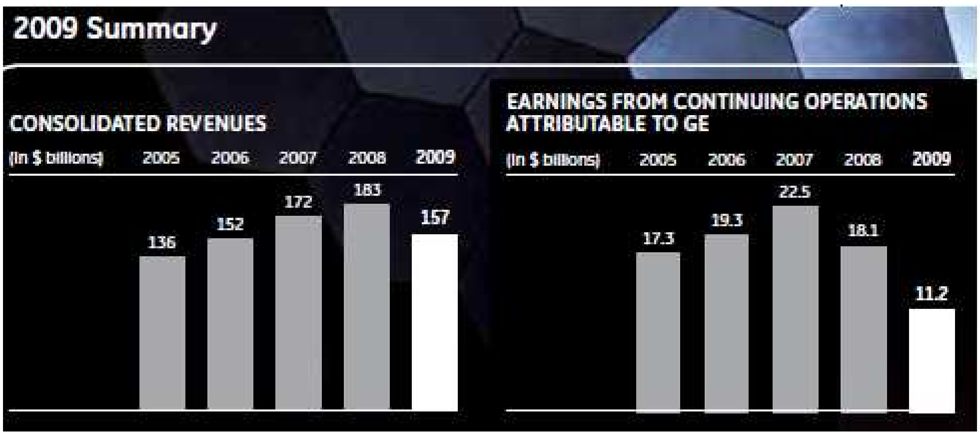

Figure 10.6: 2009 GE annual report (Ge.com).

In 1878 Thomas Edison founded the Edison Electric Light Company, and in 1889 merged all the companies he founded under the name of Edison General Electric Company. In 1892 the company merged with Thomson-Houston Electric Company and eventually changed the name to General Electric Company (GE). After few years, GE started being traded on the New York

[9] Source: http://www.forbes.com/lists/2010/18/global-2000-10_The-Global-2000_Rank.html

Stock Exchange and was one of the top 12 companies to be included in 1896 in the newborn Dow Jones, where it continues to appear after 114 years.
GE has an important role in the technological history of the United States, from simple home laboratory of Thomas Edison to one of the largest companies in the world. General Electric has evolved over the years into a conglomerate, which is characterized by an increasing shift of focus from technology to services, with 11 main business units:

- **GE Advanced Materials** specializes in the design of thermoplastic high-performance products based on silicon, quartz and ceramics used in a wide variety of industries;

- **GE Consumer & Industrial** is one of the world's leading manufacturers of lighting equipment for both B2C and industrial. It also provides equipment, services and integrated systems for industries;

- **GE Energy** is a leading provider of technology in the energy sector;

- **GE Equipment Services** offers leases, loans, and other services to medium-large business to help in the management of business equipment;

- **GE Healthcare** is a global leader in medical diagnostic technology and services related;

- **GE Infrastructure** is responsible for high-tech solutions in the areas of water purification, facility security, industrial automation;

- **GE Transportation** is the largest producer of large and small jet engines for commercial aircraft in the world and even the largest producer of diesel engines for ships in North America;

- **NBC Universal** is a famous TV network;

- **GE Commercial Finance** provides a range of financial services and products, including loans and forms of financing to business customers;

- **GE Consumer Finance** is a leading provider of financial services, dealing with B2C customers and retailers in about 30 countries;

- **GE Insurance** is involved in life insurance, asset management, insurance on loans.

GE is a huge group. This results evident, considering that each of the 11 business units, if listed separately, would qualify among the Fortune 500 list of largest companies in the world. GE operates in more than 100 countries worldwide and generates approximately 45% of its sales within the U.S. In this huge and complex context, this thesis focused specifically on GE Oil & Gas and GE Capital.
In the figure below, the organizational chart of GE is represented; the complexity and size of the organization are evident.

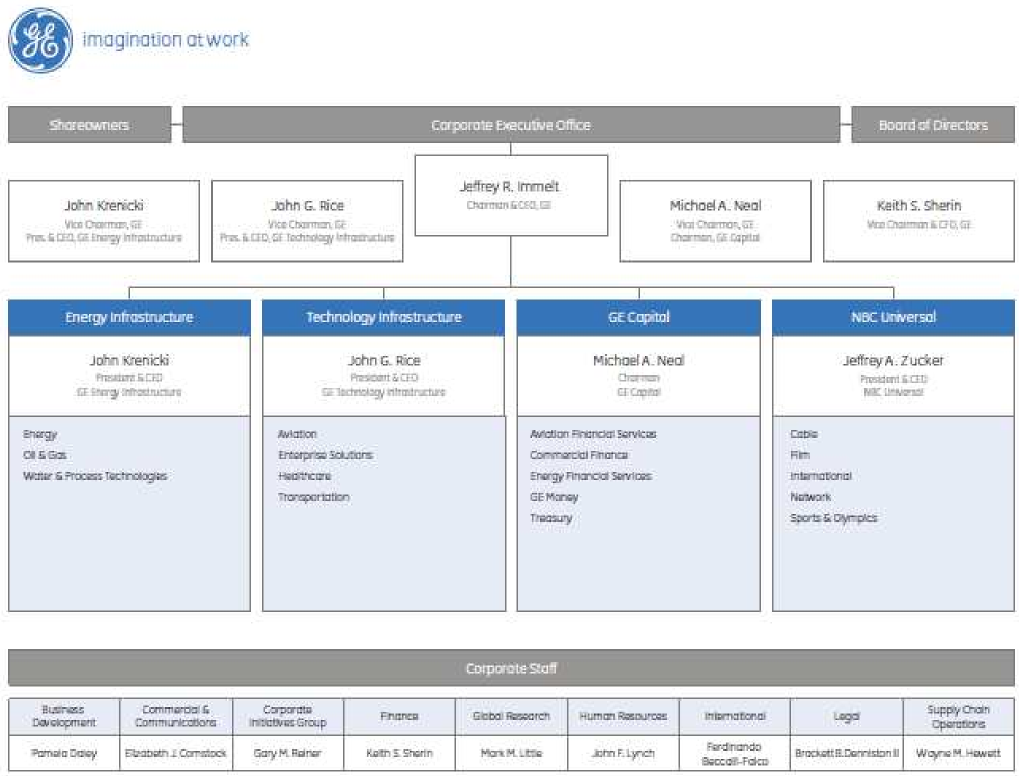

Figure 10.7: GE Organizational chart (Ge.com).

10.5 General Electric Oil & Gas

This section presents the case study of GE Oil & Gas, based on analysis of data collected during two field visits. Data comes from various sources such as direct observation, official documents of GE and in particular, are the result of four semi-structured interviews with Mr. Massimiliano Spadini (1), Mr. Cristiano Crinisio (1) and Dr. Pazzi (2). Information about Dr. Pazzi are limited due to the need of performing the interviews by telephone and consequent time constraints in the preliminary questions.

10.5.1 General description

GE Oil & Gas is the world leader in advanced technology equipment and services for all segments in the field of oil and gas. The company deals with equipment for drilling and production, pipelines and storage, energy production industry, and refining and petrochemical equipment. GE Oil & Gas also provides solutions for the integrity and maintenance of pipelines.

Details relating to the business[10]:

- Sales in 2009: $ 7.7 billion;
- 12,000 employees;

[10] Source: GE Oil and Gas Fact Sheet

- Operating in 100 countries around the world;
- Serves the oil and gas sector for more than a century.

As outlined in the initial characterization, in this study GE Oil & Gas can be considered a supplier of ancillary services. The following discusses the key products and services offered by the business.

- Applications, products and services for subsea and surface drilling systems;
- Applications, products and services for production of oil and gas;
- Applications, products and services for oil and gas transportation and storage;
- Petrochemical equipment and refining;
- Inspection and maintenance of pipelines;
- Products for oil rigs;
- Industrial production of energy.

A very interesting aspect for the purposes of this study concerns the role of Global Service area of GE Oil & Gas. This area is dedicated to providing customized solutions to maintain and provide adequate performance over the life cycle of the customer assets. Global Service offers a wide range of services, from spare parts, field service, technical support, repair and analysis of the state of the art equipment installed. Everything is done by 1200 trained engineers located in 46 key locations in order to provide a continuous service, 24 hour and 7 days a week.
The business of GE Oil & Gas is included in the segment of GE Energy Infrastructure, along with GE Energy and GE Water and Process Technologies. For the study carried out in this thesis were carried out interviews at the headquarters of GE Oil and Gas located at Nuovo Pignone in Florence, Via Matteucci 2.

<u>General information about Mr. Massimiliano Spadini</u>

Mr. Spadini is in GE since 1998, and entered as a team leader during the first implementation of Oracle ERP system. After following a series of projects has become IT leaders reporting directly to the CEO of GE Oil & Gas. In GE an IT leader serves as a reference point for a given IT department, especially Mr. Spadini held the position of IT leader in the sourcing function of GE Oil & Gas.
Beyond to be a Lean Leader for supporting functions, Mr. Spadini is also a certified Master Black Belt with responsibility for internal training and supervision of Green Belt and Black Belt. From the operational point of view is concerned with improvement projects using Lean and Six Sigma methodologies in the finance function of GE Oil and Gas.
In the organizational chart, Mr. SPadini reports directly to the Quality Leader of GE Oil & Gas, and indirectly to the CFO and the Quality Leader of GE Energy Infrastructure.

<u>General information about Mr. Cristiano Crinisio</u>

Mr. Crinisio graduated in Engineering and has been working since three year at GE Oil & Gas. He has always been involved in Lean and quality in GE, and in previous experiences has improved the use of statistics and total quality management in the manufacturing processes. In GE, he has been immediately enrolled in Six Sigma projects. Thanks to his first 18 months experience, he has acquired the certification as a Lean Six Sigma Black Belt with the

participation in some courses, a test on the various chapters of DMAIC and presentation in front of the Quality Committee of two large projects on quality.
At GE he worked for a year in the ITO process (Inquiry to Order) i.e. the phase leading from the first contact with the client, to the offer and the acquisition of the contract. Currently he has been working for two years in the OTR (Order to Remittance) phase, i.e. any part of the process that involves both the execution of what is sold and then make concrete the contract, as well as the after sales services. In particular, it deals with the CSA (Contractual service agreement), a business for which the most loyal customers sign an agreement with GE (even twenty years contracts), during which the company guarantees the availability or performance of the machine at peak of its possibilities. Crinisio reports to the Lean Leader, who is the coordinator of all Lean initiatives within the global service, above which there is the Quality and Lean Leader, or the person who has responsibility for projects and Lean quality of the entire business, position that is currently covered by Paul Wise.

General information about Dr. Simone Pazzi

Simone Pazzi earned his Master's degree in engineering in 1996. Afterwards, he started to work for some famous organizations and as private consultant in the oil and energy industry. In 2002 he started to work as contract researcher for the University of Firenze. His area of interests was the optimization and aerodynamics applied to machinery. In the same field he got his Ph.D. in 2004. In the same year he started to work for GE Infrastructure and in 2010 began his activity in GE Oil & Gas as Engineering Black Belt. Currently he is Black Belt in the area of New Product and New Service Development.

Lean and Six Sigma in GE Oil & Gas

Lean and Six Sigma in GE Oil & Gas are definitely connected. In general terms, Six Sigma has the purpose to eliminate errors and defects, Lean to eliminate activities that do not add value to the customer. Then in a process that goes from supplier to customer, Six Sigma action to remove errors in the step, the Lean works to remove the steps themselves or to reduce the time from one step to another.
Lean tends to reduce the cycle time of the process, in terms of steps that do not add value. Moreover, sometimes between one step and another may be necessary approvals and inspections, procedures that sometimes require days, even weeks, and Lean seeks to intervene even to reduce these losses in terms of time. Contrarily, Six Sigma, acts to reduce the variance within a certain step of the process.
Consequently, from the analysis between Six Sigma and Lean, particularly in the transactional aspects, its boundaries are not well defined and there are overlaps.
In the vision of GE, whether in one step the aim is to remove errors and waste, the way should be reducing the cycle time. On the other hand, if you try to reduce the cycle time, beyond streamline the process, the variability and errors should be reduced. These observations allow outlining how Six Sigma and Lean have combined to Lean Six Sigma in GE Oil & Gas.

10.5.4 Operational aspect

Methodology implementation

GE has always been focused on quality, so much so that early in 1989 began doing the workout, which is the meeting where all the people involved were part of a process, in order to have a full and clear sight of it, and have the support of all to eliminate waste and errors. In 1992, GE has introduced the "Change Acceleration Process", or courses in order to make it clear to employees how important it was to change and accept change. In fact, the main difficulty is to change the way people work, if a person has certain habits, he's afraid of change. With this course GE tries to open people's minds trying to make them understand that change is good.
In '96 we began to apply Six Sigma, whose knowledge was a prerequisite for management. Since the mid-2000s, in 2005-2006, there was a change in approach, which has become kind of Lean Six Sigma. In this way we wanted to change the application of Six Sigma methodology, which took place in points isolated process, to address specific problems that plagued the operators but that hardly were linked to business objectives. With the introduction of Lean Six Sigma approach was given a "wing to wing" approach to the methodology, i.e. a whole managing of a cross functional process, from initial supply to the delivery to the customer. It was created so that a team of Project Leader dealt with projects beyond the barriers of individual business functions. For that reason we created a Lean Team, now merged with the quality and then called Quality and Lean, who had inside of people with the ability to manage a complex quality project, some quality project managers.
The Lean team of global service is functional. It has four global service business, one of spare parts and assistance in the field, one for solutions, one of Contractual service and one for processing. These are supported by four business functions that are centralized in Oil & Gas, engineering, sourcing and information management. The Lean team reports directly to the vice president of business and work cross functionally at all the functions that manage activities within Oil & Gas. In addition, the Lean team has the authority to intervene and manage projects involving high-level management functions.
Six Sigma is therefore used extensively in GE, including in areas such as transactional processes of finance, not only in production processes. Focus on quality is one of the commitments that each employee takes each year, within its competence to satisfy the customer. It is a transversal behavior across the entire corporate.

- Using Six Sigma to design/redesign new service processes in GE's global service

The Lean Team's mission is to follow the business strategy and to achieve the company's business objectives. In order to achieving these objectives, the vice president for quality invests even on re-designing of business and production processes belonging to different locations. Oil & Gas has in fact the hub in North America, Mid east, Algeria to be managed in a common way. The Lean team helps the business to achieve this objective since the mid-2000s. At operational level the team plays the re-design of production processes, more precisely Kaikaku than Kaizen, which is made more of a re-engineering rather than a gradual revision of some existing entities.
In addressing the issues of the service with a Six Sigma approach starts with the observation of the process to be influenced. In fact, it is difficult in the service area that there are activities carried out from research and development of an idea. Team Lean does operational working with other people in a process, and with these resources and top management defines the

problem through an initial phase of the Pre Action Workout. Also there is a measure of available information. That information is a problem that plagues the world of service in a special way. The manufacturing has a lot of data available, the service instead very few and too often there are too specific situations. Assembling the information from the beginning to the end of the process is very complex.
After performing these preliminary stages and analyzed them together with the management, it comes the phase of the Action Workout. The Action Workout is a moment in which the formal review process with managers and actors involved in it. From an operational point of view the work is divided into two weeks: first week in which you get from the brainstorm a plan of action, an Action Plan to bridge the gap from baseline to the one you want. The Action Plan is the source of the daily work of the team of Lean, and of course the use of Lean and Six Sigma tools in the analysis and process control changes. In the second week the actors come together to play what has been developed in the previous week and produce evidence that will convince the top management to make the investment. It is an investment in terms of training, reorganization of the structure and sometimes also in terms of digitization, but usually is done by computing the transition at a later stage. Then, in the second week you start to check the validity of the process, trying to figure out if the same will become a workflow, and therefore whether the component assets will be digitized.

- The specificity of the transactional environment

The specificity of transactional environment, if compared to manufacturing one, is linked to the fact that you do not handle physical objects. In fact, this environment manages transactional information that can run on different systems. The initial difficulty is in finding information and management of the organization throughout the process.
A second peculiarity of the facilities is certainly the lack of data. In the assembly lines, for example, the timing to make out each individual station is easy to calculate. In transactional systems, instead, this is a much more difficult procedure.

- The search for process standardization

Usually people with a great knowledge of customer needs have limited competence of internal processes. As a result, these people are struggling to make the company comprehend what are the needs of the customer. These people can escape the complexity of the process, something hardly manageable for the immediateness necessary to respond to emergencies. Thus, these figures tend to look for shortcuts, behavior and situation that the Lean Team has tried to eliminate. This has drawn a new trial OTR along which there are three check points, and implies that 100% of the activities must be carried out properly. For the customer, the goal is to develop mistake-proof systems for the quality of the process from beginning to end, without the need for internal controls.

- Influence of strategy in the methodology

The company's strategy certainly involves the development of the methodology. The vice president, in all communications to the Team Lean, require a very high level of accuracy, until 99th percentile of transactions executed. Even when statistical data must be communicated, usually there is no average of 75th percentile, but only 99th percentile, because the vice-president wants to stress this target.

Furthermore, in certain types of activities the goal was a 100% percentile quality at the various steps of the process. This has led to an extreme care to details and the need to have the situation completely defined. For some processes it has come to create Value Stream Map containing 3-400 processsteps. In addition, measurements of the data used in the development process had to be absolutely reliable. So this attention to detail, this need to go deep, was strongly supported by management, and strongly influenced the application of the methodology.
Six Sigma target of 3.4 DPMO is only a reference, in fact there is some difference between this target and the level of defects corresponding to the ninetieth percentile. Consequently, the Six Sigma in service environments in GE has been applied as a cultural approach. The reference level, and thus the possibility of defects, process exceptions, out of 100 opportunities, is defined according to the level of service required by the customer or the market. That is a goal of 3.4 DPMO in the future, in line with perfection, one of the five states of Lean that GE is inspired. However, some global service processes have reached the 90th percentile from levels around 35-40%. These improvement initiatives have been very effective.

- <u>The reference cycle of the methodology at GE Oil & Gas</u>

Six Sigma deals with DMAIC cycle and DFSS. In Oil & Gas DMAIC is used as the 5-cycle stages for defining the problem, analyze it, understand the actions for the improvement and control of it. So the DMAIC is one of the methods that are used extensively in business, especially in the case of IT applications, as GE's motto is "Lean first and then digitize with regard"; this represents the best tool for digitization.
The culture requires GE to think of continuous improvement, there is nothing that cannot be improved, in some cases we proceed with the improvement of a process, sometimes this is redesigned instead. However, in view of GE is not something new, but to structure something that previously was not the same; from this view, a DMAIC cycle is applied anyway. For the transactional aspects appears to be the most appropriate methodology to provide a rigorous structure to processes.
In summary, we can say that, especially in global service, there is a Six Sigma approach to change production processes to attain the objectives. To explain this, here is a real example of application. In 2008, coinciding with the financial crisis there was a liquidity problem. In a situation where the financial problems had affected the whole world, the financial exposure was one of the greatest concerns of management. From an operational point of view, to help the management the inventory should be minimized while providing the same service to internal customers and then to materials managers and PM, securing parts to production sites end-use customers. Consequently, an Action Workout was performed to create a new model of management of spare parts through which it could operate with much lower stock levels ensuring the same level of service. In taking forward this project are carried out all steps under the DMAIC cycle, but the ultimate goal was to meet the needs of the business at that time.
Then, after passing a difficult period, the goal became to provide the best possible service to the customer in order to retain them. Thus, once established the new process, the organization tried to improve the performance of on-time delivery, and then sending spare parts to customers according to the rules stipulated in the contract in relation to their needs. In this second phase of the Lean team then worked on an existing process, improving only a section, since the initial redesign was allowed to meet the needs that were expressed at the origin. We

can stress again, in conclusion, that the cycle of reference is the DMAIC with an adaptation resulting from the objectives that may emerge from a transactional environment.
The DFSS is used mostly in purely engineering functions, when it comes to introducing new products, such as the launch of a new technology. The DMAIC is used when one wants to intervene with the process of improvement, while DFSS to design new entities which find its main application in the field of engineering, and applications in NPI (New Product Introduction) and in general when has to do with new technology. By the way, in Oil & Gas, the same tool used to define the Six Sigma projects in DMAIC, is also used for DMADV.

- Key factors for the success of Six Sigma projects and methodology

In GE the company is organized in corporate culture that was instilled by top management. Hence, the need for a top management convinced and prepared on the methodology is certainly one of the key factors for success.
It is also important to be clear about the problem and the objective to be achieved, as well as the involvement of appropriate people and the commitment of GM and the company. With the availability of resources without the right skills you cannot in fact achieve such goals. As regards the vision of GE, the ingredients to successful implementation of Lean and Six Sigma are the contributions of employees in close contact with the process, thanks to their knowledge and expertise.
The Six Sigma approach should not be seen as a fad but it must be systemic, it must not be an accessory tool for personal growth goals, rather than the growth has to be a consequence of a good use of methodologies in projects that have carried out. In fact, very often those who come to work in projects of a certain vision ends up being named manager of certain business, since those projects can be shown in tangible ways the quality of a human resource.
If instead the use of the methodology is only functional, there might not be sustainability of the project over the years. It is easy to introduce a change in the wave of enthusiasm, the same methodology Lean lives of propaganda. For this reason, in the selection of projects are preferred those that can facilitate, through the enthusiasm, the spread of quality culture within the company. The greatest difficulty lies in maintaining the quality of the changes introduced by limiting the effects of the return to the initial situation, i.e. the Control/Verify phase. In fact, the percentage of the changes introduced by the improvement projects that is maintained during this time is around 10%. Thus, it is essential to build processes that beyond the initial enthusiasm, have made the changes introduced by the project, standard procedures.

Methodology tools

The tools of DMAIC methodology used in most GE transactional environment
In GE show that the Value Stream Map is the best tool to map a process and a clear view of the steps to follow as well as the systems and resources involved in each step. Furthermore, it indicates how often a given step is functioning optimally the first time. In particular to identify and manage information throughout the process is essential, according to the majority of GE managers, using a very detailed Value Stream Map, which allows us to understand the players involved, the information supplier and the systems.
Compared to the traditional approach of GE, the global service is taught to use the Value Stream in pre-work, if it was used in the next step of Action Workout it would require the whole week of work to be defined.
In all pilot new processes, the Lean team had to create a progressive system for defining themselves. All activities were reported to be carried out in the written form, i.e. a standard

work, which was then transformed into a sort of template or a checklist with things to do. This check list was passed from operator to operator, making it possible to build the flow of the process and its subsequent digitization.
Another very useful practice in the transactional environment is to perform a wide brainstorming session. Due to the intangibility of services, the experience is more important than observation.
In the phase of definition is often used a tool called “In and Out of Scope”, with which it is defined what is included in the objectives of the project, what are the issues to address and solve out.
Another tool is the “Thread versus Opportunities”, part of the SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) that will help you understand the opportunities and threats in the short term, as well as to make assessments on the impact of the project. Another tool is the “ARMI” (Approval, Resource, Member, Interest), which can be used in each of the phases. For each phase of the methodology the team member who can make decisions should be reported, what resources are needed, what are the team members who can serve at any one time and get immediate approval by those responsible.
Another useful tool can be GRPI, in order to test the effectiveness of a team. If at some point something in the project goes wrong, this tool is used to identify which elements clearly affect the outcome.
Finally, another widely used tool is the fishbone diagram, or Ishikawa, allowing each area to understand the root causes of the problem.
In this context even the tools to prioritize actions to be performed are used.
No systematic use, although, of statistical tests, even if in the transactional processes there is still an initial system of statistical measurement, which allows you to checking whether the data have a normal distribution. Given the heterogeneity of the data collected in the transactional systems that verification is carried out to assess whether to build on that data statistics that are used in the analysis phase.

- <u>Using the statistical tools</u>

While statistical tools and tools for the detailed calculations and statistical analysis (e.g. defects, changes, etc..), are used in 100% of cases in the manufacturing and production environment, in the transactional environment is more difficult to use. Because if we deal with a process, trying to reduce waste or reduce cycle time, or trying to optimize any parameter, such tools are not always the most appropriate ones. In these cases may be the most useful tools of Lean, such as value stream map, so you have a baseline to go from the AS IS to TO BE.

10.5.2 Organizational aspect

<u>Culture and intangible assets</u>

- <u>The importance of compliance and integrity</u>

GE has very strict rules regarding information management in general and specifically to compliance and integrity. Customers often require to include GE in their press release as a major customer. However, the marketing manager normally does not allow the supplier to use the logo of GE; this is an example for the level of rigor required.

Furthermore, Jeff Immelt, CEO of GE has several times stressed in his speeches as the errors are accepted and resolved; for example the errors of a project manager can be solved, but there is no tolerance against those who violate the integrity (e.g. benefits and accepting gifts from suppliers) and in general against those who infringe, by their own conduct, the company's image and brand.

- <u>Mission and vision of GE Oil & Gas</u>

GE has the customer as first priority: the mission is to provide what is requested by the customer with the highest level of quality ever. The requirements of this company are, of course, the focus on the customer, the closeness to it, the support and help, being a partner rather than a supplier, for their growth and development.
The mission and vision are unique in the entire organization, as well as the values. It normal that being in business of a different nature, there may be different objectives, but the values such as integrity and compliance are transversal. For example, the NBC has different customers than Oil & Gas, which sells equipment and turbines, but the values and vision are common to all businesses.

- <u>The four strategic pillars of growth in GE global service</u>

In the GE culture of Lean has been a necessity spread to the entire company from top management. At GE Global Services is a strategy for growth that is based on four assumptions.
The first is “quality and speed”, previously identified as "speed and quality" and later renamed to emphasize the consideration of quality as a primary and essential element in the company.
The second pillar is the “expertise”, that it the experience and competence of people.
The third is “innovation”, i.e. a term for technology but even non technical aspects such as the ability to innovate, a feature that emerges from the GE slogan "Imagination at work".
The fourth pillar is the “regionalization”, the ability to be able to provide a service to the customer, being close to it geographically. From this point of view of GE Oil and Gas has a comprehensive strategy that stresses the need to leave the headquarters in Florence to open outposts in areas where the business operates. Thus, strategic needs are very clear and defined, and in fact the four conditions are shown in all templates used in projects for improvement.

<u>Actors and organizational structure</u>

Within GE, there are different segments and the organizational structure is extremely complex. Inside GE, one of the divisions is named GE Energy Infrastructure. Within Infrastructure there are different units, e.g. Oil & Gas, Water, Wind and so on. We can consider them a business within another business following a logic similar to that of Chinese boxes. Oil & Gas, for example, has a CEO that reports directly to the CEO of Energy Infrastructure, which reports directly to the CEO of GE Jeff Immelt. Similarly, in Oil & Gas, for example, the CFO reports directly to CEO Oil and Gas, but indirectly to the CFO of Energy Infrastructure, which in turn reports to the CFO Keith Sherin of GE.
In the corporate structure of GE Oil & Gas the CEO has a number of GM, or a Vice President for each business unit. In addition he has two supporting roles in the field of Quality, i.e. the Product Quality Leader for the production and Transactional Quality Leader for transactional

processes. There are also other supporting roles, the CFO with regard to finance, legal counsel, and responsible for human resources.
The services complement the product, such as those after-sales are not part of the transactional part of that, but associated with the product. For example, after selling GE products still have 24-36 months of warranty and any problems inherent in the guarantee is, however, be attributed to the product. It often happens that senior executives, members of the board of GE, are interested in individual projects that belong to the most peripheral of GE, analyzing them in weekly conference calls. Often, GE project managers are used to deal directly with top management, in order to immediately understand the need for accuracy, consistency and effectiveness in transmitting information.

- Roles

Roles in the Six Sigma methodology represent a standard in GE Oil & Gas: there are the Green Belt, the Black Belt, Master Black Belt to the right up to the Lean and Quality Leader. However, in other businesses, such as in healthcare, there are people qualified as Value Stream Manager, rather than other roles created to meet the specific needs of the business. In particular, in healthcare there is a need to have a figure to take care of all processes in a horizontal as well as a figure with a detailed knowledge of a specific phase of the process.
In Oil & Gas there is no such specific roles, but there are the Black Belts and Master Black Belt. However, the Green Belt is not an organizational role but is simply a certification that takes an operator who works in a given position. GE acquires any resources within the Green Belt certification through a training course, a written examination and a project with a Black Belt mentor to be submitted to a Master Black Belt. Not all the employees are certified as Green Belts, but only who voluntarily exceed the expected step in the process of training; not all the projects submitted by the candidates in fact are approved. One time, the Green Belt certification was mandatory for all employees, now is not, even if the push toward the pursuit of certification and in general to the knowledge of the methodology is still present among the resources.
Under the function for transactional quality are usually the Lean Leaders, instead, under the function of product quality are the Black Belts and Master Black Belt, but such roles are not so fixed. There are Black Belts, in fact, for each functional area, including the transactional side, where involved in reviewing and improving processes. These figures, dealing with projects in the areas of expertise, supporting them in terms of quality. However, there are also some projects that require cross functional meetings to set deadlines and management of critical situations.
GE Oil & Gas expects the Black Belts support functions to which they belong by introducing the culture of Lean and Six Sigma.
One more responsibility of being a Master Black Belt is being the mentor of the Black Belts, and holding the courses for Green Belts. In GE there is a Master Black Belt for any function that serves as a mentor and supervisor for the Black Belt and Green Belt for all projects of that function. Black Belts support Green Belts projects and with regard to their areas of expertise. The Green Belts working on projects as project leader or at least as an active collaborator.
Given the large number of active projects, Black Belt participate in the projects of their area. The Master Black Belt monitors and follows all the steps involved in the function of competence, the Black Belt supports individual projects more in detail; obviously, each initiative has a functional project leader, a IT project leader, and a different number of team members.

• Human Resources training

Human resources are formed through a training course, recently redesigned and set from two weeks to one week for the Green Belt.
During this week of theoretical class resources acquire more knowledge on the methodology and are sent to the management of a quality project. This course is monitored by some Black Belts which follow later the Green Belt in the development of the project to develop.
Specifically, the week of the course is divided as follows: the first 4 days in class, extremely important from the educational point of view. On the morning of the exercises are performed on the stages of the simulations and measure, analyze and Improve the methodology, in the afternoon, instead, the Green Belt candidates are supported by the Black Belt in the development of a project, which is necessary for their certification.
Furthermore, in the first 4 days, candidates also learn to use Minitab, essential tool in the analyze phase. Then there are 2 half days for the Define and Control phases. At the end of the course there is a test with about a hundred questions. This is a test of some complexity, part of the rigorous and structured process to obtain certification.
Subsequently, the Green Belt returns to his operational role with the statement of the project that will be developed to obtain the certification. However, it is preferable that at the return of the resource to the operational role, it has already completed the steps of define and measure of the project to be developed, so that some raw data to work with are available. Afterwards, there is the development phase of the project, requiring an implementation, the production of a pilot and a verification phase of the pilot. Everything should then be inserted into a power point presentation package to present to that board for certification. For both the Black Belt that the Green Belt, are absolutely essential, since the roles of leadership, skills of presentation of the data collected and results obtained. In fact, these presentations are often exposed to top management, then you need the skills of synthesis and the ability to be effective and essential in the short time available.
As regards the Black Belt, the training process lasts 18 months. Initially there is a two-week course, during the first week we delve into the DMA phases of the cycle, in second stage the IC phases, followed by written tests on each of the five DMAIC phases.
Later, during the 18 months there are two quality projects that are presented during both opening and closing phase to a board that verifies all the requirements for certification. The request is then forwarded to the function and then approval for the certification comes directly from corporate.
Internal training is extremely beneficial, teachers can in fact bring more examples related to the company. Sometimes, however, training can be even external, like the courses that GE offers to its customers.

• Organization and Six Sigma projects

In addition to the corporate organization chart, there are even matrix structures to follow each project and draw on cross-functional skills necessary for its operation.
Within a project there are two key figures, the Champion and Sponsor. The Champion is the person who will provide the resources to pursue the project, the Sponsor is the one who blesses at high levels in the project. Usually the sponsor as a Vice President level in the organizational structure. The Champion may be responsible for a function, or in case of very large projects the head of P&L (Profit & Loss) business.

Regarding the choice of projects and responsibilities, there is a dichotomy between the person authorizing the project chart or the Sponsor, and one who takes the commitment to continue the project within the project chart that is the Champion.

In a project in addition to the Master Black Belt, which acts as a supervisor, are also assigned one or more Black Belt in the case of large projects. In terms of team selection is made on the basis of specific knowledge of the process involved rather than the role of resources. The project team is always made by people in positions where it is involved in the project, who will share their knowledge and implement changes in their area of expertise. Competent people are placed in areas, familiar with the problems, which are able to signal the alert to go ahead with the project. These people usually report to the Champion, but in cross functional projects, Champions must consider supporting figures, e.g. sourcing. These figures provide the resources that are part of the project, however usually do not deal with only a single project but also other activities that involve the business not closely related to the project itself.

In addition there is a Leadership Steering Committee which includes the GM involved in the project, a Business Leaders Initiative, and Project Management Review Team that is impacted by the changes brought by the project. The process owner is a team member and often acts as project leader, being the person with greater impact and responsibility in the project. So the structure of a project is very broad and includes figures and expertise from different business functions.

For the purposes of a proposed transaction, you need the help of a major sponsor. Often, projects in transactional area lead to changes of implementation, resulting in digitization, which requires huge investments in capital.

Another feature of transactional environment in terms of human resources is the need for good facilitators during brainstorming sessions or Action Workout. This is because, on average, those involved in the transaction have a level of experience and preparation higher than that in manufacturing. Usually an operator involved in manufacturing improvement projects, joins the quality group highly motivated, because sees in what he does a great opportunity. However, in the transactional projects is much more difficult deal with managers who in order to monitor the project, must leave for a week important jobs or give up activities very important for them. Moreover, when working on projects, facilitators have a critical approach and are able to make trouble handling the exceptions that only who lifts an excellent knowledge of the process is able to manage. There is therefore a need for conflict management in a constructive manner, and thus the role of the facilitator is crucial.

10.5.3 Strategic aspect

<u>Strategic project selection</u>

- <u>Origin and management of improvement projects</u>

In GE the input for the improvement projects can come from any source, whether employees, customers or executives. Until a few years ago the top managers had the only right to decide on the implementation and the initiation of processes for improvement: there was a top-down approach.

Today, given the large penetration within the culture of Lean and Six Sigma, employees totally realize the benefits of such practices in their working lives, and are ready to propose changes, or Lean workout actions for the improvement of a process. In the vision of GE, what

is important for a successful implementation of Lean and Six Sigma are the contributions of employees in close contact with the process, thanks to their knowledge and expertise.
When the source of improvement projects comes from top management, it is linked to the need to adapt the business to the highest quality standards. The definition of projects by top management is at the level of vision; from here, the Team must develop a concrete project. For example, in the OTR process there is a need to ensure levels of service standards to customers. This vision was given to the Lean Team, who then supported with data and details this requirement, benchmarking with other business in GE; this is actually a widely used business practice. Once you have identified areas that needed immediate improvement, you have created a multi-generational plan of implementation, consists of more than a dozen projects, then developed by the team together.
A multi-generational project plan (MGPP) is a tool for project managers to manage projects quickly and easily. Specifically, this tool helps managers define the objectives of a project going beyond the boundaries, providing a better base on which to make operational decisions. In fact, with this tool are also considered possible developments (or generations), future analysis of the project, both in terms of achieving long-term technology to use. In this way the organization can work on the technologies needed for future projects already in the implementation of the first project and while the benefits arising from the same will be achieved. Using information gathered and lessons learned during the first generation, managers will be able to describe future generations of processes in a much more detailed way.
The projects are created in one version, then developed over time to meet the needs of the business. So whenever there is a need to model the process on new requirements, there is a new adaptation multi generational project. This to ensure that what has been done in adapting to emerging needs of business.
The projects are shared by the head of the structure of Lean and Quality, and Vice President. After defining the requirements of the project, one or more Black Belt becomes responsible for it in order to develop and carry out the project; the number of Black Belts involved varies depending on the complexity of the project. In summary the vision of the project belongs to top management, then the mission which spells out the vision with numbers is borne by the Lean Team, and finally the operation is borne by the Black Belt and officials who then are required to effectively implement the project.

- The influence of internal and external customers in the design of new processes

GE Oil & Gas is a mature business with regard to the relationship with the client, so there is rarely need for a new trial against an explicit requirement of the customer.
Sometimes there is a need, to meet the needs of the customer, to review the internal process, not only in terms of efficiency and thus reducing costs, but also to ensure a satisfactory service level to the customer, which is also inclined advertise to other customers at the quality of the performance achieved. For example, the problem of many project managers is to identify, within the standard processes what are the priorities. The requirement is to identify the priorities and give them a fast track to the process standards and controls. Afterwards, the external customer will probably not see this difference, which is perceived by internal customers instead; formerly he had to handle the situation personally, do follow up and try to figure out how to bypass the obstacles put in front of the process.
In the service sector, moreover, difficulties arise more often from external customers; external customers have a greater variability in needs, while internal customers, being more competent on internal processes, can highlight needs that must be met with new processes.

- Selection of projects

Basically GE, for all non-priority initiatives, always performs a cost-benefit analysis, trying to understand the benefits brought in terms of growth, cost savings, better management of resources by a project. The initiatives with the best performance index are selected in these terms. Another selection criteria is based on the matrix of the impact and implementation used in brainstorming: only the projects to be concluded in a reasonable time and with high impact are chosen.
A common denominator for the selection of a Six Sigma project should be the financial benefit unless there are no regulations that require the company to introduce certain changes. In that case there could be no benefit but only costs to be incurred. This unless you are talking about an absolute requirement as a result of a quality problem found, in which that project would have priority. There are also initiatives due to the statutory complaint, or the change of rules or laws that become a priority. Moreover, such initiatives can be based, at least in the finance, interest on specific details, with the choice of initiatives that have the greatest impact on function.
Customers, whether internal or external, have some influence in the projects selection. Areas as the global service, which is constantly interfacing with the external customer, is imperative to take account of their needs, that become a priority.
There are two broad categories of projects, the first is related to the relationship with those customers, whose priorities become those of the company. The second category concerns the internal projects, such as the objective of business growth, expansion into areas where sales are limited or the introduction of new technologies. This includes also projects to improve internal processes that positively influence business growth.

- Approval of projects

The projects are authorized and approved by the GM of the affected function. The initiatives are usually vertical, but any business spending request is subject to approval by the CFO of the company.

10.6 General Electric Capital

This section presents the case study of GE Capital, based on analysis of data collected during a field visit. The data comes from various sources such as direct observation, official documents of GE and in particular, are the result of two semi-structured interviews.
The first interview with Mr. Bianchi was conducted at GE Capital Solutions Fleet Services, based in Rome (Italy), Via Rosaccio 33; the second one was a conference call with a Black Belt who operates in the Dutch area of GE Capital.
The transcription of the second and most important one with Mr. Bianchi is expanded in the appendix of this paper.

10.6.1 General description

GE Capital is a leading provider of credit in the world, with more than one million business as customers of different size. The company provides financing for purchase, lease and

distribute equipment. It is also even involved in capital for acquisitions and corporate real estate, refinancing and acquisitions. Furthermore, with regard to the more than 100 million B2C customers, GE Capital provides credit card programs for financing purchases of cars and real estate, personal loans and credit insurance.
GE is an extremely diverse and complex world, in which there are a number of products and services that correspond to P&L (Profit and Loss) units and then to the business units. GE business units ranging from appliance, healthcare, lighting, consumer electronics, media and entertainment, i.e. the NBC, and many others.
GE Capital is the finance side of the group and in particular all part of business to business and business to consumer.
GE Capital offers a range of products that were previously the prerogative of different business units and that have now been merged. For example, for the B2B services they offer equipment financing, fleet services, commercial distribution finance, all products of corporate financial service activities so as factoring, corporate finance, project management in companies. Also the whole area of financial services, healthcare and then all financial services for the financing.
In summary, GE Capital is responsible for worldwide financial services for B2B and B2C. In each macro-segment can be a variety of financial products. For example, the equipment leasing or financing may cover other forms of financing for all types of equipment, from computer to the car used in the construction sector.

Details relating to the business[11]:

- Net profit in 2009 of $ 2.3 billion;
- Operates in 55 countries around the world
- 1 million business customers
- More than 100 million customers comsumer
- 60,000 employees
- Total assets of $ 625 billion.

GE Capital may therefore be described as a pure supplier of services, particularly finance and insurance type. Specifically in this study we discuss the main products supplied to its business and consumer customers.

Commercial Products:

- Leasing and loans for equipment;
- Fleet services;
- Franchise Financing;
- Optimizing Financial Stores;
- Corporate financing;
- Financing of buyouts[12], mergers and acquisitions;
- Finance for reorganizing business;
- Healthcare finance;

[11] Source: GE Capital fact sheet
[12] Investment transaction for which a company is acquired largely by a group of managers (generally defined management team) who become managers/entrepreneurs. The acquiring management team is generally accompanied by a financial sponsor, traditionally a private equity fund, which provides most of the financial resources for the operation.

- Energy finance;
- Real Estate Financing.

Products for consumer customers:

- Credit cards and bank cards;
- Personal loans and purchases of houses and vehicles;
- Savings and deposits;
- Insurances.

Basic information on Mr. Giancarlo Bianchi

Mr. Giancarlo Bianchi has been working for GE for about 13 years. His background is in marketing, and his first significant work experience at Procter and Gamble was in the product and brand management.

Moved to GE, he continued to work in the marketing area. Afterwards, he made a first experience as Black Belt in the commercial area, opening new opportunities in his career because that was his first experience with Six Sigma, and generally in a different area at the commercial front end or pure marketing. After that experience he began to work in the process and operations and so far has been in charge for eight years of various positions in the operations area. He has held positions of pure operation, conducting teams who ran the network for the maintenance of vehicles for the area of fleet management. Therefore, he had the opportunity to work in the field of quality for Lean Six Sigma team, and in this role, he held a variety of tasks. He made his European Master Black Belt, managing some European Black Belt and some areas of process specifications, like billing and collection. He was in charge of Pan-European projects using the methodology and developing best practices with respect to these two process areas.

Around 2003-2004 GE wanted to give greater focus to Lean, a relatively new practice in transactional scope, although if it was already used in the field of manufacturing in business since the early 90s.

The Six Sigma was widespread for many years, there was much awareness as well as many inputs, Lean instead was a novelty. Top management decided to create a Lean Leader, that is, someone who has, among its responsibilities, the promotion of the methodology, and propose the use of Lean where needed. Thus, because of its experience in the use of the methodology has served as a Lean Leader for a business segment, called Capital Solutions.

He worked at the global level, by carrying out projects in Australia, Korea, India and of course in Europe. More recently, again in Lean Six Sigma area, after the creation of GE Capital, which brings together all the financial business first divided into independent business units, came as European leader in quality, and still follows a team of Black Belts in Europe.

In particular, it deals with the Pan-European projects, which may be plans for the global partnership, relating to clients and partners in all European countries, which should be followed with high size teams. Furthermore, among these projects there may be issues of common initiatives in various countries. Mr. Bianchi is a certified Master Black Belt, however, this qualification is not linked to its role within the organization. This is a specificity of its role as there are also local and Quality Leader following major projects for individual countries such as Italy or Spain can be. The name of his role is Leasing and Lending Leader for Europe and indirectly reports to the Quality Leader in Europe and directly to the CEO of GE Capital Italy.

Relations between Lean and Six Sigma at GE Capital

There are important overlaps and interdependence of a great use of these two methodologies. The vision of GE suggests that in response to a problem, the most appropriate solution should be applied, no matter if it is that in the field of Lean or Six Sigma.
For example, if you encounter a problem of cycle time, you will probably use instead of the Six Sigma tools some Lean tools, because it can address more effectively this kind of problems.
Moreover, much depends on the progress of the process, its sophistication. If you are facing a context in which some KPIs (key performance indicators) already exist in order to measure and monitor systems or even to reduce defects and errors, then in that case, the Lean tools will be less useful. You can still use the Lean tools, but for improving the working environment such as workstations. If there is a need to work on reduction of defects in very complex processes, with the help of detailed statistical analysis, the use of Six Sigma tools is prevalent. Other companies will not need such sophisticated statistical analysis and will be more appropriate to use the Value Stream Mapping, outlining the best processes on which to intervene.
Often, in their experience, the manager of Capital have to mix these methodologies. In addressing an issue or project to be managed, depending on the stage, there could be used statistical analysis, regression analysis and even the Value Stream Mapping. Often the projects also take over the problems of organizing and motivating people and it is convenient using CAP (Change Acceleration Process).
GE's vision of a manager has available a toolkit containing tools from which to draw for the resolution of the issues it faces. These tools could belong to one or Lean Six Sigma toolkit, what matters is choosing the most suitable instrument for addressing the issue in question. If there is no flexibility in the use of these tools there could be functional limitations and difficulties to solve out the problem.
The strict application of the methodologies brings benefits in terms of creating knowledge and approach to problems. However, the constraints are too tight can be too limiting. In addition, GE is also considered the possibility of integrating Lean within the DMAIC, entering after the cycle phases define and measure and analyze the lean, instead of the Improve and Control phases. Thus, there are efforts to formalize the integrated use of both methodologies.
Overall the DMAIC is the modification of a systematic approach to problem-solving. The problem should be understood, measurements to understand their position must be made, the main driver output and what are the elements that can be changed must be analyzed. Finally, we must improve and change the setting of the process, and eventually the change should be made permanent and verifiable over time.

10.6.4 Operational aspect

Methodology implementation

At GE, there are differences in the application of Six Sigma due to the width and magnitude of the group both in terms of products/services and as geographical coverage. Consequently, there may be areas less or more advanced than others but the structure is similar. In GE in fact, there is a Vice President who is responsible for quality. The guidelines

followed are similar, the implementations are significantly different depending on the timing of the areas, but it follows the same approach.
Six Sigma at GE started in 1995-1996, and has now reached a good level of standardization as well as the good level of Lean. GE has been following Toyota with regard to Lean, so the application is known and settled. Wherever in GE, Lean and Six Sigma projects, less or more complex depending of the aim, are carried out.

- Reference Cycles

For the launch of new products and services to GE is used a methodology called the NPI (New Product Introduction) that conceptually follows a DMAIC approach. Only for the launch of the products DMADV is also used.
In the area services we focus on defining the relevant market, the need. It is also trying to identify the CTQ (critical to quality) or the specific requirements, i.e. how long the company must be able to launch a product when the request is made by the customer. Another method used is the CECOR, mainly used by marketing.

- Key success factors for Six Sigma projects and program

In the vision of GE Capital, managers should first focus on the processes driving competitive advantage, which are priorities. The more you work on issues that really matter to your business and make the difference, the greater your chances of success of a project. Secondly, there is the balance between *speed*, *cost* and *quality*. It is necessary, especially early in the launch of a methodology, the right mix of business, large or small, simple or complex. Another important factor is to define simple metrics, measure results and tie them to financial performance. The purpose of GE (but even of most of organizations) is the financial performance, so it is absolutely essential to be able to demonstrate, in a project, the values of performance indicators before and after the implementation of the project, in terms of financial impact. The greater the measurability of results, the more credibility and you will be able to build a robust Six Sigma project.
The team should have suitable resources for the project; as regards this, the success of a project will be related to the presence of a clearly identified business owner for whom the project is a priority.
Finally, another aspect to consider is the *leverage set of tools*; the team must demonstrate the ability to use the right tool to solve a given problem. This last aspect is definitely very important, not only for the success of a project, but more generally for a manager of process improvement or even a consultant.
In GE, when the methodology is applied to services is focused on the Voice of the Customer, given the great interaction, continuous over time, which is established with the client. In the industrial sector, the Voice of the Customer is very important, especially during the creation and development of the product. When the product leaves the factory, such interactions with the customer end or become very limited. Contrarily, services after the definition of optimal settings and configuration for sale or delivery, the interaction takes time and is very intense. So certainly a peculiarity of services is the importance of *in life*, or the next contact with the customer.
Moreover, in business services and especially in the case of GE Capital, i.e. financial services, performance is often repeated and repetitive over time.
For example, in fleet management services, there is a portion of funding, for which the customer is directed to GE Capital, related to the acquisition of the machine and re-hire, and a

range of additional aftermarket services. These services involve a daily relationship with the customer, e.g. finding the location where the car can be repaired, quality repairs, car replacement, are all interactions between the service provider and the customer.
The service sector even offers a lot of customer service, and therefore many projects related to customer care, while in the manufacturing improvement projects are more focused on defects and on the quality of the finished product.

Methodology tools

In the vision of GE there are no substantial differences from the theoretical point of view between applying the methodology for the design or the radical change of processes and the standard use such as manufacturing processes. Most of the tools, indeed, are available in both cases. However, there are some best tools, used and usable for the manufacturing and other part in the transactional.
Service processes focus more on the cycle time, the capacity of the team, the creation of leaner team managed to equal volumes, productivity, simplification of the services and documentation. So, therefore, it seems more suitable to use more tools such as Value Stream Mapping, Kaizen, Five S, Standard Work. In contrast, in this context, tools such as Just in time, the Takt time, level loading, Order forecasts, Autonomation, Kanban are less used.
The Kanban used in transactional environment is not the same that is used in manufacturing, in GE Capital may be, for example a color code of practices that are ready to be handled if problems or the hospital bed where it is inserted all that is faulty to avoid blocking the process flow.
Takt time analysis are performed in the services, but less frequently, particularly in transactional processes simple and repetitive.

- The innovation toolkit

Another tool used in GE is a toolkit of innovation that is exploited during the generation of ideas, prior to the launch of the new product or service. This is a collection of about 30 instruments, some of which are also used in the DMAIC cycle.

- The digitization in GE Capital

The digitization is certainly an area of stress in GE Capital. With digitization refers to the set up of processes and services designed in a simpler and less intensive way as possible, both internally and for final customers. In that sense there are many initiatives to digitize as much as possible interface with the customer. For example, the request quotes up to the approval of the credit or the creation of documentation is now a process increasingly to do through e-document. Also where possible we try to implement electronic signatures, or reducing the manual billing invoices replacing it with EDI (Electronic Data Interchange) and similar technologies. This interchange of data between information systems through defined formats is in order to not require manual activities (shipping, corrections or other actions). Furthermore, the purpose is going towards the implementation of the workflow with the scanning of documents.
In GE Capital these technologies for sure help to follow the motto "Lean first and then digitize”. This practice is appropriate for all stakeholders, both customers and companies.

- Tools for the Voice of the Customer Analysis

QFD is part of the set of available tools provided by the DMAIC methodology and, moreover, according to the projects is used in GE.
At GE Capital are carried out many activities aimed at listening the voice of the customer, and here, Capital and other divisions are using a tool called IPSEN, a promoter score, a gauge of satisfaction that can be applied to both the products and services. This tool provides a score on customer satisfaction and indicate the potential areas of work.
Also in GE there are the Customer Advisory Boards, i.e. sessions involving the Leader GE, people with important business relationships with customers, operations manager, and individuals with commercial or operational responsibilities.
By involving these boards in a panel of major customers, GE understands what is best, the areas in which needs to improve and is committed to undertake specific projects for improvement or redesigning. For example, if the customer during these meetings shows some problems in one area, this is taken in consideration and teams with figures representative of the customers are formed, in order to resolve the problem by presenting tangible results.
In addition, again to capture the VOCs, GE performs periodic survey. Data can then be used as indicators of possible development projects, which will produce a charter and then pass under the screening process.
Moreover, in marketing is used a methodology called CECOR (Calibrate, Explore Create Organize Realize), to evaluate and innovate the market, leading the team through a series of phases and critical questions for the marketing function.

10.6.2 Organizational aspect

<u>Culture and intangible assets</u>

- <u>Mission and vision in GE Capital</u>

The mission and vision of GE Capital does not differ from those of GE. They are just specific to the area. GE's vision is "better bring things to life", that GE intends to help customers bring their products and services, to make their lives better. The variation in GE Capital is similar and reads: "Provide Financial Solutions That Enable Companies to Build Stronger and better future, connect with people that understand your industry and your need." GE aims to help building the future of their clients or their own future in a stronger and better way, through a team of people who know the customer's products and its industry. Thus, the vision is shared by the whole group, GE aims to provide support to customers in their business; GE Capital just represents a simple variation of a general concept.

- <u>The relationship between corporate culture and methodology in GE Capital</u>

There are some important concepts related to the corporate culture of GE Capital. The first is to "Engage the hearts and minds of the employees", and then work with employees to simplify the way they work, develop a process faster with fewer defects, less re-work. Also carry out training, the resources involved in a workout, of course, all this organization has a positive effect in addition to being a source of enrichment for the people.
A second concept is "Aligning employee effort with business and customer success," and the launch of a project should be clearly defined through the DMAIC and Lean business case, vision and the benefits expected to align the efforts of staff towards the goals .

A third concept is "Stimulate innovative thinking and practices, change drive continuous improvement functions": using clearly and practically the methodologies of Lean and Six Sigma improves the involvement of the staff that starts using them within their own team. This year, GE Capital has developed a project in Europe by HR through which over 700 people have been involved with the Lean training and innovation. Thus, in this sense, GE Capital invests heavily on training and training resources. These issues must be seen as a synergy between corporate culture and methodology.

Actors and organizational structure

Consider the organization chart of GE worldwide: GE has a worldwide CEO and this person has in his area of responsibility also quality. There is a senior vice president who reports directly to the CEO of GE Jeff Immelt. Consequently this person has the overall responsibility for IT, quality and other aspects. This approach is respected even by GE Capital, where there is a CEO, in this case European, to whom reports an Operation Technology and Quality Leader for EMEA (Europe, Middle East, and Africa) and is head of technology, IT, quality, operations and sourcing. At the same time, the Leaders for each specific function, e.g. IT quality, and sourcing operations report to this Leader.
In the classification of resources based on the knowledge of the methodology, at the lowest level there are employees with a basic level of awareness thanks to on-line training methods; at the end of this online training, a certificate is issued.
Then there is the Green Belt certification that is no longer totally widespread in the organization; today there is no such requirement that all team leaders possess this certification. It is a goal that can be pursued more or less depending on the business unit or team quality. Some business are more interested in certifying their own resources, others are still interested in their involvement in the methods but not the certification.
In summary, the three certificates on the methodology are still Green Belt, Black Belt and Master Black Belt.
At GE Capital is to be achieved this year the target of 20% of employees who were at least somewhat involved in a DMAIC project or have received the training for the awareness of Lean and Six Sigma methodologies, plus of course the Green Belts, Black Belts and Master Black Belt.

- Training and main figures

The basic level of awareness has the duration of four hours; it is a mix of theory and practice in conducting the exercises.
The duration of the course for the Green Belt certification is one week while the Black Belt of two weeks plus one week of training for CAP in the whole three weeks.
To be certified as a Master Black Belt Black should have been involved in a number of important projects, with co-ordination role of the other resources involved in the projects. The role of Master Black Belt is different from that of Black Belt. The Black Belt is a project manager, Master Black Belt is responsible for a team of improvement, serves as a mentor for the Black Belt, it also has a function of development and promotion of the methodology as well as coaching on product management methodology. Therefore, the Master Black Belt certification does not, however, follow a specific course. A Black Belt to be certified as a Master Black Belt must include a number of projects with high impact evidence, or certified by the finance function. Virtually any business must certify the existence of these projects and their financial impact.

Thus, with regard to human resources training in the methodology, before a simple awareness is given, then the Green Belt certification, then the Black Belt certification. The Master Black Belt certification is awarded through the field and even a final exam. For the Green Belt and Black Belt there is a written examination to be carried out on-line with questions; the Master Black Belts are evaluated by a panel of persons employed in the quality certification.
About the Process Owner, it is not necessarily that is at least a certified Green Belt. However, all project participants are still undergoing a short training on the methodology in order to have a certain awareness.
Finally, some notes about the Quality Leader. This important figure reports directly to the CEO of his business unit; he is a member of the leadership team and reports indirectly to the Quality Leader's superior role. For example, the Quality Leader for Italy reports directly to the CEO of GE Italy and indirectly to the European Quality Leader.
In addition, a Quality Leader is part of the Quality Council. The European Quality Leader is part of the European Quality council; moreover, usually the Quality Leader of the countries involved in the projects are part of the council.
The Quality Leader is the person that bring together all the quality resources, usually divided between Black Belt, which usually refer to a Master Black Belt and Green Belt. For example, GE Capital has a Quality Leader for each country.
The Quality Leader for individual countries refer indirectly to the European Quality Leader, which reports indirectly to the CEO for the functions of quality, IT, sourcing and operation.

- Benefits of internal training resources to the methodology

A first advantage is the fact that trainers know, in addition to the methodology, the company's business, and then the examples and topics during the course will be more relevant to the business itself, as well as more interesting to participants.
In-house training also allows developing important skills in team trainers, who in addition to understanding the methodology must have the skills necessary to pass their knowledge to resources to be trained. This brings an advantage for the company that does not depend on third parties, but has within itself the necessary skills. Also in this way the company is more flexible, since the internal team of trainers that can be managed more easily in relation to the needs of the company. Finally it brings an advantage in terms of costs.
GE also form on the methodology some of its customers; for this customers do not have to pay, as many other activities that are performed for them. In projects it happens to work jointly on processes that involve both GE and its customers. This could definitely be one of the influences of the Lean philosophy that is intended to be extended to suppliers and customers.

- Criteria for project teams, tasks and internal hierarchy

The projects have a quality organizational standards. There is a quality manager, which can be a Black Belt, or Quality Leader if the project is particularly important. There is a Business Champion, i.e. the person which should provide a general direction to the project and intervene in case of problems like constraints to overcome. Then there is a Business Project Leader, i.e. a figure belonging to the business involving the project. Typically it could be the Functional Leader if it is a project concerning a specific process area, or it could be the Business Process Owner. Finally of course the team members selected according to the type of project.

All these figures are SME (Subject Matter Experts), usually associated with the process, plus all the other main actors related to the process itself, for example those who are upstream or downstream, so for example members of the marketing function or the controller. Even customers, sometimes, may operate within the project team.

10.6.3 Strategic aspect

Strategic project selection

The improvement projects are selected not only by the quality function, but are subject to a screening process.
The choice of a project can find inspiration from a country, a function, the CEO, or generally from any stakeholder, including customers. However, when a country or a function propose a project, this should have been proposed following the Voice of the Customer. The origin of a project may be the most disparate but then it is subject to a screening process, otherwise there would be too many requests to be handled. Selections are then made with a scoring system of the projects. The criteria by which projects are evaluated are for example: compliance, the level of customer impact that identifies the urgency of the project, the expected financial impact and the expected ROI.
The combination of these elements provides a score that allows the assessment of the project, in that sense there is indeed a link between strategy and projects. So for example, as a project will have an impact of compliance and hence its implementation is critical to law or regulation, rather than a strong financial impact; furthermore, the higher the score the greater the chance of being selected. Compliance is one of the benchmarks, so if there is a project that has a maximum level of compliance it must be implemented independently of other factors.
Whatever the score assigned to a project then it needs to be discussed by the Quality Council where business comes into play abilities, skills and experience of the resources involved. The screening process helps provide a rationale to select the most deserving projects, but final decisions on projects are not just based solely on a mathematical model but are the result of the evaluation of the Quality Council business.
There are Quality Council at local and European level; all requests for projects are brought together and assessed from the council. Thus, after the screening it is the Council itself to decide which projects to start.

10.7 UniCredit Group

The last organization in our in-case analysis is UniCredit group. In the first sections we will outline the reality of this group, going then in detail on the different aspects of the methodology. This case study was developed mainly thanks the four interviews performed at the Quality Department of UniCredit Group, located in Milan (Italy). The first two interviews were made to Mr. Fabrizio Majorana, while two other interviews were made respectively to Mr. Emil Brudek, Black Belt of UniCredit and Mr. Michele Cavagna, Green Belt of UniCredit Group. We are now going to give a brief description of the main interviewee, i.e. Mr. Fabrizio Majorana.

10.7.1 General description

<u>The origin of UniCredit Group</u>

The origins of the group dates back to the creation of Rolo Banca in 1473, when he created the institution of public loan Monte di Pietà di Bologna. In recent times, UniCredit Group is the result of the merger of nine of the major Italian banks and the subsequent aggregations with the German group HVB and the Italian Capitalia. In 2007, the Group strengthened its presence in Central and Eastern Europe, now has nearly 170,000 employees and has built more than 1500 companies all over the world.
The steps outlined below describe with greater detail the recent history UniCredit Group:

-(1998) UniCredit di Credito Italiano, Rolo Banca 1473, CariVerona, Banca CRT, Cassamarca, Cassa di Risparmio di Trento e Rovereto, Cassa di Risparmio di Trieste merge, creating **Unicredito Italiano**;

-(1999) Banck Pekao (Poland) gets acquired;

-(2000) Pioneer Investments (USA), Bulbank (Bulgaria), Pol'nobanca and Unibanka (Slovakia) get acquired. Mid east markets are growing;

-(2001) The group has three business divisions: Retail, Corporate, Private Banking and Asset Management;

-(2002) Banka (Croatia), Demirbank (Romania), Živnostenskå Banka (Czech Republic) get acquired;

-(2004) New business division: Global Banking Services. Its responsibilities are cost optimization and internal process improvement;

-(2005) UniCredit merges the German group HVB;

-(2006) New Business division: Markets & Investment Banking;

-(2007) New acquisitions in Kazakistan, Tagikistan e Kirghizistan. UniCredit Group also merges with Capitalia Group, born in 2002.

UniCredit Group is the first European banking group and one of the largest banking groups worldwide. The group, which is headquartered in Rome, has its administrative and operational headquarters in Milan. It has over 40 million customers worldwide, operating in 22 countries and has representative offices in 28 other markets.

Table 10.9: Data on UniCredit Group.

UNICREDIT GROUP	
Operating countries	22
Employees	166000
Revenues	€ 27.57 billion
Net income	€ 1.702 billion
Legal office	Rome
Operational office	Milan

Source: www.UniCreditGroup.eu/ (2009)

Vision and Mission

The Vision of UniCredit Group is:

"To create a new way of banking by thriving to serve our clients with innovative solutions."

The Mission of UniCredit Group is:

"To be the Bank of Choice for our customers by putting their interests at the forefront of every company initiative; to be the ideal business for capable, motivated people by listening to their input and feedback"

The set of shared values that are the foundation of the UniCredit Group are described in a Charter of Integrity.
The values of UniCredit Group are customer-oriented, as well as the mission of the group. This is obvious, because especially after the economic and financial crisis of recent years, customers have lost confidence in the banking and credit world.
The values of UniCredit are:

- Equity;
- Reciprocity;
- Freedom;
- Respect;
- Trust.

For this reason, the sharing of values as much as possible oriented to customer satisfaction is the right starting point to create a new relationship of trust and loyalty that is the basis of continuous creation of mutual value.
The importance of this approach to consumer-oriented values is also demonstrated by this statement of Mr. Fabrizio Majorana, Chief Quality Officer of UniCredit Group, and main interviewee for this case study:

> *"La crisi ha cambiato molto il mio modo di lavorare e a cambiato il modo di lavorare in banca, mi ha dato una mano per spingere su certe progettualità, voglio una qualità molto votata al cittadino che entra in banca, piuttosto che ai grandi aspetti finanziari, è un'occasione fantastica per far entrare il cittadino in banca e per fargli dire dove dobbiamo lavorare"*

(Fabrizio Majorana)

The business model

The group UniCredit has adopted a divisional business model that ensures both flexibility and strength. The service delivery is guaranteed through a network that operates in multiple markets through local banks are strongly rooted in the territory.
The network management benefits both of the work of centralized divisions that typically offer high quality products at competitive prices and the factories of global service that supports the entire group and maximize the effectiveness and efficiency of processes.
This organizational structure allows you to better allocate resources, relying on domestic capabilities in all aspects of banking business and a branch network that connects the group to local communities and millions of customers.
In this way, the UniCredit Group is able to create value in all activities and readily seize growth opportunities wherever they arise.
This business model is based on four pillars, namely the centrality of the customer, the multi-local approach, global product lines and global service lines.

- Focus on customer and network management. It is the main focus areas of retail, corporate and private banking, which specialize in the business relationship with clients to maximize the value and satisfaction in the medium to long term;

- Multi-local approach. It allows local banks to be responsible for managing the distribution network and relationship with customers;

- Global product lines. They are the centers for the creation of value for all geographic areas, that leverage the significant expertise within the group: Markets & Investing banking, asset management, leasing, house hold finance, global transaction banking and marketing and retail segment;

- Global service lines. Support the functions of network management and centralized product factories, and factories with specialized services: back office, ICT, procurement, real estate and shared service centers.

Divisions chart

As you can see from Figure 10.7 here below, the organizational structure of the group is composed of four main business divisions:

- CEE: It deals with the organizational and strategic management of the group;

- Retail strategic business area: Relations with existing customers, rather than companies or other banks.

- CB (corporate banking) & PB (private banking) strategic business area: they are the centers for the creation of value for all regions;

- GBS (Global Banking Service) strategic business area: it is a strategic business support area for other business areas.

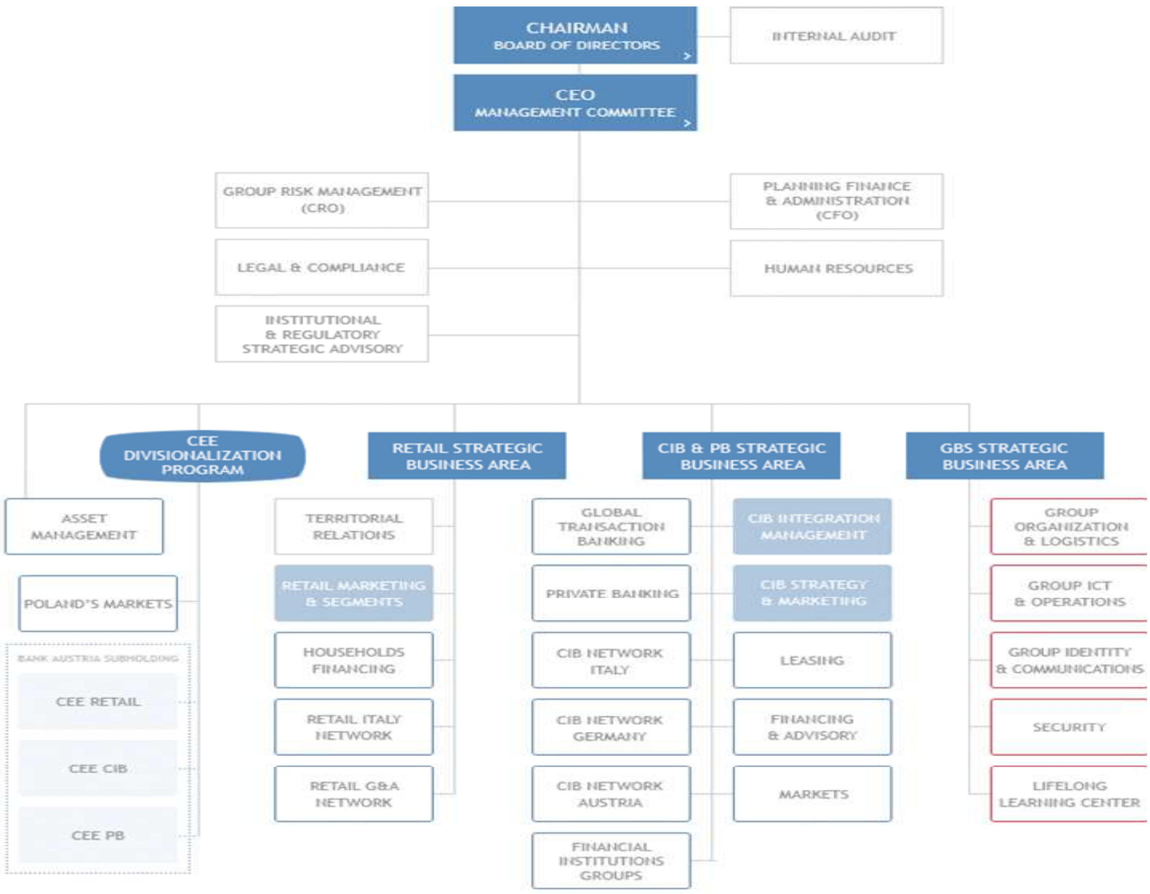

Figure 10.8: UniCredit Group divisions chart (Source: www.unicreditgroup.eu).

General information about Mr. Fabrizio Majorana

Mr. Fabrizio Majorana got a degree in Mechanical Engineering with concentration in the automotive sector and aerodynamics in 1993/1994. In 1994 he became Black Belts and in 1996 Master Black Belt, receiving a training on the principles of Six Sigma and quality between U.S. and France.
He began his career with Six Sigma in Allied Signal, one of the first multinationals that with General Electric launched the Six Sigma program. He worked as Black Belt with responsibilities for the airbags project. This allowed him to work with big names of motor such as Porche, Nissan, Sat and Alfa Romeo.
After two years working as a Six Sigma Black Belt gets the prize in 1995 as the best waste reduction in Europe.
In 1996 he joined General Electric (GE) within the group launched Six Sigma in Europe. He trained and certified almost 350 people within the Black Belt Six Sigma projects. In 1996, he specializes in Design For Six Sigma (DFSS).
In Ferrari, where he worked for four years as head of the quality of processes participated in several Six Sigma projects that encompassed both the processes that design activities (areas of DFSS).
After a period in Maserati as a quality manager, he goes in Formula 1 (F1) where he was responsible for quality and reliability of the car of Michael Shumacher. During this period he develops several Six Sigma projects.
During these years he joined the panel of jury of two quality committees (one in the U.S. and one in London) evaluating the best quality projects applying Six Sigma methodologies, Lean Six Sigma and Design For Six Sigma.
As a member of the jury assesses different projects belonging to a mix of sectors (including a project on oil and one on Boing).
He is currently Chief Quality Officer of UniCredit Group, and continues the work as expert and judge of quality in committees mentioned above.
Mr. Majorana has now exceeded 400 projects within the Lean Six Sigma and Design For Six Sigma, of which about 40 within UniCredit Group.

General context of UniCredit Group

The problem is in services that often there is no perception of customers feelings, because of the difficulty of managing data in a standardized and valid way. Such data are subjective and dependent on the presence of numerous filters of perception that does not allow analyzing the threshold that determines the defect as something actually intended.
The defects in the case of services have a greater variety of weights and we can consider those defects due to filters of perception of certain customers or not. Contrarily, in a manufacturing, a defect is a defect is more objectively identified.
For this reason, the service provided that the customer does not perceive as fitting to their expectations (because of the filters of perception) should not be regarded as a full defect, but must be weighed to determine the real DPMO.
To be able to perceive correctly the consumer is important to replace the concept of media with that of standard deviation. In fact, the standard deviation is the element that is actually perceived by the customer.
For example, a process that can fit on average is within the limits of control, but due to the large amplitude distribution could result in many unhappy customers. All this would lead to a mismatch between what the company sees and what the customer feels.

It is therefore necessary to identify the appropriate metrics; the comparison of key metrics that emerged from the study of literature and the metrics used by UniCredit can identify the following common points:

- Costs of poor quality;
- DPMO;
- Process capability;
- Response time to complaints;
- Process time;
- Complaint recovery time;
- Queue time for a service.

You may notice that there was a substantial confirmation of critical studies, in particular, the UniCredit case has identified two additional causes of process variability: the difficulty of data aggregation and internal communication, i.e. the need to simplify and standardize the language of Six Sigma in order to ensure the participation of everybody.

Lean Sigma in UniCredit Group

UniCredit has chosen to implement Lean Six Sigma (LSS) as the only official group methodology for process improvement. As a result of this choice, the group has taken responsibility for its implementation on the organizational and operational dimension.
This methodology provides an effective approach because it looks for creative solutions and not always trivial, especially when you have goals to reach or difficult to solve complex problems.
The Six Sigma can improve the quality or design, efficiency, flexibility and validity of the processes by eliminating defects and reducing sources of variability.
Lean Production organization is instead more focused on improving the process flow. The synergy between the approach and methodology of Lean Six Sigma has two concurrent effects:

- Flexibility of production processes and decision-making (Lean management);
- Improving the quality of business operations, products and services (Six Sigma).

It should be stressed that Lean Six Sigma is not only the use of instruments of two methods for the quality but it is culture and continuous improvement, something that goes beyond the tool.
The application of the main instruments of the two methods must be more integrated as possible, but it has not to be a constraint:

"E' importante sottolineare che una metodologia, per essere efficace, deve lavorare per le persone e non

viceversa. Questo significa che essa non può e non deve essere applicata sempre con vigore e inflessibilità, ma che deve adattarsi continuamente alle condizioni in cui viene applicata.”

(Emil Brudek)

For example, if the project team notes that a specific process can be reorganized at Kaizen level, even if that tool is not typical of DMAIC or DFSS, you should use it if it can help the team to solve the problem more quickly.
Again, if an analysis of variance generates invalid results, the project team can focus for example only to improve the process flow through the Value Stream Map which is a typical tool of Lean.

10.7.3 Operational aspect

Methodology implementation

The problem facing companies operating in the service sector regards often the applicability of Six Sigma and Design for Six Sigma.
The applicability of the methodology in a service company like UniCredit mainly depends on two factors:

- The ability to data standardization processes;
- The ability to identify the right indicators and the right metrics to measure processes.

Six Sigma needs standardization, but standardize service processes is much more difficult, because they are more variable and there is more customization. Therefore this could lead, rather than in manufacturing, to tighten a range of behaviors related both to people and processes.

“La realtà è che nei servizi manca il prodotto, mancano le variabili tecnico, meccaniche e produttive, c’è un quantitativo di fattore umano molto grande, per questo è difficile individuare le giuste metriche di misura; l’oggetto di studio non è più il prodotto ma il processo, ad esempio la gestione del tasso di interesse, dei processi di reclamo o di credito”

(Fabrizio Majorana)

Service companies, to successfully implement Six Sigma, should manage these two aspects, not neglecting them, but manage according to the context and needs.
For example, UniCredit at the beginning managed the written complaint process as 0.7 sigma and after reaching 3.1 sigma it has stopped because of the high variability of the measures.
Apart from the DMAIC there is scope to implement other cycles; for example in the provision of credit some statistical models such as DFSS, simulation and so on can be applied.
In general, we can say however that six sigma is not a standard to reach but a long-term vision.
In fact, for the factors just mentioned is almost impossible to achieve six sigma, the company is deciding whether, how and to what extent its application.

“Credo che la cosa importante non sia l’obiettivo ma l’utilizzo di una metodologia. Gli obiettivi sono

qualcosa difficili da raggiungere ma che comunque vedo, questo per me è il 3.4. E' importante il modo in cui ci arriviamo, da dove partiamo e dove arriviamo"

(Fabrizio Majorana)

This means that the principles and tools of Six Sigma are valid even in services, but they must be managed in a specific and customized way, according to the process.

- Language and Communication

The context for the application of Six Sigma has evolved with the development of the service sector and the level of customization. In particular, as applied to DFSS is the latest step in the development of Six Sigma methodology, because the first application of the methodology in this area is date back to early 2000.
For this reason, the concepts, metrics and tools of the methodology were completely new for most people who work in this area.
To prevent the development and use of this method as a privilege of a few experts, services should greatly simplify the language that should be easy compared to the highly technical.

"In una azienda di servizi come UniCredit, al contrario delle Formula 1, per diffondere la metodologia e la cultura del Six Sigma dobbiamo semplificare enormemente il nostro linguaggio per evitare di diventare isolati"

(Fabrizio Majorana)

It should also be considered that the language and terminology used in the field of services may be different from that of manufacturing. For example, in UniCredit while for retail product has the same meaning as in the case of manufacturing (e.g. the credit card, mortgage, loan, etc.) for the quality holding division the product is the provision of a service through the management of a process that becomes the sole object of change.
In conclusion, it is important to unify the way of working to solve the problems of language and interaction.

- The data

The Six Sigma methodology needs data. In UniCredit is guaranteed this necessity. Indeed, sometimes the size and complexity of such data does not allow to be managed with standard software tools.
For example, if you want to study the evolution of ATM withdrawals you must consider that in Italy there are almost 11,000. If you consider that the group has nearly 10,000 branches around the world is easy to understand that the amount of data to manage becomes huge. Another example is a management process for written complaints from customers. UniCredit has 19 different mapping processes depending on how the complaint is made. This implies that the available data are huge and highly diversified.

Methodology tools

As outlined, data and information need analysis of customer satisfaction and come to the quality department already aggregated.
Therefore, in projects for process improvement, tools are not used directly for obtaining and study the needs and customer satisfaction.

However, very often during the measurement of customer feedback, have been used techniques such as:

- Focus groups, interviews, questionnaires for VOC analysis;
- Brainstorming and benchmarking (for multiple analysis of different processes);
- Survey techniques (for process monitoring and analysis of behavior).

The Quality Department in order to analyze the needs, also uses the internet monitoring (in particular through click stream analysis) and customer relationship management.
The latter two instruments for studying the needs of customers are having an increasingly important role especially on the spread of mobile banking that allows, through the use of the Web, better tracking of behavior and the real needs of consumers.
Although SERVQUAL has been used frequently, usually to measure customer satisfaction, analysts are based on TRI*M index.
The TRI*M index returns an orientation on where to focus their efforts, is monitored over time (usually quarterly or monthly) by the majority of top managers.
It is not only used for the external customer but also for internal ones. For example, the retail uses to evaluate the service given by GBS, analyzing the internal entities including the quality department, as if they were internal customers.
Each department that supplies services to another entity is subject to the TRI*M. For example, the security, responsible for the safety of people, is evaluated with the TRI*M through a series of targeted interviews.
This indicator is the parameter of internal and external measurement of satisfaction. It is even used to measure the effectiveness of project selection and results, to stress the importance of an improvement project or measure the customer value.
Perhaps a limit of one such extensive use of the TRI*M is the lack of analysis of the relationship between customer satisfaction and performance improved by the process of Lean Six Sigma team.
In other words, it is important that this index does not serve only to say that the customer is not satisfied but also defining the real areas of improvement, otherwise you could schedule improvement actions that do not impact heavily on the performance of process.

> *"Non ci sono sempre i dati delle prestazioni di processo perché esso può non essere misurato, sappiamo che il cliente non è soddisfatto ma possiamo non vedere da dove nascono le cause di tale insoddisfazione. La misura di customer satisfaction ci dice che manca soddisfazione, ma noi dobbiamo capire come migliorare il processo che impatta sulla soddisfazione. Per questo motivo la nostre attività di misurazione di processo sono reattive"*
>
> (Emil Brudek)

10.7.2 Organizational aspect

Culture and intangible assets

According to the strategy of UniCredit to strengthen the culture of quality is necessary that the aims and motivations of the individual align with the company.
From the perspective of the strategy, the mission of UniCredit allows to check this will, because it seems based on the cultural foundations of Lean Six Sigma methodology.

To change attitudes to people, it is essential that all understand that mission. For this to happen the organization needs to explain directly to the individual the importance of focusing on the culture of quality, customer.
This cultural problem must be faced both top-down, from top management to the operational frameworks, and bottom-up. If the culture of top managers is not aligned to this strategy, it is difficult that it can spread throughout the rest of the organization because it is from them that decisions come to life.
Even obtaining the first results plays an important role, in fact, through the launching of projects, the perception by persons of concrete results facilitates the dissemination and awareness of the new methodology.
It is probably more difficult to disseminate a culture Lean Six Sigma in banking than in other situations because this method is less direct connected with the way in which the bank creates value.
For example, in corporate and private banking, managers are more oriented to the fluctuation of securities on the stock market rather than the activities of process improvement. In these segments is also much more difficult to standardize processes.
If you do not improve or you do not respond effectively to the needs of customers, they will leave the bank in favor of competitors, reducing the profitability of the business, because of the loss of purchases and the satisfaction of shareholders and employees, because of the impossibility to obtain promotions and an interesting work.
The importance of employee satisfaction is also evidenced by the recent change in the mission of the group.
While the former mission considered the value to the customer the only tool for the creation of shareholder value, now it points to this goal considering employees and process efficiency and excellence.
In any case, the mission is customer oriented but UniCredit has realized that to create value for the customer is necessary to ensure excellence, process efficiency combined with employee satisfaction.
To get the satisfaction of customers, shareholders and employees must be competitive in the market through the development of excellent and efficient processes, it is necessary to draw a guideline to describe where the company wants to go, what they want to achieve and why. The guidelines are UniCredit improving its global leadership through market growth. In order to obtain such growth there are four pillars:

- Customer satisfaction through the improvement of services;

- Lower costs to increase profitability;

- Risk reduction through better process management.

The crisis in global banking and financial system has changed the way to work in banks and financial institutions. In particular, it has pushed the system to:

- A quality very devoted to the citizen, who has lost confidence in credit and financial system;

- Reduction of costs and risk especially to avoid similar crises in the future.

The concepts of customer satisfaction and risk mitigation are now part of the quality of banking companies.

Actors and organizational structure

The holding company of UniCredit Group is organized into segments called Strategic Business Areas (SBA). These are three segments: retail, corporate and private banking, global banking service (GBS).
The GBS is a strategic business area of support that is not in direct contact with the customer and does not directly create value and business.
His task may be, for example to draw a new organization, change of procedures, to support those who want to create a new product, improve internal processes, design and organization of work processes and so on.
Each will serve a SBA deputy CEO, that a figure which in turn responds to the Group CEO, Mr. Federico Ghizzoni.
Within the GBS segment there are a number of service providers for retail and corporate segments, including the organization and logistics area, which includes the Quality Holding Department (QHD), managing the Lean Six Sigma projects for quality.
Currently, the department, in order to identify priorities for action, it interfaces directly with the Customer Satisfaction Holding Department (CSHD) of the group, that is in the retail segment.
If the Customer Satisfaction Holding Department realizes that it is necessary to improve some specific organization and business aspects, it collects and aggregates all the information from all banks, indicating the QHD, on the basis of a group strategy, where to focus the Six Sigma projects.
It is like the QHD of the group was a service provider and CSHD an internal customer.
As the QHD is unable to manage all the processes of improvement at the same time, to spread the culture of quality throughout the organization, UniCredit decided to create a series of quality departments within each strategic business area (SBA).
Currently a Customer Satisfaction Holding Department which is within the Retail area, specific guidelines to the Quality Holding Department to start new projects through Six Sigma analysis of data collected data.
The goal of UniCredit for the future is to have organized and integrated departments of quality made by a quality holding, a quality department and a quality department for each segment within the different banks. All this is summarized in the figure here below.
The head of the quality of an individual financial institution will report to the CEO of the institution itself; the Quality Manager will report to the deputy CEO of the segment, but the guidelines on quality methodologies to be applied to solve problems will always be given by QHD. In fig. 10.9, the integrated organizational structure of UniCredit, the red arrows represent such relationships between these departments.
The quality of the various departments of banks such as HVB in Germany, in Poland, Pekao, Bank of Austria in Austria, which are part of a segment should report first to the quality department of its segment and then to the quality department of the group.
This pattern of organization allows different departments to deal with problems, from a better organizational, political and business processes point of view.
The ultimate goal is the independence of the bank through the dissemination of a culture of Lean Six Sigma throughout the group.

The QHD will still be involved because they serve as important reference point and training by providing:

- Methodological support, guidelines and policy of the group;

- Training of people involved within the various departments;

- They are the supervisor of the methodology;

- Management of multi-lateral and international projects (including ensuring repeating the project in different areas);

- Implementation of Lean Six Sigma (LSS) as the only official group methodology for process improvement.

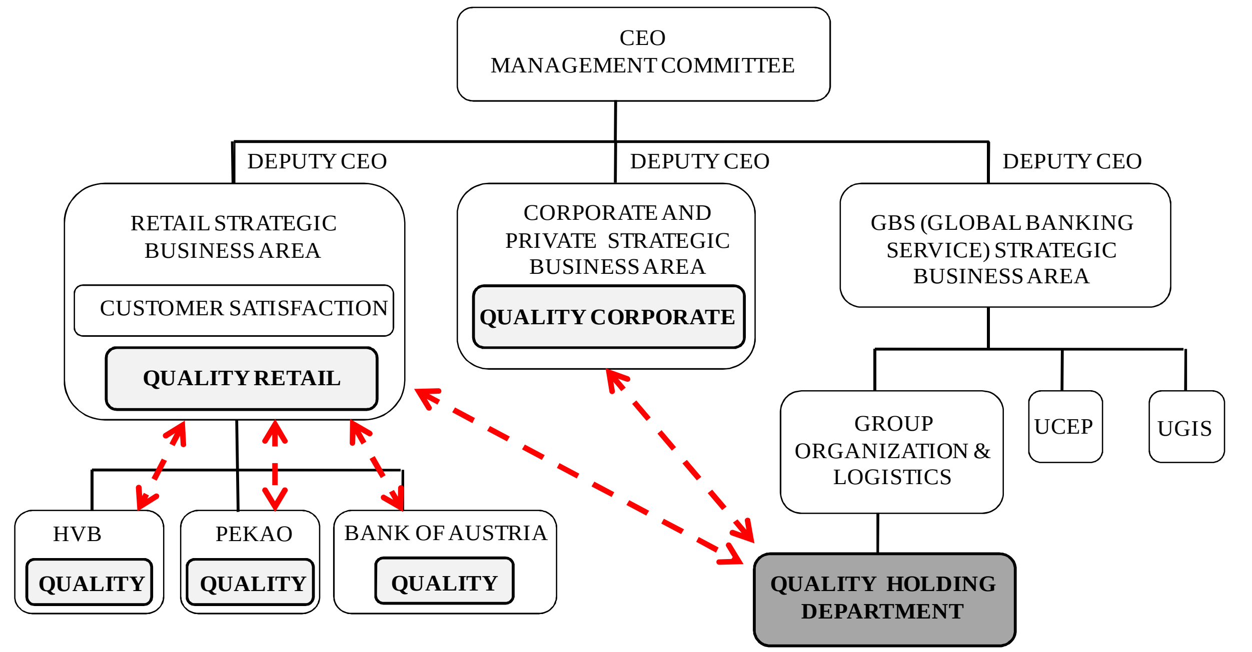

Figure 10.9: Integrated organizational structure of UniCredit Group.

It is clear that in order to successfully and uniformly implement the methodology and, especially in such heterogeneous and huge group, it is important to have good internal communication group.
The diversity of sectors, markets, customers, and people is the main difficulty encountered in the process of implementing a strategy of strong cultural impact; for this reason UniCredit wants to move forward by steps.
First, it aims to the diffusion of quality concepts and the belief (through continuous improvement projects of the Holding Quality Department) of the importance of the methodology, then implements the actual plan for the creation of various quality department.
The objective of UniCredit to have an organized structure and quality of integrated

departments that work for the customer; this is part of the long-term strategy: the strategy to settle the culture of quality, policies, internal regulations and internal growth in individuals. The achievement of these objectives is however slowed down at this time because the group is also focusing on a complete structural reorganization, which appears to be the priority.

- The project team

The composition of a project team is decided by the QHD responsible according to the complexity and characteristics of the project.
It depends on several factors, including the importance, internationalization and interdependence with other nations and with other projects, strategic effects, and so the expected saving.
So far, the Quality Holding Department has not developed projects internationally, but only improvement projects for individual companies in the group.
This is one of the reasons because the teams are not very numerous. However, if the project is particularly complex can also work alongside a dozen people.
The current problem is that, having the group only recently started the implementation of the methodology, there are few people who have trained and prepared the necessary skills to deal with Six Sigma projects.
In general we claim that in UniCredit, for every Six Sigma project it is necessary:

-A Master Black Belt (MBB) that acts as a supervisor;

-1 or 2 black belt (BB);

-Some resources of the client, such as an expert who deals with the process or project management and acts as a green belt (GB);

-A Champion (CH);

-A project owner (PO) in charge of the process.

The involvement of MBB, which normally is represented by the director of the QHD Mr. Majorana, depends on the project. Even the BBs are usually internal to the QHD. The presence and the competence of internal resources (such as managers of the group) play an important role because they work directly in the process.
The process owner (e.g. a manager of the bank involved in the project) in order to justify the use of its resources should be fully convinced of the truth and validity of the project. The champion, who is usually a top manager who is very familiar with the general aspects of the methodology, often even serves as a sponsor. His task is to support the QHD’s team and check that the objectives are achieved regularly; he must understand, manage and supervise the project (and therefore also the process owner), breaking the functional barriers that are created.
The sponsor usually even has to decide, through a comparison with the quality team responsible for providing methodological support, whether or not the project deserves to be carried out.
As regards the study of literature, it stress the figures of the quality leader and of the business quality council, which in UniCredit correspond respectively to the chief of the quality

department of strategic business area (with strategic responsibilities and coordination between Projects) and to the deputy CEO (with responsibility for initiation of projects).
The main difference is that in literature the figure of the process owner is not always distinct from the others but is often associated with the master black belt or champion.

- <u>The training</u>

As mentioned earlier, at the moment, there are many people who have a strong preparation in the field of Lean Six Sigma.
The group's objective is to achieve a good critical mass of GB and BB (now there are about 130 GB already trained and certified within the segment Global Banking Service), which will directly manage the various quality departments created for the development path of methodology within the group.
Training is done either by the staff of QHD and suppliers and external consultants, appropriately selected.
The quality department is divided into three holdings: Methodology & Training (M & T), Monitoring & Metrics (M & M) and Operation & Communication (O & C). The M & T takes care of creating the material with which the training is done.
Even the BBs of M & T, in turn, are training courses to understand the main techniques to make training in the best way.
UniCredit is currently using mostly outside training suppliers but the aim in the medium-long term, is aimed at developing the trainers within the group. In any case, the training programs made by consultants are always agreed with the group M & T Department, depending on the nature of the projects, markets and strategic objectives.
The group policy says that the Six Sigma belts should preferably come from within, but if this is not possible they can also be hired from outside.
Training from inside gives you greater credibility and expertise on the banking system, people, language, methods and difficulties of interfacing, and changes typical of the organization.
The training should also focus on leadership skills and culture of quality. In fact sometimes culture, communication, the ability to lead and manage people and the language are more important than that the ability to use specific tools.

10.7.4 Strategic aspect

<u>Strategic project selection</u>

For banking sector, government compliance is the first variable for the choice of projects. The second and the third variable in order of importance are respectively the voice of the customer (customer satisfaction) and the project's impact on saving and on both legal and operational risk.
Another very important variable for project selection is calculated through the benchmarking group. In fact, only through an integrated analysis of group you can find the weak areas within the organization rather than those of excellence.
In summary, the main but not the only variable in the selection of projects are currently UniCredit:

- Government compliance;

- Voice of the customer (customer satisfaction index);
- Saving;
- Legal and operational risk;
- Support of the sponsor;
- Group benchmarking.

The QHD, being a domestic supplier of the group, very often does not address the selection of projects, because the department of customer satisfaction develops such activity.
The strategy for projects selection in UniCredit is customer oriented. The customer is essential and satisfaction is often measured by the TRI*M index.
It is interesting to note that compliance with government laws, which for UniCredit and probably the financial services industry in general is the main criterion for project selection, was not found in the literature as well as support the sponsor of the project.
As for UniCredit, it also emerged during the selection processes that the company still relies heavily on subjective factors and personal experience rather than on objective data.
At the time, UniCredit is not yet organized to process, so it is difficult to identify suitable metrics for select processes with the characteristics and needs of different customer.
Again, very often the selection decisions do not focus only on the data collected, but especially at the level of top managers, experience and feelings.
The UniCredit Group has within it some 6500 jobs, it is clear that the wrong identification process means working for a very long time in a useless and unprofitable way.
It should therefore develop scientific models, which identify and focus properly the different projects with.
The future goal of the organization consists precisely in the official selection of a model of project performance group keeping track of the performance requirements of the process and allows the customer to determine whether or not the project is worth to be implemented.
This model of project selection, which has already been developed by the QHD but it has not yet officially released and used within the group, is called PSP (Project Selection Program).
The innovation of the PSP is not so much in the instrument itself because it must be easy to understand and use even for people who are not familiar with this type of activity.
The added value is the fact that decisions are made uniformly and strongly on the basis of objective data.
It allows you to select the projects comply with the three basic items that have emerged from the literature (Antony, 2006):

- Voice of the process;
- Voice of the consumer;
- Voice of strategic business objectives.

10.7.5 Participation to a DFSS project in UniCredit Group

Towards the end of this case study, there has been the possibility to gather additional data as participant observer in a service redesign project. The project pertained the applicability of Design For Six Sigma in services and in particular the methodology was used develop a plan for managing the cash flow inside of automated teller machines (ATM).
In this case it has been considered more convenient redesign the process rather than trying to slightly modify it through a DMAIC classical incremental improvement cycle.

<u>Project description</u>

The process to redesign must properly handle a certain amount of money in the ATM, trying to follow a trend of peaks and valleys.
This raises serious problems when establishing a strong concentration of demand in time and space because the ATM may not be able to provide the service due to lack of money internally. For example during Christmas demand for money gets drastic increases due to higher expenses.
The aim of the service provider must be to guarantee the performance to ensure customer satisfaction.
In order for this to occur the amount of money inside of the door cannot follow a constant trend, but must always be greater than demand.
This difference between charge and request inside of the ATMs is not a good thing for the banks because the money invested cannot be invested or used for other business purposes. If you consider the size of the UniCredit group, which in it has more than 11,000 ATM machines it is easy to understand what it means for the company to recover at least some of this money.
Besides this, we must consider the fact that the more money is in the ATMs, the greater is the cost of managing the risk (e.g. risk of robbery).
In summary the project must consider several variables:

- Presence of peaks and valleys of demand;
- Presence of flat thresholds of money to that between the charge and request for money there is money in excess;
- Excess money cannot be used for other purposes and reduces the cost and risk;
- Safety wants to limit the cash used for ATMs;
- Banks want to increase cash flow to ensure customer satisfaction.

<u>Project Goals</u>

The project's goals are to find a logic to follow the trend of the curve by taking the customer's historical analysis of a seasonal pattern, week per week for one year, for each ATM. Following the trend of the curve and an offset for safety reasons, you can:

- Mitigate risk (e.g. risk of robbery, even during transportation);

- Reduce the amount of cash assets;
- Reduce operating costs of the cover (e.g. due to travel to load or amount of information that run);
- Provide the service to the consumer.

The objectives of the project thus meet the pillar of UniCredit, i.e. customer satisfaction (money always available), less costs and risk.

<u>Applicability of the DFSS project</u>

This DFSS project is interesting because it might involve, from in-depth analysis of information (about the needs of consumers and the process variability, trends, the possible correlations between the different branches, the forecasting, etc.) a plan of activities to build a new process customizing single ATM lines with the objectives of the organization.
All historical data collected should be included within the model, in order to obtain the flow of money that should be available in every moment in the ATM.
The great advantage of a model like this is that it can be applied simply and flexibly to all banks in the same way, while with a simple DMAIC cycle improvement, difficulty the process would.

PART III – RESULTS

Chapter 11 -CROSS CASE ANALYSIS

In this chapter we deal with the transversal analysis of the four case studies previously expounded. The cross-case analysis (Eisenhardt, 1989), as explained in the previous chapters, allowed identifying a number of best practices for every of the five aspects of the DFSS applied to services. Furthermore, the possible connections have been analyzed, both between the best practices in the same aspect (i.e. intra-aspect) and those of different aspect (i.e. inter-aspect). This allowed responding to the second research question.

11.1 Initial proposal of best practices

A best practice is defined as a technique, process, activity, incentive or reward that the conventional wisdom considers it more effective in bringing a result more than any other (British Dictionary, 2010). The idea is that with the appropriate processes, with appropriate controls and the correct analysis, the desired result can be achieved by avoiding problems and unforeseen complications. Also a best practice can also be defined as the most efficient and effective way to achieve a result, based on repeatable processes, time-tested and over a large number of people.
The definition given by the British Dictionary summarizes all aspects fully explained:

> *"Methods and techniques that have consistently shown results superior than those achieved with other means, and which are used as benchmarks to strive for. There is, however, no practice that is best for everyone or in every situation, and no best practice remains best for very long as people keep on finding better ways of doing things"*
>
> (British Dictionary, 2010)

11.1.1 Methodology implementation (Operational)

In this area are considered requirements, practices and activities necessary to effective implementation of the methodology in a transactional environment.
First, analysis of data from the case studies asserted the importance of a clear formulation of the problem and the objectives to be achieved in the projects (Antony, 2004; Pande *et al.*, 2000; Goldstein, 2001; Antony, 2006; Van Iwaarden *et al.*, 2008), which must also be measured clearly (Antony, 2004; Pande *et al.*, 2000; Goldstein, 2001; Antony, 2006; Van Iwaarden *et al.*, 2008). Antony (2004, p. 1011), sums up perfectly this need in the following sentence:

> *"…Project objectives must be clear, succinct, specific, achievable, realistic and measurable…"*
>
> (Antony, 2004)

In addition, great importance has been given by the respondents to define simple metrics for measuring those objectives (Panda *et al.*, 2000; Goldstein, 2001; Sehwall and DeYong, 2003; Goh, 2002; Antony, 2006; Akpolat, 2004; Heckl *et al.*, 2010).
At this regard, both Goh (2002, p. 406):

> *"…There are many factors that contribute to the potential of Six Sigma, of which the critical ones are as follows:…*

…clear performance metric (sigma levels; defects per million opportunities (dpmo));…"

(Goh, 2002)

and Sehwall and DeYong (2003, p. 1):

"…Focus on selecting the good metrics: the define, measure, analyze, improve and control methods, (DMAIC) present a clear strategy for Six Sigma implementation. While bottom line numbers, such as sales and revenues indicate the current financial health of the company, process measurements create lead indicators and drives waste out of processes without drastic costs cut… "

(Sehwall and De Yong, 2003)

have stressed the importance of a correct definition of clear metrics for the implementation of the methodology.
Another aspect connected to the definition of objectives regards the use of 3.4 DPMO standard as a stimulus, a long-term goal. However, no tangible evidence in the literature has been found as regards this.
From the point of view of the skills required, what emerged in all case studies is that the in-depth knowledge of the methodology and tools is definitely a prerequisite for the successful implementation of the same (Bañuelas and Antony, 2002; Antony, 2006).
As regards this, Bañuelas and Antony (2002, p.97) observe:

"…With the knowledge obtained, it is important that employees will be capable of adopting and developing the Six Sigma methodology. Since methodologies vary from organization to organization, there is no standard methodology and organizations must be capable of choosing the most appropriate tools and techniques applicable to them…"

(Bañuelas and Antony, 2002)

Another point of interest brought to evidence by the data of the four cases relates to the involvement of appropriate resources for the implementation of DFSS projects (Raisinghani *et al.*, 2005; Antony *et al.*, 2007; Antony, 2006; Ying-Chin *et al*, 2008).
Ying-Chin *et al.* (2008, p.264) stress the importance of the involvement of suitable resources:

"…companies must invest resources in Six Sigma programs…
…the importance of allocating resources effectively…
…the need for companies to provide sufficient resources to their Six Sigma teams…"

(Ying-Chin *et al*, 2008)

The analysis in particular of the GE Oil & Gas suggested that the Six Sigma approach should be systemic; it should not be an accessory tool for personal goals, rather than growth must be a consequence of a good use of methodologies in projects that have followed. So in that sense there must be a focus on the sustainability of the improvements over time, which is also referred to in the literature (Anand *et al*, 2009; Bañuelas and Antony, 2002).
Anand *et al* (2009, p.452), illustrate the need for continued sustainable development:

"…Although the essence of dynamic capabilities is change, for sustainable continuous improvement such change must punctuate periods in which disciplined and standardized methods are used for operational processes…"

(Anand *et al.*, 2009)

A special hand emerged specifically in the two cases in the pure services sector concerns the balance between quality, cost and speed of projects. Especially early in the launch of a methodology, the right mix of large or small, simple or complex Six Sigma projects must be chosen. This implies the selection of projects that can be completed in a reasonable time, to provide tangible results in terms of financial benefits and help improve customer satisfaction.
Moreover, in either case study, we found the importance of a comprehensive assessment of the implementation on the basis of the financial impact (Henderson and Evans, 2000; Goh, 2002; Goldstein, 2001; Sehwall and DeYong, 2003; Van Iwaarden *et al.*, 2008; Antony, 2006, p.244).
This latter author observes:

> *"Six sigma strategy places a clear focus on achieving measurable and quantifiable financial returns to the bottom-line of an organization…"*
>
> (Antony, 2006)

Exploratory analysis of the literature also revealed more common practices in the implementation of the methodology in services, such as conducting a long review and documentation in response to the introduction of new services (De Brentani, 1991, 2001; Stevens and Dimitriadis, 2005; Heckl *et al.*, 2010), or the use of formal procedures in NSD (Fitzsimmons and Fitzsimmons, 2010; George, 2003; Akpolat, 2004; Vermeulen, 2004; Kelly and Storey, 2000; De Brentani, 1991).
De Brentani (1991, p.44) illustrates the need for a formal evaluation after the introduction of the service in the market:

> *"…The new services undergo pre-launch testing to determine customer response and to rehearse the service production and delivery procedure. During commercialization, a deliberated program is directed at both the market and the firm's service personnel, while formal post-launch evaluation is used for gauging the extent to which the new service met planned objectives…"*
>
> (De Brentani, 1991)

Kelly and Storey (2000, p.46) stress the importance of the use of formal procedures in NSD as follows:

> *"…Ideas for new service products have been shown to be generated in many ways. They can arise inside the firm and outside it; they can result from formal or informal search procedures, they may involve the organization in creating the means of delivering the new service product, or they may involve the organization in obtaining the rights to the service product. In general, whilst many service firms find it relatively easy to generate new service ideas, they tend not to engage in formal idea generation. However, it has been found that successful firms establish systems and procedures for stimulating idea generation on a long-term basis…"*
>
> (Kelly and Storey, 2000)

Finally, it was particularly important even the pre-launch test during the NSD process, like in Motorola, for a following effective introduction (De Brentani, 1991, 2001; Stevens and Dimitriadis, 2005, pp. 184-185).
These two authors describe the importance of testing services introduced on customers:

> *"…Faced with the uncertainty of the NSD, the actors used a variety of action rules and behaviours…The team implements a solution in order to analyze the reactions of its adopters. Most often this trial results in adjustment of the solutions…"*
>
> (Stevens and Dimitriadis, 2005)

Here below there are a summary table with the original proposals of best practices for the Methodology implementation aspect and a correlation matrix between the best practices identified in literature by the authors.

Table 11.1: Proposal of best practice for Methodology implementation (1).

OPERATIONAL ASPECT (METHODOLOGY IMPLEMENTATION)		
Best practice	***References***	***Description***
Use of common metrics for quality and Six Sigma projects	Antony, (2004), Pande´ *et al*, (2000), Goldstein, (2001), Antony, (2006), Van Iwaarden *et al.*, (2008)	Involves the use of common metrics (eg DPMO) to secure the quality objectives to be achieved in improvement projects.
Problem setting and clear formulation of project purposes	Antony, (2004), Pande´ *et al*, (2000), Goldstein, (2001), Antony, (2006), Van Iwaarden *et al*, (2008)	The objectives of projects and problems to be solved are formulated in a clear and understandable.
Availability of suitable capabilities	Raisinghani *et al* ,2005), Antony *et al*., (2007), Antony, (2006), Ying-Chin *et al*., 2008)	E 'key, in the course of a project, it had all the resources (human, financial, etc..) required to attain the objectives.
Project results are consolidated over the years	Anand *et al*, (2009), Bañuelas and Antony, (2002)	The Six Sigma should not be seen as a fashion accessory or a tool for personal growth goals, but it must be systemic.
Trade-off between results and project duration	–	Implies the selection of projects that can be completed in a reasonable time, to provide tangible results in terms of financial benefits and satisfy the customer.
Performance metrics and measurements based on project purposes	Pandé *et al*, (2000), Goldstein, (2001), Sehwall and DeYong, (2003), Goh, (2002), Antony, (2006), Akpolat, (2004), (Heckl *et al*., (2010)	When you start an improvement project is necessary to define clear metrics (eg DPMO) the objectives to be pursued.
Project post-evaluation according on financial impact	Henderson and Evans, (2000), Goh, (2002), Goldstein, (2001), Sehwall and DeYong, (2003), (Antony, (2006), Van Iwaarden *et al*, (2008)	The financial impact is the main indicator of successful implementation of the methodology.

Table 11.2: Proposal of best practice for Methodology implementation (2).

OPERATIONAL ASPECT (METHODOLOGY IMPLEMENTATION)		
Best practice	***References***	***Description***
In-depth knowledge of methodology and tools	Bañuelas and Antony, (2002), Antony, (2006)	To effectively implement the methodology you need to know all the tools that it makes available to their users.
The project objectives must be measurable	Antony, (2004), Pande´ *et al*, (2000), Goldstein, (2001), Antony, (2006), Van Iwaarden *et al*., (2008)	The project objectives must be measurable, so It need to have a great deal of data with statistically significance.
3.4 DPMO must be a long term objective rather than a standard	–	The reference level, and thus the possibility of defects, process exceptions, out of 100 opportunities, is defined according to the level of service required by the customer or the market.
The firm conducts a long post launch review and documentation after the new service launch	De Brentani, (1991), De Brentani, (2001), Stevens and Dimitriadis, (2005), Heckl *et al*., (2010)	Given the intangible nature of services, it is essential to continuous review through the use of reporting after the introduction of the same.
Use of formal procedures for NSD projects selection	Fitzsimmons and Fitzsimmons, (2010) , George, (2003), Akpolat, (2004), Vermeulen, (2004), Kelly and Storey, (2000), De Brentani, (1991)	Despite the NSD is the result of a purely creative process, provide a rigorous framework that helps to achieve long-term goals.
Pre-launch tests of the service process before actual launch are performed	De Brentani, (1991), De Brentani, (2001), Stevens and Dimitriadis, (2005)	The nature of services means that important pre-launch tests to ascertain the response of customers on them.

Table 11.3: Best practices and references for Methodology implementation.

	BEST PRACTICES												
AUTHORS	Use of common metrics for quality and Six Sigma projects	Problem setting and clear formulation of project purposes	Availability of suitable capabilities	Project results are consolidated over the years	Trade-off between results and project duration	Performance metrics and measurements based on project purposes	Project post-evaluation according on financial impact	In-depth knowledge of methodology and tools	The project objectives must be measurable	3.4 DPMO must be a long term objective rather than a standard	The firm conducts a long post launch review and documentation after the new service launch	Use of formal procedures for NSD projects selection	Pre-launch tests of the service process before actual launch are performed
Antony, (2004)	✓	✓							✓				
Pande´ *et al*, (2000)	✓	✓				✓			✓				
Goldstein, (2001)	✓	✓				✓	✓		✓				
Antony, (2006)	✓	✓				✓	✓	✓	✓				
Van Iwaarden *et al*, (2008)	✓	✓				✓	✓		✓				
Raisinghani *et. al* , (2005)			✓										
Antony *et al*, (2007)			✓										
Ying-Chin *et al*, (2008)			✓										
Anand *et al*, (2009)				✓									
Bañuelas and Antony, (2002)				✓				✓					
Sehwall and DeYong, (2003)						✓	✓						
Goh, (2002)						✓	✓						
Akpolat, (2004)						✓						✓	
Heckl *et al*, (2010)							✓				✓		
Henderson and Evans, (2000)							✓						
De Brentani, (1991)											✓	✓	✓
De Brentani, (2001)											✓		✓
Stevens and Dimitriadis, (2005)											✓		✓
Fitzsimmons and Fitzsimmons, (2010)												✓	
George, (2003)												✓	
Vermeulen, (2004)												✓	
Kelly and Storey, (2000)												✓	

11.1.2 Methodology tools (Operational)

The operational aspect refers to the tools and practices used for the effective application of the methodology to the services.
From this point of view, one of the most significant observations made during the analysis of data collected in each case study is linked to an increased use of quality tools with respect to statistical tools, especially in particularly good service and high contact with a strong presence of human interactions. These indications have also found evidence on the confirmatory analysis of the literature (Anthony *et al.*, 2007; Henderson and Evans, 2000).
Specifically, Antony *et al.* (2007), claim:

> *"…The successful implementation of Six Sigma requires systematic and disciplined applications of the tools and techniques. Although the tools and techniques used within the six sigma methodology are not new, the strength lies in the integration of these tools and techniques into the five stages of the methodology. It was observed from the research that many service organizations are reaping benefits from the application of the simple tools of process improvement (e.g. process mapping, Pareto analysis, cause and effect analysis or root cause analysis, etc.)…"*
>
> (Antony *et al.*, 2007, pp. 300-301)

The former observations are connected to the wide use of GE of CAP, i.e. the Change Acceleration Process, a toolkit for change management brought in the company in the '90s (Antony *et al*., 2007; Akpolat, 2004).
To this point, Antony *et al.* (2007) continue:

> *"…The most commonly used tools and techniques in the UK service organizations are: process mapping, brainstorming, root cause analysis, run charts, benchmarking, Pareto analysis, change management tools (GE work-out, CAP, etc.)…"*
>
> (Antony *et al.*, 2008, pag. 301)

Furthermore, both in GE Capital and UniCredit there is a huge utilization of tools for the Voice of the Customer analysis, in order to gather customer needs during the NSD process and measure their satisfaction (George, 2003; Akpolat, 2004).
About the importance of tools for VOC analysis in services George (2003) assert:

> *"…The key objective of the Measure phase is to understand the Voice of the customer (VOC), and to translate the customer feedback into measurable design requirements…While customers needs play a central role in shaping priorities in a DMAIC project, here, a good understanding of customer needs is the single most important determinant of success…"*
>
> (George, 2003, pp. 366-67)

In all the case studies it has been observed a combined use of Six Sigma and Lean tools. In general, from this analysis, the ideas is that team members for the Six Sigma project must use different tools, evaluating which is the best one time after time (De Koning *et al*., 2008; George, 2003; Hayler and Nichols, 2006; Hensley and Dobie, 2005; Delgado *et al*, 2010; Pepper and Spedding, 2010; Fitzsimmons and Fitzsimmons, 2010).
This quote from the interview to Mr. Bianchi in GE Capital results emblematic to this point:

> *"…Vi sono sicuramente delle grandi sovrapposizioni e una grande interdipendenza nell'utilizzo di queste due metodologie, io sono un manager e di fronte ad una problema devo applicare la soluzione più idonea, che può rientrare sia nel campo del Lean che del Sei Sigma. Alla luce dell'esperienza maturata*

negli anni utilizzando queste metodologie le posso dire che mi è capitato anche di mescolarle. Come dicevo per ogni problematica vi è una soluzione più idonea…”

(Giancarlo Bianchi, 2010)

The introduction of projects for improvement through Six Sigma methodology, as confirmed by information from case studies, requires the extensive use of tools and skills of traditional project management, e.g. Gantt diagrams (Akpolat, 2004; George, 2003; Antony, 2006; Bañuelas and Antony, 2002; Antony *et al*., 2007; Firka, 2010).
To this point Firka (2010) claim:

“…The formality of the DMAIC approach was useful when coping with complex problem, creating an ordered pathway that fosters the development of analytical skills…
…the sequencing and interlocking of the tools in the DMAIC process is the largest contribution of Six Sigma to the continuous improvement methodology…”

(Firka, 2010, pp. 428)

In GE is given great importance to the digitization, namely the construction of processes and services designed in a simpler and less intensive as possible both internally and for end customers. In that sense there are many initiatives to digitize as much as possible interface with the customer. Moreover, in order to promote innovation and creativity of employees, GE uses a specific innovation toolkit. Exploratory analysis of the literature showed that during the NSD process, is very useful the use of periodic reports to assess the progress of the project (Van Iwaarden *et al*. 2008; Pande *et al.*, 2000; Antony , 2004, Antony *et al*., 2007).
Furthermore, in order to monitor the performance of service, it is common practice to use key performance indicators, such as process capability indices (Akpolat, 2004; Fitzsimmons and Fitzsimmons, 2010; Hensley and Dobie, 2005; Antony, 2006; Chakrabarty and Tan, 2007). Antony (2006), has identified some of the most commonly used KPIs in the services sector:

“…The key performance indicators (KPIs) vary from process to process, and from company to company. Nevertheless, there are some commonly and widely used KPIS or performance metrics of Six Sigma, across a number of service industries. The following are some of the commonly used Six Sigma performance indicators (KPIs) within service sector: cost of poor quality (COPQ); DPMO; process capability; time to respond to customer complaints; processing time (mortgage applications, insurance cover, bank loans, etc.); delivery time or speed of delivery; time to restore customer complaints; waiting time to obtain the service; service reliability; and accuracy of information provided to customers…”

(Antony, 2006, pp-241-42)

This analysis revealed that the majority of best practices identified for the operational scope of the case study analysis has been widely reflected in literature.
Below there are a summary table with the original proposals of best practices for the tools and a correlation matrix between the best practices identified in literature by the authors.

Table 11.4: Proposal of best practice for methodology tools (1).

OPERATIONAL ASPECT - METHODOLOGY TOOLS		
Best practice	***References***	***Description***
Use of periodical reports during NSD	Van Iwaarden *et al*., (2008), Pande´ *et al.*, (2000), Antony (2004,), Antony et al., (2007)	Given the intangible nature and the greater complexity of the transaction, it is very useful to monitor the progress of a proposed NSD through the use of periodic reports.
Use of Project Management tools and skills	Akpolat, (2004), George, (2003), Antony, (2006), Banuelas and Antony, (2002), Antony *et al*., (2007), Firka,(2010)	The improvements through Six Sigma are introduced through different projects, which require an approach and its tools of project management.
Carefully gather customer needs and inputs during NSD	George, (2003), Akpolat,(2004)	The design of a service requires a focus even more than products, on the needs and demands of customers. This activity is mainly carried out with the aid of instruments for the collection of VOC.
Great importance of VOC analysis tools	George, (2003), Akpolat, (2004)	It involves the extensive use of tools for the collection of VOCs, such as QFD, the IPSEN promoter or the SERVQUAL score, especially in early and evaluation of a project.
The firm monitors service performance using a clear set of Key Performance Indicators	Akpolat, (2004), Fitzsimmons and Fitzsimmons, (2010), Hensley and Dobie, (2005), Antony, (2006), Chakrabarty and Tan, (2007)	In order to monitor the performance of service, it is common practice to use key performance indicators, such as process capability indices.
Greater use of qualitative tools rather than statistical and quantitative tools	Antony *et al*., (2007), Henderson and Evans, (2000)	This practice requires that companies in the design of processes and services, make more use of qualitative tools such as brainstorming or value stream mapping
Great importance of Change Management tools (e.g. CAP)	Antony *et al.,(* 2007) , Akpolat, (2004)	In a complex environment characterized by continuous development is helpful to use tools for managing change as CAP (Change Acceleration Process) that will help and guide the work of employees.

Table 11.5: Proposal of best practice for methodology tools (2).

OPERATIONAL ASPECT - METHODOLOGY TOOLS		
Best practice	***References***	***Description***
Joint use of Six Sigma and Lean Management tools	De Koning *et al*, (2008), George, (2003), Hayler and Nichols, (2006), Hensley and Dobie, (2005), Delgado *et al*, (2010), Pepper and Spedding, (2010), Fitzsimmons and Fitzsimmons, (2010)	The project team using the shell in a combined Lean and Six Sigma tools, drawing from a common pot and in every situation using the most appropriate instrument.
Use of innovation toolkit	–	This is a collection of about 30 instruments, some of which are also used in the DMAIC cycle.
Great importance of digitization.	–	With digitization refers to the set up of processes and services designed in a simpler and less intensive as possible both internally and for customers.
Use of tools for Customer Satisfaction analysis	George, (2003), Akpolat, (2004)	This practice is linked to the use of instruments for the collection of VOC, and involves the extensive use of tools such as SERVQUAL to measure customer satisfaction.
The project team uses the most suitable tools in a wider bundle	De Koning *et al*, (2008), George, (2003), Hayler and Nichols, (2006), Hensley and Dobie, (2005), (Delgado *et al*, (2010), Pepper and Spedding, (2010), Fitzsimmons and Fitzsimmons, (2010)	The project team using the shell different types of instruments, drawing from a common pot and in every situation using the most appropriate instrument.
Use of different management tools	De Koning *et al* ,(2008), George, (2003), Hayler and Nichols, (2006), Hensley and Dobie, (2005), Delgado *et al*, (2010), Pepper and Spedding, (2010), Fitzsimmons and Fitzsimmons, (2010)	The project team using the shell different types of instruments, drawing from a common pot and in every situation using the most appropriate instrument.

Table 11.6: Best practices and references for methodology tools.

	BEST PRACTICES												
AUTHORS	Use of periodical reports during NSD	Use of Project Management tools and skills	Carefully gather customer needs and inputs during NSD	Great importance of VOC analysis tools	The firm monitors service performance using a clear set of Key Performance Indicators	Greater use of qualitative tools rather than statistical and quantitative tools	Great importance of Change Management tools (e.g. CAP)	Joint use of Six Sigma and Lean Management tools	Use of innovation toolkit	Great importance of digitization	Use of tools for Customer Satisfaction analysis	The project team uses the most suitable tools in a wider bundle	Use of different management tools
Antony, (2004)	✓												
Pande´ *et al*,(2000)	✓												
Van Iwaarden *et al*,(2008)	✓												
Antony *et al*, (2007)	✓	✓				✓	✓						
Akpolat, (2004)		✓	✓	✓	✓		✓				✓	✓	
George, (2003)		✓	✓	✓				✓			✓	✓	✓
Bañuelas and Antony, (2002)		✓											
Antony (2006)		✓			✓								
Firka, (2010)		✓											
Hensley and Dobie, (2005)					✓			✓					✓
Fitzsimmons and Fitzsimmons, (2010)					✓			✓					✓
Chakrabarty and Tan, (2007)					✓								
Henderson and Evans, (2000)						✓							
De Koning *et. al*, (2008)								✓					✓
Hayler and Nichols, 2006)								✓					✓
Delgado *et. al*, (2010)								✓					✓
Pepper and Spedding, (2010)								✓					✓

11.1.3 Culture and intangible assets (Organizational)

In this context, we consider the values, behaviors, practices, corporate culture and all the intangibles assets that can help the effective implementation of the methodology in services. From the perspective of corporate culture, in the first approach with GE there was the great importance towards the compliance and integrity in each practice or organizational behavior. This little speech of Mr. Spadini (GE Oil & Gas) is particularly relevant:

> *"…Questa azienda ha delle regole molto restrittive per quanto riguarda la gestione delle informazioni e in generale per quanto concerne compliance e integrity. Inoltre il nostro CEO ha più volte sottolineato nei suoi interventi come gli errori siano accettati e risolvibili, se un project manager sbaglia può dover seguire un training per rimediare, tuttavia non vi è tolleranza contro chi viola l'integrity e in generale contro chi lede, con il proprio comportamento, l'immagine dell'azienda…"*
>
> (Massimiliano Spadini, 2010)

Among the organizational behaviors, one important aspect stressed in all the four cases is the need of long term commitment of top management, definitely quoted in literature (Bañuelas and Antony, 2002; Snee and Rodebaugh, 2002; Antony, 2004; Pande´ *et al*., 2000; Goldstein, 2001; Henderson and Evans, 2000; Chakrabarty and Tan, 2007; Antony *et al*. 2007). Another practice is the support to NSD from senior managers (Antony, 2006; Goldstein, 2001; Bañuelas and Antony, 2002; Pande´ *et al.*, 2000; Antony *et al.*, 2007; Antony 2004; Antony *et al.*, 2009).
Chakrabarty and Tan (2007, p.200) stress the top management commitment as critical success factor:

> *"…Almost all the literature reviewed agrees that this factor is a must for successful Six Sigma implementation. This has to be "top-down" rather than initiated by a particular department or from the ground. Top management involvement helps to influence and restructure business organizations and the cultural change in attitudes of individual employees toward quality in a short implementation period…"*
>
> (Chakrabarty and Tan, 2007, p. 200)

About the senior managers' support Goldstein (2001) comment:

> *"…Neither the Six Sigma program nor any major initiative will survive for long without support and commitment from the senior leadership of the organization. I'm not talking about someone who approves expenditures and assigns someone the task of doing the job and coming back with a report. I'm talking about rolling up your sleeves and wading in with your people…"*
>
> (Goldstein, 2001, p. 37)

When it comes to companies that provide services, whether they support such as those of Motorola, or as pure as GE Capital, one of the fundamental practices is certainly the focus on the customer, both internal and external, as a mission (Chakrabarty and Tan , 2007; Antony *et al*, 2007; Ying-Chin *et al.*, 2008; Antony 2004; Heckl *et al.*, 2010).
Ying-Chin *et al.* (2008) claim:

> *"…for a Six Sigma program to be successful, a company must connect it to both its business strategy and its customers…"*
>
> (Ying-Chin *et al.*, 2008, pp. 264)

In addition, a prerequisite for the application of Six Sigma in an organizational context is certainly the spread of quality culture throughout the company (Bañuelas and Anthony 2002; Van Iwaarden *et al*, 2008; Zu *et al*, 2010).
Zu *et al.* (2010, p.86) stressed that this aspect is important for the application of the methodology:

> *"…An appropriate organizational culture is widely considered a necessity for successful implementation of TQM. While the impact of organizational culture on TQM has been extensively studied in the literature, little research has been done to examine the implementation of Six Sigma relative to culture, despite the recognized importance of organizational culture for Six Sigma adoption and deployment…"*
>
> (Zu *et al.*, 2010, p. 86)

For successfully apply the methodology, especially in organizations such as GE, where this practice is now at an advanced stage, it is necessary to support and help that those who use it to develop new projects (people-centered system). In addition, each employee is encouraged to provide suggestions on activities covered by his job.
Moreover, with a view to facilitating the implementation of the methodology, the wide dissemination of the concepts behind the methodology in wide optical company has found a wide application in all the four case studies, and found evidence in literature (Bañuelas and Anthony, 2002; Anand *et al.* 2009, Hatch and Dyer, 2004). In particular Bañuelas and Anthony (2002, p.97) stressed the importance of widespread knowledge in order for an appropriate choice of instruments best suited to each organization:

> *"..During the belt training, employees learn three main groups of tools and techniques, which are divided into team tools and leadership tools. With the knowledge obtained, it is important that employees will be capable of adopting and developing the Six Sigma methodology. Since methodologies vary from organization to organization, there is no standard methodology and organizations must be capable of choosing the most appropriate tools and techniques applicable to them…"*
>
> (Bañuelas and Anthony, 2002)

In both case studies it was found that innovation and creativity of employees will be encouraged and facilitated, it is an important aspect of problem solving in an original way, these aspects have also found some evidence in the literature (De Jong and Vermeulen, 2003; Kelly and Storey, 2000). See below a contrinution of Kelly and Storey (2000, p. 46).

> *"Ideas for new service products have been shown to be generated in many ways. They can arise inside the firm and outside it; they can result from formal or informal search procedures, they may involve the organization in creating the means of delivering the new service product, or they may involve the organization in obtaining the rights to the service product…In service firms, given the physical and psychological proximity of customer contact personnel to customers, steps should be taken to establish a mechanism to solicit and reward new service ideas from contact personnel…"*
>
> (Kelly and Storey, 2000)

In all the case studies, and in particular in GE, Lean and Six Sigma are used in a combined way. Following the Lean philosophy, the purpose is therefore extend the culture of the methodology along the supply chain (Bañuelas and Antony, 2002; Pandé *et al*,2000; Antony, 2006). Bañuelas and Antony (2002, p.96-97) have outlined this concept as follows:

> *"…Six Sigma should begin and end with the customer. Projects should begin with the determination of customer requirements. It is essential to set project goals on reducing the gap between the company's*

expected and actual performance, especially in terms of delivery time, reliability, and customer satisfaction…
…Companies need to explain Six Sigma beyond the company walls. One way is to share it with the suppliers, who have a direct participation in company's manufacturing deliveries..”

(Bañuelas and Antony, 2002)

Since the early '90s, GE has been developing a toolkit, called CAP (Change Acceleration Process), based on a study on the best academic and industry best practices in the field of change management. This stressed the importance towards an effective application of the methodology with a widespread culture of change (Bañuelas and Anthony, 2002; Anand *et al.*, 2009; Sehwall and DeYong, 2003, Chakrabarty and Tan, 2007; Antony et al, 2007; Antony, 2006; Heckl et al, 2010; Firka, 2010).
Here is the contribution of Anand *et. al* (2009, p.453) about the importance of a corporate culture open to change:

“…To achieve a culture focused on change, it is also important to engage employees in the continual scanning of the environment for opportunities and threats that warrant change in existing processes. Scanning improves an organization's capacity to react to or even preempt environmental changes that pose risks or provide opportunities…”

(Anand *et al.*, 2009)

The exploratory analysis of the literature showed that the culture of quality is made up of shared mental mechanisms, and of the logic of managerial mentality spread (Conti and De Risi, 2002). In this sense it is necessary that the aims and motivations of the individual be aligned with the company through the consistent and correct translation of the mission. These considerations are summarized by the term reduction of internal resistance factors. At this regard Conti and De Risi (2002, p. 498) illustrates the importance of these variables in competitive and evolving environments:

“ ...E' chiaro che lo scenario non è dei più semplici, per cui le aziende che intendono acquisire e mantenere dei vantaggi competitivi lo devono fare cercando di operare un costante ripensamento del proprio business, abbinando a ciò una continua capacità di adattarsi e di cambiare..
…Per il raggiungimento di tali obiettivi, è tuttavia fondamentale la condivisione aziendale delle metodologie e dell'approccio adottato, sia orizzontalmente (a tutti i reparti/funzioni), sia verticalmente (dal top management al personale operativo)…”

(Conti and De Risi, 2002)

Below there are a summary table with the original proposals of best practices for the culture and intangible assets and a correlation matrix between the best practices identified in literature by the authors.

Table 11.7: Proposal of best practice for culture and intangible assets (1).

ORGANIZATIONAL ASPECT – CULTURE AND INTANGIBLE ASSETS		
Best practice	***References***	***Description***
Top Management long term commitment	Bañuelas and Antony, (2002), Snee and Rodebaugh, (2002), Antony, (2004), Pande´ *et al*, (2000), Goldstein, (2001), Henderson and Evans, (2000), Chakrabarty and Tan, (2007), Antony et al (2007) , Antony, (2006), Ying-Chin *et al*, (2008), (Van Iwaarden et al, (2008), Heckl *et al*, (2010), Firka, (2010)	The top management must support and provide the necessary resources for the duration of projects, in the long term.
Senior managers strong support for NSD	Antony, (2006), (Goldstein, (2001), Bañuelas and Antony, (2002),(Pande´ *et al*., (2000), Antony *et al*, (2007), Antony, (2004), Antony *et al*, (2009)	Senior management must provide support and approval, facilitating the arrival of the necessary resources to the implementation of the methodology.
People-centered system	–	For successful application of the methodology is necessary that those who use it to develop new projects to be supported and helped.
High compliance ed integrity as organizational milestone	–	It implies the respect of company procedures, all actions and activities of the resources should be conducted with maximum transparency and fairness.
Company-wide quality culture	Bañuelas and Anthony (2002), Van Iwaarden *et al*, (2008), Zu *et al*, (2010)	It involves the dissemination of practices, behaviors, customs, such as to facilitate the application of a methodology to improve quality.
Customer-focused vision	Bañuelas and Anthony ,(2002), Pandé *et al* , (2000), Goh (2002), Goldstein, (2001), Chakrabarty and Tan, 2007), Antony *et al*, (2007), (Ying-Chin *et al*, (2008), Antony, (2004), Heckl *et al*, (2010)	In an industry characterized by strong customer interaction such as services, the focus is on the same mission as fundamental.

Table 11.8: Proposal of best practice for culture and intangible assets (2).

ORGANIZATIONAL ASPECT – CULTURE AND INTANGIBLE ASSETS		
Best practice	***References***	***Description***
Boosting innovation and creativity of employees	De Jong and Vermeulen, (2003), Kelly and Storey, (2000)	The new services are the result of the creativity of employees, who should be encouraged and stimulated to produce new ideas and solutions.
Widespread culture of change	Bañuelas and Anthony, (2002), Anand *et al* (2009), Sehwall and DeYong, (2003), Chakrabarty and Tan, (2007), Antony *et al*, (2007), Antony, (2006), Heckl *et al*, (2010), Firka, (2010)	In a complex and evolving environment such as the service is absolutely necessary to spread across the culture of change across the enterprise
Encourage employees to give suggestions on their task activities	-	Employees in close contact with the process to improve design or can provide useful tips and important.
Eliminate internal resistance factors	Conti and De Risi, (2002)	The objectives and motivations of individuals must be aligned with the company through the correct translation and uniform of the mission.
Company-wide Six Sigma knowledge	(Bañuelas and Anthony, 2002), (Anand *et al* 2009), (Hatch and Dyer, 2004)	Knowledge, however small, of the methodology by the largest possible number of corporate resources
The firm aims to extend the methodology awareness along the supply chain (customers and suppliers)	Bañuelas and Antony, (2002), Pandé *et al*, (2000), Antony, (2006)	This practice, which results from the Lean philosophy, facilitates the application of the methodology in an environment with large interactions with customers like the services.

Table 11.9: Best practices and references for Culture and intangible assets.

	BEST PRACTICES											
AUTHORS	Top Management long term commitment	Senior managers strong support for NSD	People-centered system	High compliance ed integrity as organizational milestone	Company-wide quality culture	Customer-focused vision	Boosting innovation and creativity of employees	Widespread culture of change	Encourage employees to give suggestions on their task activities	Eliminate internal resistance factors	Company-wide Six Sigma knowledge	The firm aims to extend the methodology awareness along the supply chain (customers and suppliers)
Bañuelas and Antony, (2002)	✓	✓			✓	✓		✓			✓	✓
Snee and Rodebaugh, (2002)	✓											
Antony, (2004)	✓	✓				✓						
Pande´ *et al*, (2000)	✓	✓				✓						✓
Goldstein, (2001)	✓	✓				✓						
Chakrabarty and Tan, (2007)	✓					✓		✓				
Antony *et al*, (2007)	✓	✓				✓		✓				
Antony (2006)	✓	✓						✓				✓
Ying-Chin *et al*,(2008)	✓					✓						
Van Iwaarden *et al*, *(*2008)	✓				✓							
Heckl *et al*, (2010)	✓					✓		✓				
Firka, (2010)	✓							✓				
Antony *et al*, (2009)		✓			✓							
Zu *et al*, (2010)												
Goh, (2002)						✓						
De Jong and Vermeulen, (2003)							✓					
Kelly and Storey, (2000)							✓					
Anand *et al*, (2009)								✓			✓	
Sehwall and DeYong, (2003)								✓				
Conti and De Risi, (2002)										✓		
Hatch and Dyer, (2004)											✓	

11.1.4 Actors and organizational structure (Organizational)

This area covers practices related to the practices for human resources management, personnel training, organizational structure, created to effectively apply the methodology. In terms of organizational aspects, it has emerged from the analysis of case studies, the importance given to the structured training methodology to resources (Ingle and Roe, 2001; Bañuelas and Antony, 2002, Henderson and Evans, 2000; Ying-Chin *et al*, 2008). In this context we also outline the certification of roles such as Black Belts and Master Black Belt as result of participating in projects which have yielded positive financial results and impact and spent a discrete amount of time in training.
As regards this, Ingle and Roe (2001, pp.276, 278), describe the process of structured training of Black Belts and Master Black Belts and the characteristics of these figures:

> *"…Training to become a Black Belt includes a rigorous learning schedule of the statistical techniques described earlier, as well as the practice of applying these tools in real-life business situations. Allied to these criteria, before being awarded Black Belt status, the person must demonstrate problem-solving, project management and team leadership skills. The systematic training approach followed typically involves the five (sometimes only the last four are mentioned) problem solving-steps of: define, measure, analyze, improve and control…"*
>
> *"…A Master Black Belt in Motorola has practiced as a Black Belt for at least five years. This employee is a full-time practitioner in Six Sigma tools and has been a mentor to at least five successful Black Belt candidates. A Master Black Belt needs the recommendation of upper management from their own and one other Motorola business unit. In GE a Master Black Belt is a leader in the implementation of Six Sigma methodologies, and is usually trained directly by the Six Sigma Institute. They will have completed a number of projects and are full-time working on Six Sigma and Black Belt cost-saving programs…"*
>
> (Ingle and Roe, 2001)

Henderson and Evans (2000, p.271), illustrate how an initial investment in job training can lead to substantial returns in terms of profit within two years:

> *"…Training can come in a variety of packages including outsourced training and internally provided training. In support of outsourcing training, some think that cultural changes such as Six Sigma rarely come from within an organization. Greg Brue, senior partner and a founder of Six Sigma International Ltd (SSI), a six sigma consulting services firm, compares training using insiders to brain surgery ± a process that cannot be self-performed. Some SSI customers pay SSI a daily consulting rate of US$3,000, while others sign long-term contracts that are based on the company size. SSI is so confident in the results they deliver that they offer a money-back guarantee if a company does not obtain at least a 200 percent return on investment of training cost over two years. SSI has been performing surgery on US manufacturers for the past three years by building a database of pertinent data and training ``black belts'' within the company to train other employees…"*
>
> (Henderson and Evans, 2000)

Furthermore, with the level of investments in training, it is necessary to develop a system of rewards and professional growth based on the results of Six Sigma projects (Henderson and Evans, 2000; Bañuelas and Antony, 2002, Anand *et al*, 2009; Goldstein, 2001; Antony *et al*, 2007; Ying-Chin *et al*, 2008).
Goldstein (2001, p.43) highlights this need as follows, referring to GE:

> *"… Create rewards for meeting individual goals and team goals. This was my first experience with a manager who set a team goal. It had a tremendous impact on our first group of MBBs.*
> *We didn't let anyone fail. I never saw people bond like this. It was one of the best experiences of my career at GE...*

> *... Advancement into leadership positions in the business requires experience as a BB. The message in this is clear. Six Sigma will not derail your career. It is the career path…"*
>
> (Goldstein, 2001)

One of the fundamental organizational prerequisites for the effective implementation of the methodology is certainly the ability of the NSD project team to use Six Sigma tools to improve the quality and design processes (Antony and Bañuelas , 2002; Antony, 2006).
At this point, Antony (2006, pp.242-243) emphasizes how knowledge of Six Sigma is one of the key success factors for implementation of the methodology:

> *"…If any of the critical success factors is missing during the development and implementation stages of a Six Sigma program, it would then be the difference between a successful implementation and a waste of resources, effort, time and money. The following success factors have been identified from existing literature:…*
> *… understanding the DMAIC methodology, tools, techniques and key metrics;…"*
>
> (Antony, 2006)

Secondly, the presence of a flexible and responsive organizational structure is essential (Bañuelas and Antony, 2002, Anand *et al.*, 2009), as the presence in each business function of Master Black Belts, Black Belts and Green Belts (Bañuelas and Antony 2002, Henderson and Evans, 2000; Goldstein, 2001).
Goldstein (2001, p.38) provides guidance on choosing the appropriate number of Black Belts and Master Black Belt required:

> *"…I've seen guidelines, but I think this is best determined by your own situation. Start with your organizational goal and work from there. The number of projects and your pace will guide the number of BBs required to implement and lead the projects…Finally, the number of BBs in the organization will determine the number of MBBs you'll need to support them. An MBB should expect to spend at least one hour of contact time each week for each BB he or she is mentoring. When deciding on the number of MBBs you need, consider also the time an MBB will devote to classroom training and other deployment related activities…"*
>
> (Goldstein, 2001)

The development of an organization managed by processes, a practice originated with the introduction of ISO quality system, is a prerequisite for the implementation of the methodology (Akpolat, 2004; Bañuelas and Antony, 2002).
Akpolat (2004, p.14) describes perfectly the relationship between this process approach and the Six Sigma methodology:

> *"…The process approach can be demonstrated by the three main activities:*
> *identifying the core processes*
> *determining the key performance indicators (KPIs) and*
> *monitoring the processes…*
>
> *…It is argued by many quality practitioners that is not the purpose of the ISO 9000 standards to prescribe any specific program or initiative to be used for process improvement. Six Sigma is perfectly suitable for this purpose…"*
>
> (Akpolat, 2004)

Moreover, a good communication and coordination between the different functional areas involved in the NSD is fundamental
In all the case studies, there has been the aim of spreading knowledge of the methodology to all business assets, or at least to extend to a minimum level of awareness on it. Furthermore,

since the first half of the ‘90s in GE there was the creation of courses for the development of leadership skills and change management (Antony ***et al.***, 2007).
At this regard, Antony *et al.*, (2007, p.301) observe:

> *“…The most commonly used tools and techniques in the UK service organizations are presented…*
> *…Change management tools (GE work-out, CAP, etc.)…”*
>
> (Antony *et al.*, 2007)

To make more efficient and effective the projects, in every case study, reference was made in the presence of process owners (Van Iwaarden *et al.*, 2008) and figures from different functional areas in the project team (Anand *et al.*, 2009, Antony *et al.*, 2005, Henderson and Evans, 2000). Van Iwaarden *et al.* (2008, p. 6751), through a survey, have verified as the involvement of process owners make a positive influence in the implementation of the methodology:

> *“…respondents indicate what factors contribute to the sustainability of Six Sigma. All factors score above three on a five point scale from 1= major negative influence on the sustainability of Six Sigma, to 5= major positive influence. Positive benefits from projects, management commitment, getting process owners involved, getting employees who are trained involved, and communication about overall progress with the Six Sigma approach are in the top five…”*
>
> (Van Iwaarden *et al.*, 2008)

At GE Capital and UniCredit, pure service companies, have also seen the presence of customers within the project team, such as workers at the company's customer relationship. Finally, with particular relevance to Motorola and GE Oil and Gas, there are indications on the need for good facilitators (Antony *et al.*, 2007), and the creation of figures designed to meet the specific needs of individual business.
Antony *et al.* (2007, p.301) stress that the presence of excellent facilitators is a key element for the successful implementation of the methodology:

> *“…Tools and techniques require certain key ingredients to make their application effective. Some of these ingredients include:*
>
> - *uncompromising support and commitment from top management;*
> - *well-designed education and training programmes;*
> - *co-operative environment;*
> - *backup from facilitators;…”*
>
> (Antony *et al.*, 2007)

Here below there are a summary table with the original proposals of best practices for the Actors and organizational structure aspect and a correlation matrix between the best practices identified in literature by the authors.

Table 11.10: Proposal of best practice for Actors and organizational structure (1).

ORGANIZATIONAL ASPECT (ACTORS AND ORGANIZATIONAL STRUCTURE)		
Best practice	***References***	***Description***
Structured approach for training the employees involved in the methodology	Bañuelas and Antony, (2002), Henderson and Evans, (2000) , Ying-Chin *et al*, (2008)	The process of internal training is structured and planned, both in life and in the issues to be addressed in that task in hand.
Release the BB or MBB certification only after participating to high results projects	Ingle and Roe, (2001), Bañuelas and Antony, (2002), Henderson and Evans, (2000) , Ying-Chin *et al*, (2008)	An integral part of training resources in order to obtain the certification includes the complete performance of actual improvement projects.
Good communication and coordination among functional areas	–	An efficient and effective system of communication between the business areas is essential for the coordination of resources towards the achievement of objectives.
Development of skills for leadership and change management	Antony et al, (2007)	In a complex environment characterized by continuous development is helpful to use tools for managing change as CAP (Change Acceleration Process)
High investments in training	Henderson and Evans, (2000)	It 'requires a large initial investment in external training resources, to trigger mechanisms that will enable future savings.
Internal training for Six Sigma certification of human resources	Ingle and Roe, (2001), Bañuelas and Antony, (2002), Henderson and Evans, (2000) , Ying-Chin *et al*, (2008)	Internal training of human resources allows economic benefits and efficiency, as well as training more focused on internal needs.
Great importance of facilitators	Antony *et al*, (2007)	The transactional environment, in its complexity, requires the presence of figures to facilitate the flow of information and activities.
Involvement of the process owner within the project team	Van Iwaarden *et al*, (2008)	The process owner provide the evidence base, as they are into direct contact with key challenges.

Table 11.11: Proposal of best practice for Actors and organizational structure (2).

ORGANIZATIONAL ASPECT (ACTORS AND ORGANIZATIONAL STRUCTURE)		
Best practice	***References***	***Description***
The firm involves customers within the project team	–	Members of the client may be an integral part of project teams to launch new services.
Widespread presence of Master and Black Belts in the organizational functions	Bañuelas and Antony , (2002), Henderson and Evans, (2000), Goldstein, (2001)	The presence of skilled resources on the methodology and certified in each business function facilitates the overall implementation of the same.
Six Sigma awareness for all human resources in the company	–	Practice that aims to impart a basic knowledge of all company resources, in order to facilitate the implementation of the methodology.
Flexible and responsive organizational structure	Bañuelas and Antony, (2002), Anand *et al*, (2009)	The organizational structure needs to adapt to changing a complex and evolving environment such as the service requires.
Reward and career advancement system based on Six Sigma projects results	Henderson and Evans, 2000), Bañuelas and Antony, (2002), (Anand *et al*, 2009), Goldstein, (2001), (Antony *et al*, 2007), Ying-Chin *et al*, (2008)	Professional growth and career shots are positively influenced by the results of the projects to which resources are involved.
Manage organization by processes	Akpolat, (2004), Bañuelas and Antony, (2002)	The organization process is a prerequisite for any quality program.
Project teams are composed by HR from different functional areas in order to broaden the skills	Anand *et al*, (2009), Antony *et al* (2005), Henderson and Evans, (2000)	This practice increases the diversity of skills available in the team, helping to achieve the project objectives.
Six Sigma teams skilled in using six sigma tools for quality improvement and process design	Bañuelas and Antony, (2002), Antony, (2006)	To effectively implement the methodology you need to know all the tools that it provides to members of the team.
Specialization of human resources to specific business problem solving	–	Provides for the establishment of specific professionals to meet the special needs of an individual business.
Certification of all human resources	–	It aims to certify all company resources on the methodology, ambitious and difficult to reach.

Table 11.12: Best practices and references for Actors and organizational structure.

AUTHORS	Structured approach for training the employees involved in the methodology	Release the BB or MBB certification only after participating to high results projects	Six Sigma teams skilled in using six sigma tools for quality improvement and process design	Good communication and coordination among functional areas	Development of skills for leadership and change management	High investments in training	Internal training for Six Sigma certification of human resources	Great importance of facilitators	Involvement of the process owner within the project team	The firm involves customers within the project team	Widespread presence of Master and Black Belts in the organizational functions	Six Sigma awareness for all human resources in the company	Flexible and responsive organizational structure	Reward and career advancement system based on Six Sigma projects results	Manage organization by processes	Project teams are composed by HR from different functional areas in order to broaden the skills	Specialization of human resources to specific business problem solving	Certification of all human resources
Ingle and Roe, (2001)	✓	✓					✓											
Banuelas and Antony, (2002)	✓	✓	✓				✓				✓		✓	✓	✓			
Henderson and Evans, (2000)	✓	✓				✓	✓				✓			✓		✓		
Ying-Chin *et al*, (2008)	✓	✓					✓							✓				
Antony, (2006)			✓															
Antony *et al*, (2007)					✓			✓						✓				
Van Iwaarden *et al*, (2008)									✓									
Goldstein, (2001)											✓			✓				
Anand *et. al*, (2009)													✓	✓		✓		
Akpolat, (2004)															✓			
Antony *et al*, (2005)																✓		

11.1.5 Strategic project selection (Strategic)

This aspect is focused mainly on procedures, criteria and practices used to identify, prioritize and select Six Sigma projects.

From this point of view, it was first observed in all the case studies, overall in Motorola, the need to link clearly the selection of NSD projects with corporate strategy, (Antony, 2004, Antony *et al*, 2009; Antony, 2006; Ying-Chin *et al*, 2008; Bañuelas and Antony, 2002, Antony *et al*, 2007; Heckl *et al*, 2010; Firka, 2010).

Antony (2006, p.243) explains the importance of this aspect:

> *"…The selection of right projects in Six Sigma program is a major factor in the early success and long-term acceptance within any organization…*
> *…The project selection process should be listening to three important voices: the voice of the process, the voice of the customer and the voice of the strategic business goals. The following guidelines may be used to select six sigma projects:*
> *(1)Linkage to strategic business plan and organizational goals…"*
>
> (Antony, 2006)

Furthermore, the projects selected must be compatible with other improvement projects in the company (Snee and Rodebaugh 2002).
Snee and Rodebaugh (2002, p.80), explains the importance of structuring a coherent and coordinated system of Six Sigma projects selection:

> *"…Of course, there are other improvement activities, besides Six Sigma, competing for resources and management attention, such as capital improvements. The long term goal should be to combine all the improvement initiatives into an overall improvement system, make Six Sigma an integral part of this system and create the supporting management systems required to sustain it…"*
>
> (Snee and Rodebaugh, 2002)

A further indication that can be verified across all the types of services, and generally applicable to all improvement projects, is that the approval for the project must be blessed by the top management (Snee and Rodebaugh 2002, Antony, 2004; Pande 'et al., 2000).
Antony (2004, pp. 1010-1011) emphasizes that this aspect should be taken into serious consideration during the selection process of projects:

> *"…The following guidelines may be used to select Six Sigma projects:…*
> *…(6) Projects have the support and approval of senior management…"*
>
> (Antony, 2004)

A detailed financial analysis, with great importance for the financial impact and ROI are the key practical choice for all Six Sigma projects, as observed in empirical data and literature (Bañuelas and Antony 2002, Henderson and Evans, 2000; Goh, 2002; Goldstein, 2001; Sehwall and DeYong, 2003, Antony, 2006; Van Iwaarden *et al*, 2008).
Van Iwaarden *et al*, (2008, p.6754) have explored through a survey on the characteristics of the methodology. This study confirmed the same focus on the financial impact of the projects:

> *"…Indicated by the scores on the key factors differentiating between Six Sigma and TQM, it can be concluded that the difference between Six Sigma and TQM can be captured by the following key factors (ranked according to their scores):*
> *(1) Emphasis on project by project savings.*
> *(2) Clear financial gains…"*
>
> (Van Iwardeen *et al.*, 2008)

The use of formal procedures and objective factors for the scoring and prioritization of projects is a widespread and well established practice in all the four organizations, as it facilitates the subsequent definition of metrics and goals. Even this aspect, as identified in the experimental data, is reflected in the literature (Anthony *et al*, 2009; Antony and Fergusson, 2004). As regards this, Antony *et al.* (2009, p.672) observed:

> *"…Project selection criteria must be established and should be based on realistic and good metrics that are easily measurable (defect per million opportunities, yield, process capability, cost of poor quality, cycle time, net cost savings, customer satisfaction, etc.). Selecting metrics to monitor the project in progress is perhaps the most critical aspect of a Six Sigma project and provides measurable benefits in terms of cost, quality, and timing…"*
>
> (Antony *et al.*, 2009)

However, especially in GE Capital, it is usual to analyze the projects according to objective criteria and sometimes select on the basis of subjective criteria such as experience, real opportunities for project development at a particular time.

Under the criteria for project selection, it was found that they may also be skimmed on the basis of the time requested to finalize them (Antony, 2004; Antony *et al*, 2009).
Even Antony *et al* (2009, p.671), illustrate this aspect:

> *"..A sense of urgency must be created based on the priority of the project…*
> *… The Six Sigma team should start with a meaningful and manageable project that can keep the assignment small and focused to enhance the probability of success, i.e. the project may be delivered within four to six months…"*
>
> (Antony *et al.*, 2009)

One relevant aspect especially in GE Capital and UniCredit, is about the great importance given to the voice and needs of external customers, through complaints, customer advisory boards, focus groups, for the origin of the projects. In addition, the indications of internal customers, especially in the case of GE Oil and Gas and Motorola where there is a main focus on the optimization of processes, are of great importance for the proposed new projects for NSD and redesign. These experimental observations are also reflected in the literature (Anthony, 2004; Antony *et al*, 2007). Antony (2004, pp. 1010-1011) mentions the impact on the needs and expectations of customers is something to consider in selecting projects:

> *"…The following guidelines may be used to select Six Sigma projects:…*
> *…(5) Establish project selection criteria, the following criteria may be considered during the project selection process:*
> *-impact on customer needs and expectations…"*
>
> (Antony, 2004)

In this sense, the confirmatory analysis of the literature showed the importance of conducting detailed and periodical market studies in order to better understand the preferences and needs of clients (De Brentani, 1991; Akpolat, 2004).
Akpolat, (2004, p.24) highlights the importance of this practice, particularly in services:

> *"…Customer surveys are one of the most commonly used instruments in the transactional and service environments to identify customer needs and measure their satisfaction…*
> *…Understanding customer needs correctly means being able to evaluate and change company direction as appropriate…"*
>
> (Akpolat, 2004)

GE Oil & Gas often make use of multi-generational project plans (MGPP) for creating and managing projects. A multi-generational project plan (MGPP) is a tool for project managers to define the objectives of a project going beyond the boundaries thereof, providing a better base on which to make operational decisions, (George, 2003). George, (2003, pp. 279-280), highlights the usefulness of this instrument even in the choice of projects:

> *"There are many reasons why you may want look at defining different generations of improvement for the service or process being studied. For example, if there are a lot of customer requirements you're trying to meet, you may divide them into groups to be attacked sequentially…*
> *…A multi generation plan helps capture this notion by setting out the current goals plus targets for future generations of the product or service.."*
>
> (George, 2003)

Finally, the exploratory analysis of the literature has also made clear the fully analysis of the risks associated with the project of NSD (Antony *et al*, 2009), applicable as best practice of the service sector in project selection. In particular it is illustrated through a case study, a

structured approach to project selection, which takes into account risks associated with the introduction of the project.
Below there are a summary table with the original proposals of best practices for the culture and intangible assets and a correlation matrix between the best practices identified in literature by the authors.

Table 11.13: Proposal of best practice for strategic project selection (1).

STRATEGIC ASPECT (STRATEGIC PROJECT SELECTION)		
Best practice	***References***	***Description***
Thorough risk analysis of NSD project	Antony *et al*, (2009)	It involves analyzing all possible risks, primarily financial, associated with the failure to achieve the objectives of the project.
Projects selection is clearly linked to the corporate strategy	Antony, (2004,), Antony *et al*, (2009), Antony, (2006), Ying-Chin *et al*, (2008), Bañuelas and Antony, (2002), Antony *et al*,(2007), Heckl *et al*, (2010), Firka, (2010)	There must be consistency between the objectives of selected projects and the long-term strategy of the organization.
Thorough financial analysis of NSD project	Bañuelas and Antony ,(2002), Henderson and Evans, (2000), Goh, (2002), Goldstein, (2001), Sehwall and DeYong, (2003), Antony, (2006), Van Iwaarden *et al*, (2008)	The financial aspects are that specific and tangible results achieved by the project and the methodology in general.
Structured projects scoring system	Antony *et al*, (2009), Antony and Fergusson, (2004)	Using a scoring system structured project helps to provide order and clarity in the selection process.
Great importance of indicators such as financial impact, financial risk and ROI for project selection	Bañuelas and Antony (2002), Henderson and Evans, (2000), Goh, (2002), Goldstein, (2001), Sehwall and DeYong, (2003), Antony, (2006), Van Iwaarden *et al*,(2008)	The financial aspects are that specific and tangible results achieved by the project and the methodology in general.
NSD projects prioritization based on objective factors	Antony *et al*, (2009), Antony and Fergusson, (2004)	The use of objective factors such as cost savings in terms of facilitating the process of project selection.
The firm conducts periodical and detailed formal study of the market	De Brentani, (1991), Akpolat, (2004), De Brentani, (2001)	Elicit the views and preferences of customers through market research, it is very important especially in transactional.
Great importance of the voice of external customers	Antony, (2004), Antony *et al*,(2007)	E 'appropriate use of opportunities to meet with the end in order to snatch the problems and needs, to produce new projects for improvement (Complaints, focus groups)

Table 11.14: Proposal of best practice for strategic project selection (2).

STRATEGIC ASPECT (STRATEGIC PROJECT SELECTION)		
Best practice	***References***	***Description***
Strong customer-focused project selection	Antony, (2004), Antony *et al.*, (2007)	Services are often characterized by strong interaction with the customer, therefore should be reserved for a significant weight to their direction in the choice of projects.
Consistency with other Six Sigma projects in the company	Snee and Rodebaugh, (2002)	There must be consistency between the objectives of the projects in place within the company, to develop a system for better coordination.
Projects must be approved and supported by senior management	Snee and Rodebaugh, (2002), Antony, (2004), Pande´*et al*, (2000)	The approval and support of management are essential, especially in order to have available the necessary resources.
The project is easy to be completed in the time scheduled	Antony (2004), Antony *et al*, (2009)	It 'better to select projects with time and achieve certain short-medium term.
Analyze projects by objective criteria and then choose by subjective ones	-	The scoring process helps weed out the projects, but then come into play abilities, skills and experience of the resources involved.
Use of Multi-Generational Project Plans (MGPP) for selecting and managing Six Sigma projects	George, (2003)	The MGPP and tools that help managers to define the objectives of a project, providing a better base on which to make operational decisions.

Table 11.15: Best practices and references for Strategic project selection.

AUTHORS	Thorough risk analysis of NSD project	Project selection is cleaely linked to corporate strategy	Thorough financial analysis for NSD projects	Structured projects scoring system	Great importance of indicators such as financial impact, financial risk and ROI for project selection	NSD projects prioritization based on objective factors	The firm conducts periodical and detailed formal study of the market	Great importance of the voice of external customers	Strong customer-focused project selection	Consistency with other Six Sigma projects in the company	Projects must be approved and supported by senior management	The project is easy to be completed in the time scheduled	Analyze projects by objective criteria and then choose by subjective ones	Use of Multi-Generational Project Plans (MGPP) for selecting and managing Six Sigma projects
Antony *et al*, (2009)	✓	✓		✓								✓		
Antony, (2004)		✓					✓	✓	✓		✓	✓		
Antony (2006)		✓	✓		✓									
Ying-Chin *et al*, (2008)		✓												
Bañuelas e Antony, (2002)		✓	✓		✓									
Heckl *et al*, (2010)		✓												
Firka, (2010)		✓												
Henderson e Evans, (2000)			✓		✓									
Goh, (2002)			✓		✓									
Goldstein, (2001)			✓		✓									
Sehwall e DeYong, (2003)			✓		✓									
Van Iwaarden *et al*, (2008)			✓		✓									
Antony e Ferguson, (2004)				✓										
De Brentani, (1991)						✓								
De Brentani, (2001)						✓								
Akpolat, (2004)						✓								
Antony *et al*, (2007)							✓	✓	✓					
Snee e Rodebaugh, (2002)										✓	✓			
Pande´ *et al*, (2000)											✓			
George , (2003)														✓

11.2 Evaluation and selection of the final Best Practices

After obtaining an initial proposal of best practices for each of the five areas of implementation of the methodology, based on data collected through interviews and an analysis of the literature, we moved to the next assessment and skimming them. At this regard, questionnaires with multiple choice questions have been proposed to the interviewees of the case studies considered, in order to validate, together with literature, the practices that emerged in the preliminary phase of analysis. The questionnaires were aimed to evaluate previous preliminary best practices using the following rating scale:

- **Fundamental;**
- **Very important;**
- **Important;**
- **Somewhat important;**
- **Not important;**
- **Do not know/No answer.**

Even in the questionnaire, the best practices were grouped according to the five Six Sigma aspects used.
Subsequently, in order to help the evaluation of practices, was associated with the level of importance assigned to each case a numerical score using the following logic:

- **Fundamental: 5**
- **Very important: 4**
- **Important: 3**
- **Somewhat important: 2**
- **Not important: 1**
- **Do not know/No answer: 1**

For each best practice is reported in summary tables divided by field, the judgment given by the respondents of the four case studies (in case of more respondents we calculated the average) and the total score obtained by summing the scores corresponding to the ratings given.
The box represented by table 11.16 is filled with a color that matches the score obtained:

Table 11.16: Evaluation of the best practices.

	Definitely Best Practice (20:16)
	Most likely a Best Practice (15:11)
	Need to discuss (10:6)
	Not a Best Practice (5:0)

Finally, for the purposes of this study, we picked up the 8 most suitable Best Practice for each of the five aspects of the methodology. The last evaluation and the final choice of best practices for each area was made through a process of analysis, comparing the ratings of respondents and the scores obtained with the reference literature.

11.2.1 Methodology implementation (Operational)

In this aspect of application of the methodology, the best practices have received high ratings on average, confirming the value of those.
In particular, a clear formulation of the problem and the objectives to be achieved in the projects (Antony, 2006; Pande *et al*, 2000, Antony *et al*, 2007), is crucial for a good implementation of the methodology.
The use of pre-launch tests for NSD before the actual introduction got a good account in the evaluation of the questionnaires even if not at the level of other practices identified. However, the relevance of the contribution in the literature on this practice (De Brentani, 1991, 2001, Stevens and Dimitriadis, 2005), has led it to the same bundle of the final proposals. Using a unique system for measuring quality and objectives is considered as a practice, in the clear formulation of objectives and their measurability.
The balance between quality, cost, and speed of projects, as well as focus on the sustainability of the improvements over time, have found significant evidence of respondents in all the four case studies, therefore can be considered a relevant best practice.
The conduction of a long review and documentation in response to the introduction of new services (De Brentani, 1991, 2001; Stevens and Dimitriadis, 2005; Heckl *et al*, 2010) and the use of formal procedures in NSD (Fitzsimmons and Fitzsimmons, 2010; George, 2003; Akpolat, 2004; Vermeulen, 2004; Kelly and Storey, 2000), were initially identified by the analysis of interview data. However, the strong response found in the literature and assessments made by respondents in the questionnaires showed a degree of importance of such practices and their possible generalization.
The overall assessment of the implementation on the basis of the financial impact is a practice that can be understood in the best practices belonging to the sphere of strategy and project selection.
Its use of the standard of 3.4 DPMO as long-term goal, although it was considered important in all the case studies, has not found in the literature and appears as a sporadic practice. Finally, a thorough knowledge of the methodology and tools, and the involvement of appropriate resources seem to be more one of the prerequisites to practice for the success of the methodology.

The following is a summary table with the evaluation of best practices performed by respondents in the four case studies and the corresponding score obtained:

Table 11.17: Evaluation of Methodology implementation best practice.

METHODOLOGY IMPLEMENTATION	Motorola	GE Oil&Gas	GE Capital	UniCredit	Score
Problem setting and clear formulation of project purposes	Fundamental	Fundamental	Fundamental	Fundamental	**20**
Use of formal procedures for NSD projects selection	Fundamental	Very important	Very important	Very important	**17**
The project objectives must be measurable	Very important	Very important	Very important	Very important	**16**
Performance metrics and measurements based on project purposes	Very important	Very important	Very important	Very important	**16**
Trade-off between results and project duration	Important	Very important	Very important	Fundamental	**16**
Project results are consolidated over the years	Important	Important	Very important	Very important	**14**
The firm conducts a long post launch review and documentation after the new service launch	Very important	Important	Important	Important	**13**
Pre-launch tests of the service process before actual launch are performed	Very important	Somewhat important	Important	Important	**12**
Availability of suitable capabilities	Important	Very important	Important	Somewhat important	**12**
In-depth knowledge of methodology and tools	Important	Important	Important	Important	**12**
Use of common metrics for quality and Six Sigma projects	Somewhat important	Somewhat important	Important	Important	**10**
Project post-evaluation according on financial impact	Important	Somewhat important	Important	Somewhat important	**10**
3.4 DPMO must be a long term objective rather than a standard	Somewhat important	Somewhat important	Important	Important	**10**

Considering the assessments made by the interviewees and by comparison with the confirmatory literature review, the following final proposal for the best practices for Methodology implementation has been obtained:

Table 11.18: Final proposal of Methodology implementation best practice.

METHODOLOGY IMPLEMENTATION	***References***
Problem setting and clear formulation of project purposes	Antony, (2004), Pande´ *et al*, (2000), Goldstein, 2001), Antony, (2006), Van Iwaarden *et al*, (2008)
Use of formal procedures for NSD projects selection	Fitzsimmons and Fitzsimmons, (2010) , George, (2003), Akpolat, (2004), Vermeulen, (2004), Kelly and Storey, (2000), De Brentani, (1991)
The project objectives must be measurable	Antony, (2006), Pande´ *et al*, (2000), Antony *et al*, (2007), Antony *et al* (2009)
Performance metrics and measurements based on project purposes	Pandé *et al*, (2000), Goldstein, (2001), Sehwall and DeYong, (2003), Goh, (2002), Antony, (2006), Akpolat, (2004), Heckl *et al*,(2010)
Trade-off between results and project duration	-
Project results are consolidated over the years	Anand *et al*, (2009), Bañuelas and Antony, (2002)
The firm conducts a long post launch review and documentation after the new service launch	De Brentani, (1991), De Brentani, (2001), Stevens and Dimitriadis, (2005), Heckl *et al*, (2010)
Pre-launch tests of the service process before actual launch are performed	De Brentani, (1991), De Brentani, (2001), Stevens and Dimitriadis, (2005)

11.2.2 Methodology tools (Operational)

As regards the Methodology tools aspect, the data collected in each case study stressed particular relevance on the higher use of quality rather than statistical tools, especially in services characterized by high customer contact and with a strong presence of people. This practice is also reflected in literature, confirming the validity of the findings from the experimental data, (Antony *et al*, 2007, Henderson and Evans, 2000). Linked to these considerations is the great importance given to instruments of change management in both GE Capital GE Oil and Gas, where a program called CAP (Change Acceleration Process) has been developed, since the introduction of the methodology in the company.

Another fundamental practice, which has applicability across all types of service is certainly the use of a set of Key Performance Indicators for monitoring performance. For example the use of process capability indices is established practice in the majority of companies and is widely reflected in the literature (Akpolat, 2004, Fitzsimmons and Fitzsimmons, 2010, Hensley and Dobie, 2005; Antony, 2006; Chakrabarty and Tan, 2007).

The use of specific toolkit for innovation is consistent with the LSS methodology (formal structure, and process innovation), but may not be a practical and proven strong enough to give external validity.

In the Lean philosophy, digitazion is the first step towards the automation of processes and the consequent reduction of cycle time. However, it is difficult to generalize to all types of services.
In the LSS methodology plays a fundamental role the customer: a measure of its satisfaction is essential to identify which procedures and processes to focus. In this sense, however, the use of tools such as SERVQUAL can be understood in practice that refers to the instruments for the collection of VOC, which has more relevance to the implementation of the methodology (George, 2003; Akpolat, 2004).
The use of different management tools seems general practice for all services and in line with the LSS philosophy using a bundle of common tools. With this in mind that practice is closely linked to the combined use of tools and Lean Six Sigma, which is even stressed by the data from the literature (De Koning *et al*., 2008; George, 2003; Hayler and Nichols , 2006; Hensley and Dobie, 2005; Delgado et. al, 2010; Pepper and Spedding, 2010, Fitzsimmons and Fitzsimmons, 2010).
The introduction of improvements in business processes is done through projects, which requires that the resources involved using traditional tools and possess skills of project management. That finding is reflected both in the evaluations of respondents and in the literature (Akpolat, 2004, George, 2003; Antony, 2006; Bañuelas and Antony, 2002; Antony *et al*., 2007; Firka, 2010).
The analysis of data collected through interviews revealed no evidence of the use of periodic reports during the NSD, but the clear references in the literature asserting to this practice (Van Iwaarden *et al*, 2008; Pande *et al*., 2000, Antony 2004; Antony *et al*, 2007), and the positive evaluations found in the questionnaires led to insert this practice in the proposals of final best practices for this aspect.
The following is a summary table with the evaluation of best practices performed by respondents in the four case studies and the corresponding score obtained:

Table 11.19: Evaluation of Methodology tools best practice.

METHODOLOGY TOOLS	Motorola	GE Oil&Gas	GE Capital	UniCredit	Score
The firm monitors service performance using a clear set of Key Performance Indicators	Fundamental	Fundamental	Fundamental	Fundamental	**20**
Great importance of VOC analysis tools	Fundamental	Very important	Fundamental	Fundamental	**19**
Use of Project Management tools and skills	Fundamental	Very important	Very important	Fundamental	**18**
Greater use of qualitative tools rather than statistical and quantitative tools	Very important	Very important	Very important	Important	**15**
Great importance of Change Management tools (e.g. CAP)	Important	Very important	Very important	Very important	**15**
Joint use of Six Sigma and Lean Management tools	Important	Very important	Very important	Important	**14**
Use of periodical reports during NSD	Fundamental	Important	Somewhat important	Very important	**14**
Use of different management tools	Important	Important	Very important	Very important	**14**
Carefully gather customer needs and inputs during NSD	Important	Somewhat important	Important	Important	**11**
Great importance of digitization.	Somewhat important	Somewhat important	Important	Somewhat important	**9**
Use of innovation toolkit	Somewhat important	Important	Somewhat important	Somewhat important	**9**
The project team uses the most suitable tools in a wider bundle	Somewhat important	Somewhat important	Somewhat important	Somewhat important	**8**
Use of tools for Customer Satisfaction analysis	Somewhat important	Not important	Somewhat important	Somewhat important	**7**

Considering the assessments made by the interviewees and by comparison with the confirmatory literature review, the following final proposal for the best practices for Methodology tools has been obtained and represented in table 11.20:

Table 11.20: Final proposal of Methodology tools best practice.

METHODOLOGY TOOLS	*References*
The firm monitors service performance using a clear set of Key Performance Indicators	Akpolat, (2004), Fitzsimmons and Fitzsimmons, (2010), Hensley and Dobie, (2005), Antony, (2006), Chakrabarty and Tan, (2007)
Great importance of VOC analysis tools	George, (2003), Akpolat, (2004)
Use of Project Management tools and skills	Akpolat, (2004), George, (2003), Antony, (2006), Bañuelas and Antony, (2002), Antony *et al*, (2007), Firka, (2010)
Greater use of qualitative tools rather than statistical and quantitative tools	Antony *et al*, (2007), Henderson and Evans, (2000)
Great importance of Change Management tools (e.g. CAP)	Antony *et al*, (2007), Akpolat, (2004)
Joint use of Six Sigma and Lean Management tools	De Koning *et. al*, (2008), George, (2003), Hayler and Nichols, (2006), Hensley and Dobie, (2005), Delgado *et. al*, (2010), Pepper and Spedding, (2010), Fitzsimmons and Fitzsimmons, (2010)
Use of periodical reports during NSD	Van Iwaarden *et al*, (2008), Pande´*et al*., (2000), Antony, (2004), Antony *et al*, (2007)
Use of different management tools	Akpolat, (2004), George, (2003), Fitzsimmons and Fitzsimmons, (2010), De Koning *et. al*, (2008), Hensley and Dobie, (2005)

11.2.3 Culture and intangible assets (Organizational)

As regards the culture and the intangible assets aspect, the long-term commitment of top management support and direction are key and are reflected in the vast literature of the field, for example (Bañuelas and Antony, 2002; Snee and Rodebaugh, 2002; Antony , 2004; Pande *et al*., 2000; Goldstein, 2001, Henderson and Evans, 2000). The customer focus is a fundamental attitude in all types of services is vast and evidence in the literature (Goh 2002; Goldstein, 2001; Chakrabarty and Tan, 2007; Antony *et al*, 2007; Ying-Chin *et al*, 2008, Antony 2004; Heckl *et al*, 2010). The spread of quality throughout the company now seems well-founded tradition in modern enterprises and the basic prerequisite for the application of such methodologies.

Innovation and creativity of the employees are definitely a focal point for process improvement and problem solving in an original way. In fact, despite not having received a very large consensus in the questionnaires were found to be deferred in the analysis of interviews in the literature (De Jong and Vermeulen, 2003; Kelly and Storey, 2000).

Compliance and integrity are an important driver for the selection of new projects in service companies whose services are highly regulated by external institutions, such as banking / finance. However, perhaps not directly related to aspects of Six Sigma and can therefore be excluded from the final bundle of practices.

Ensure that the methodology is applied effectively, and those who will use it in the implementation and development of new projects should be supported and "facilitated”. This practice, however, could be merged with the need for good facilitators, in this organization. An analysis of questionnaires shows that the extension of the methodology also to customers and suppliers is an important practice for the company's support services, but less for pure service companies, which oversee most of the supply chain to the end customer (from end to end). However, the evidence in the literature (Bañuelas and Antony, 2002, Pande *et a*l, 2000; Antony, 2006) represents a link with the Lean sixth principle, i.e. the extension outside the company’s boundaries. Opposite hand for the wide diffusion of culture change, which is its main importance in pure service firms. However, even in this case, the many findings in the literature (Bañuelas and Anthony, 2002, Anand *et al*., 2009; Sehwall and DeYong, 2003, Chakrabarty and Tan, 2007; Antony *et al*, 2007; Antony, 2006), (Heckl *et al*, 2010; Firka, 2010), suggest its inclusion in the final bundle. Much the same could be done to encourage the employees to provide suggestions on activities covered by their job, however the lack of references in the literature has led to exclusion from all the final proposals for this area.
The culture of quality is made up of shared mental mechanisms, the logic and managerial mentality spread (Conti and De Risi, 2002). In this sense it is necessary that the aims and motivations of the individual align with the company through the consistent and correct translation of the mission. The considerations on the culture of quality and the mental mechanisms shared staff, previously summarized by the term reduction of internal resistance factors have been broadly confirmed by those interviewed, obtaining high ratings in the questionnaires. For this reason, given also the reference in the literature (Conti and De Risi, 2002), this practice is included among the final proposals.
Finally, the wide dissemination of the concepts of the methodology throughout the company got very high ratings in the questionnaires and other evidence found in the literature (Bañuelas and Anthony, 2002, Anand *et al*. To 2009, Hatch and Dyer, 2004), and therefore, is inserted in the bundle of final proposals.
Table 11.21 summarize the evaluation of best practices performed by respondents in the four case studies and the corresponding score obtained:

Table 11.21: Evaluation of Culture and intangible assets best practice.

CULTURE AND INTANGIBLE ASSETS	Motorola	GE Oil&Gas	GE Capital	UniCredit	Score
Top Management long term commitment	Fundamental	Fundamental	Fundamental	Fundamental	**20**
Senior managers strong support for NSD	Fundamental	Fundamental	Fundamental	Fundamental	**20**
Customer-focused vision	Fundamental	Very important	Very important	Fundamental	**18**
Company-wide Six Sigma knowledge	Fundamental	Fundamental	Important	Fundamental	**18**
The firm aims to extend the methodology awareness along the supply chain (customers and suppliers)	Very important	Very important	Important	Very important	**15**
Widespread culture of change	Very important	Important	Very important	Very important	**15**
Eliminate internal resistance factors	Somewhat important	Very important	Very important	Fundamental	**15**
Boosting innovation and creativity of employees	Somewhat important	Very important	Somewhat important	Important	**11**
Encourage employees to give suggestions on their task activities	Somewhat important	Important	Somewhat important	Somewhat important	**9**
Company-wide quality culture	Important	Somewhat important	Somewhat important	Somewhat important	**9**
People-centered system	Somewhat important	Somewhat important	Somewhat important	Important	**9**
High compliance ed integrity as organizational milestone	No answer	Important	Important	Somewhat important	**9**

Considering the assessments made by the interviewees and by comparison with the confirmatory literature review, the following final proposal for the best practices for Culture and intangible assets has been obtained:

Table 11.22: Final proposal of Culture and intangible assets best practice.

CULTURE AND INTANGIBLE ASSETS	***References***
Top Management long term commitment	Bañuelas and Antony, (2002), Snee and Rodebaugh, (2002), Antony,(2004), Pande´ *et al.*, (2000), Goldstein, (2001), Henderson and Evans, (2000), Chakrabarty and Tan, (2007), Antony *et al*, (2007) , Antony, (2006), Ying-Chin et al, (2008), Van Iwaarden *et al*, (2008), Heckl *et al*, (2010), Firka, (2010)
Senior managers strong support for NSD	Antony, (2006), (Goldstein, 2001), Bañuelas and Antony, (2002), Pande´et al., (2000), Antony *et al*, (2007), Antony, (2004), Antony *et al*, (2009)
Customer-focused vision	Bañuelas and Antony (2002), Pandé et. al (2000), Goh, (2002), Goldstein, (2001), Chakrabarty and Tan, (2007), Antony *et al*, (2007), Ying-Chin *et al*, (2008), Antony (2004), Heckl *et al*, (2010)
Company-wide Six Sigma knowledge	Bañuelas and Anthony, (2002), Anand *et. al* (2009), Hatch and Dyer, (2004)
The firm aims to extend the methodology awareness along the supply chain (customers and suppliers)	Bañuelas and Antony, (2002), Pandé *et al*, (2000), Antony, (2006)
Widespread culture of change	Bañuelas and Anthony, (2002), Anand *et. al* (2009), Sehwall and DeYong, (2003), Chakrabarty and Tan, (2007), Antony *et al*, (2007), Antony, (2006), Heckl *et al*, (2010), (Firka, 2010)
Eliminate internal resistance factors	Conti and De Risi (2002)
Boosting innovation and creativity of employees	De Jong and Vermeulen, (2003), Kelly and Storey, (2000)

11.2.4 Actors and organizational structure (Organizational)

From the organizational point of view there is a huge number of practices referring to the structured internal training of human resources for the methodology. These indications have been obtained in very high average ratings from respondents in the questionnaires, and even are deeply reflected in the literature. It was then decided to combine all these factors into a common practice to insert it in the final basket of those proposed under the name of internal training for Six Sigma certification of human resources (Ingle and Roe, 2001; Bañuelas and Antony, 2002; Henderson and Evans, 2000; Ying-Chin *et al*, 2008).

Moreover, the presence of figures from different functional areas in the project team has achieved considerable evidence both in the questionnaires by the respondents in the literature (Anand *et al*, 2009; Antony *et al* 2005, Henderson and Evans, 2000).

A company managed by business processes is fundamental in services, as evidenced by the evaluations of the questionnaires presented to respondents and references in the literature (Akpolat, 2004; Bañuelas and Antony, 2002), so is considered transverse and general. On the other hand, the team's ability to NSD in the application of Six Sigma for quality improvement and process design appears to be a pre requisite to the application of the methodology that a common practice.

The presence of customers, especially if internal, in the project team is very important to facilitate the acquisition phase, filtering and interpretation data as well as to build consensus on proposed improvements (Van Iwaarden *et al*, 2008).

A reward system based on the results of Six Sigma projects is an encouragement to the use of the methodology and its wide distribution company. Yet perhaps it can be considered as an implicit adoption of the methodology itself and not as a practice to be introduced. Similar comment can be made with respect to good communication and coordination between the different functional areas involved in the NSD.

The establishment of courses for the development of leadership skills and management of change is certainly a practice to be considered but may be included in the dossier being referred to the importance of CAP, the ambit of operational tools.

The goal of spreading the knowledge of the methodology to all company resources is a goal seemed too ambitious, especially for small and medium size that may not have sufficient resources for a training program so extensive. Conversely, the extension of a minimum of awareness on the methodology to the resources it seemed plausible and achievable goal, and found large reflected in the data collected in interviews.

The presence in each business function of MBB, BB and GB can definitely be considered a best practice, given the positive influence it can exercise this practice in the implementation of the methodology and the references found in the literature (Bañuelas and Antony, 2002; Henderson and Evans, 2000; Goldstein, 2001).

The need for good facilitators results clear and it is very important overall in pure service companies, less in companies that apply the methodology to complementary service processes. However, the reference literature (Antony *et al.*, 2007), and observations from the analysis of data collected through interviews suggest the importance of this practice for the application of the methodology.

A flexible and responsive organizational structure has obtained similar findings from the questionnaires, but it seems that the practice is not strongly linked to the methodology, rather than more generally to good corporate governance.

The following is a summary table with the evaluation of best practices performed by respondents in the four case studies and the corresponding score obtained:

Table 11.23: Evaluation of Actors and organizational structure best practice.

ACTORS AND ORGANIZATIONAL STRUCTURE	Motorola	GE Oil&Gas	GE Capital	UniCredit	Score
Manage organization by processes	Fundamental	Fundamental	Fundamental	Fundamental	**20**
Project teams are composed by HR from different functional areas in order to broaden the skills	Fundamental	Very important	Fundamental	Fundamental	**19**
Internal training for Six Sigma certification of human resources	Very important	Fundamental	Fundamental	Fundamental	**19**
Involvement of the process owner within the project team	Very important	Very important	Fundamental	Fundamental	**18**
Six Sigma awareness for all human resources in the company	Important	Important	Important	Very important	**15**
Great importance of facilitators	Important	Important	Important	Very important	**15**
Widespread presence of Master and Black Belts in the organizational functions	Important	Very important	Somewhat important	Important	**12**
The firm involves customers within the project team	Fundamental	Somewhat important	Somewhat important	Important	**12**
Six Sigma teams skilled in using six sigma tools for quality improvement and process design	Important	Important	Important	Important	**12**
Structured approach for training the employees involved in the methodology	Important	Important	Important	Important	**12**
Release the BB or MBB certification only after participating to high results projects	Somewhat important	Important	Very important	Somewhat important	**11**
High investments in training	Important	Important	Important	Somewhat important	**11**
Good communication and coordination among functional areas	Important	Somewhat important	Somewhat important	Important	**10**
Development of skills for leadership and change management	Somewhat important	Somewhat important	Important	Somewhat important	**9**
Flexible and responsive organizational structure	Somewhat important	Somewhat important	Important	Somewhat important	**9**
Reward and career advancement system based on Six Sigma projects results	Somewhat important	Somewhat important	Somewhat important	Somewhat important	**8**
Certification of all human resources	Not important	Very important	Somewhat important	Not important	**8**
Specialization of human resources to specific business problem solving	Not important	Somewhat important	No answer	Not important	**5**

Considering the assessments made by the interviewees and by comparison with the confirmatory literature review, the following final proposal for the best practices for Actors and organizational structure has been obtained:

Table 11.24: Final proposal of Actors and organizational structure best practice.

ACTORS AND ORGANIZATIONAL STRUCTURE	***References***
Manage organization by processes	Akpolat, (2004), Bañuelas and Antony, (2002)
Project teams are composed by HR from different functional areas in order to broaden the skills	Anand *et al*, 2009), Antony *et al* ,(2005), Henderson and Evans, (2000)
Internal training for Six Sigma certification of human resources	Ingle and Roe, (2001), Bañuelas and Antony, (2002), Henderson and Evans, (2000) , Ying-Chin *et al*, (2008)
Involvement of the process owner within the project team	Van Iwaarden *et al*, (2008)
Six Sigma awareness for all human resources in the company	–
Great importance of facilitators	Antony *et al*, (2007)
Widespread presence of Master and Black Belts in the organizational functions	Bañuelas and Antony (2002), Henderson and Evans, (2000), Goldstein, (2001)
The firm involves customers within the project team	–

11.2.5 Strategic project selection (Strategic)

From the perspective of the strategic aspect, and especially in the service sector, it is particularly important to give a voice to customers, whether internal or external, for the source and the choice of projects. In this sense, various practices have been previously detected by analyzing data in interviews, also the same proposals have received very high ratings in the questionnaires. It was therefore decided to combine all this information with a best practice for inclusion in the final bundle, defined as high priority needs of clients (internal and external) in the choice of projects, which is also reflected in the literature (Antony 2004; Antony *et al*, 2007).
A further indication comes from the cases of fundamental importance in the selection of projects over the approval and support of senior management, which has value in any type of cross-service and in general in any improvement project. That statement is also reflected in the literature (Snee and Rodebaugh 2002, Antony, 2004; Pande *et al*., 2000), confirming the high marks obtained in the questionnaires.
The characteristics of the service sector will certainly require a thorough analysis of risks associated with each project NSD, given the difficult predictability and lack of control, especially in situations of high contact and high number of personal interactions. Although it is not a practice observed by the analysis of the interviews, the reference in the literature (Anthony *et al*, 2009) and higher in the evaluation questionnaires has led to its introduction in the bundle of final proposals for best practices in this area.
As shown by data collected from the literature (Anthony, 2004; Antony *et al*, 2009; Antony, 2006; Ying-Chin *et al*, 2008; Bañuelas and Antony, 2002; Antony *et al*, 2007; Heckl *et al*,

2010; Firka , 2010), the projects selected must be connected with the organization's strategy, and in this sense with the other improvement projects in the company (Snee and Rodebaugh 2002). These descriptions are valid and have obtained evidence a high cross in the questionnaires, may therefore be regarded as common practices and general.
The use of formal procedures and objective factors for the selection of projects is very important, as it supports a clear definition of goals and metrics to be used in the implementation phase, thus facilitating the full development of the project. Confirming this there are the high ratings found in the questionnaires and references in this part of literature (Antony *et al* 2009; Antony and Fergusson 2004).
The importance of financial aspects in the evaluation of projects is not only a characteristic cross in the services sector but the whole methodology, in fact the main purpose of any improvement project is to obtain a financial benefit. This practice is also found wide acceptance in the literature (Bañuelas and Antony 2002; Henderson and Evans, 2000; Goh, 2002; Goldstein, 2001; Sehwall and DeYong, 2003; Antony, 2006; Van Iwaarden *et al*, 2008), and answered questionnaires.
The selection of projects depending on how easily they are closed on schedule would be very useful for the purposes of proper planning, however this practice, especially in services with strong personal interactions, it is difficult to apply.
Select projects on the basis of subjective criteria may be considered a best practice because it allows overcoming some limits of objective criteria (e.g. impossibility to measure and model every process in the company), allowing top management to indicate the direction to take. However, this practice may not be very general because inevitably affected by the skills and capacity of professionals in the organization.
It was found in the literature the importance of developing detailed market studies and periodicals (De Brentani, 1991, 2001; Akpolat, 2004), a practice especially valid for pure service companies like GE Capital and Unicredit, but less important in companies with support services such as GE Oil and Gas and Motorola.
The best practices regarding the use of MGPP was not perceived very high, perhaps because most of the respondents have no direct experience with the tool.
Table 11.25 summarize the evaluation of best practices performed by respondents in the four case studies and the corresponding score obtained:

Table 11.25: Evaluation of Strategic project selection best practice.

STRATEGIC PROJECT SELECTION	Motorola	GE Oil&Gas	GE Capital	UniCredit	Score
Projects must be approved and supported by senior management	Fundamental	Fundamental	Fundamental	Fundamental	**20**
Strong customer-focused project selection	Fundamental	Very important	Fundamental	Fundamental	**19**
Structured projects scoring system	Very important	Very important	Very important	Fundamental	**17**
Projects selection is clearly linked to the corporate strategy	Fundamental	Important	Fundamental	Very important	**17**
Great importance of indicators such as financial impact, financial risk and ROI for project selection	Very important	Very important	Very important	Very important	**16**
Thorough risk analysis of NSD project	Very important	Very important	Very important	Very important	**16**
Consistency with other Six Sigma projects in the company	Very important	Important	Very important	Fundamental	**16**
The firm conducts periodical and detailed formal study of the market	Fundamental	Somewhat important	Very important	Fundamental	**16**
Great importance of the voice of external customers	Very important	Somewhat important	Very important	Very important	**14**
The project is easy to be completed in the time scheduled	Somewhat important	Very important	Very important	Somewhat important	**12**
Thorough financial analysis of NSD project	Somewhat important	Somewhat important	Very important	Very important	**12**
Analyze projects by objective criteria and then choose by subjective ones	Somewhat important	Somewhat important	Important	Important	**10**
NSD projects prioritization based on objective factors	Somewhat important	Somewhat important	Important	Important	**10**
Use of Multi-Generational Project Plans (MGPP) for selecting and managing Six Sigma projects	No answer	Important	Important	Important	**10**

Considering the assessments made by the interviewees and by comparison with the confirmatory literature review, the following final proposal for the best practices for Strategic project selection has been obtained:

Table 11.26: Final proposal of Strategic project selection best practice.

STRATEGIC PROJECT SELECTION	***References***
Projects must be approved and supported by senior management	Snee and Rodebaugh, (2002), Antony, (2004), Pande´ *et al*, (2000)
Strong customer-focused project selection	Antony, (2004), Antony *et al*, (2007)
Structured projects scoring system	Antony *et al (*2009), Antony and Fergusson, (2004)
Projects selection is clearly linked to the corporate strategy	Antony, (2004,), Antony *et al*, (2009), Antony, (2006), Ying-Chin *et al*, (2008), Bañuelas and Antony, (2002), Antony *et al*, (2007), Heckl *et al*, (2010), Firka, (2010)
Great importance of indicators such as financial impact, financial risk and ROI for project selection	Bañuelas and Antony, (2002), Henderson and Evans, (2000), Goh, (2002), Goldstein, (2001), Sehwall and DeYong, (2003), Antony, (2006), Van Iwaarden *et al*, (2008)
Thorough risk analysis of NSD project	Antony *et al*, (2009)
Consistency with other Six Sigma projects in the company	Snee and Rodebaugh, (2002)
The firm conducts periodical and detailed formal study of the market	De Brentani, (1991), Akpolat, (2004), De Brentani, (2001)

11.3 Analysis of the Best Practice connections between the aspects (Inter-Aspect)

After obtaining the final proposal of best practices for the five aspects, this section will analyze the connections between the best practices of different aspects.
Using a comparison between the couples of best practices, all correlations between them will be analyzed. First between best practices from different aspects, then between best practices of the same aspect.
For “Correlation” we do not refer to the statistical meaning, but just claiming that the presence of the first best practice in exam might stimulate the presence of the second one or even allow an easier adoption. This meaning of “Correlation” is quite similar of that in the upper part of the Quality Function Deployment tool.

Here below the legend of the different kinds of correlation, afterwards we will pass in exam all the ten different combination between the aspects:

Table 11.27: Different kinds of correlation.

LEGEND	
	No correlation
VV	Positive correlation
V	Slightly positive correlation
XX	Negative correlation
X	Slightly negative correlation

11.3.1 Culture and intangible assets - Strategic project selection

From the intersection of these two areas is noted first that the use of formal procedures may negatively affect all aspects of flexibility, and creativity are essential to an effective relationship with internal and external customers. Conversely, practices such as culture change and the proactivity of employees positively affect the satisfaction of customer needs. In addition, to help achieve this goal, it is essential to the extension of the methodology along the supply chain (Bañuelas and Antony, 2002; Pande *et al*, 2000; Firka, 2010). At this regard Firka (2010, p.427) states:

> *"…One of the companies used its experience in Six Sigma to establish trust relationships with a customer, participating in improvement projects that created knowledge transfer related to the methodology. This experience increased links with the customer and established new communication channels that eventually led to commercial opportunities…"*
>
> (Firka, 2010)

Wide dissemination of knowledge of the methodology within the company helps the implementation of procedures and the use of financial indicators in project selection. In fact, to apply rigorous and objective formal procedures, it is essential to a good control of the same methodology and instruments (Antony, 2006).
Finally, the commitment and support of senior and top management certainly exerts a positive influence in the choice of projects consistent with other initiatives in the company and are in line with the strategy of the organization (Snee and Rodebaugh, 2002; Firka, 2010).
In general, the interactions between these two areas are about three main aspects, namely the priority of customer needs, using formal procedures and the commitment and support of management.

Table 11.28: Correlations between the best practices of the aspects Culture and intangible assets and Strategic project selection.

		STRATEGIC PROJECT SELECTION							
		Strong customer-focused project selection	Structured projects scoring system	Great importance of indicators such as financial impact, financial risk and ROI for project selection	The firm conducts periodical and detailed formal study of the market	Projects selection is clearly linked to the corporate strategy	Consistency with other Six Sigma projects in the company	Projects must be approved and supported by senior management	Thorough risk analysis of NSD project
CULTURE AND INTANGIBLE ASSETS	Company-wide Six Sigma knowledge		**V**	**V**				**V**	
	Customer-focused vision	**VV**	**X**		**VV**				**V**
	Boosting innovation and creativity of employees	**V**	**XX**						
	Widespread culture of change	**V**	**XX**						
	Eliminate internal resistance factors	**V**	**X**					**V**	
	Senior managers strong support for NSD					**V**	**V**	**VV**	
	Top Management long term commitment					**V**	**V**	**VV**	
	The firm aims to extend the methodology awareness along the supply chain (customers and suppliers)	**VV**							

11.3.2 Methodology tools - Strategic project selection

Looking at the intersection of the best practices of these two areas seems to be a strong positive correlation between the high priority of the needs of customers in the selection of projects and practices related to the use of qualitative tools. In fact, the qualitative tools allow you to collect effectively the needs and the needs of customers, also thanks to their flexibility, they are ideal in environments characterized by strong presence of human interactions (Antony *et al*, 2007; George, 2003; Akpolat, 2004). Antony *et al* (2007, p. 301) describe the importance of qualitative tools:

> *"…Team and process tools are used to prepare the Six Sigma project leader with the required team building and leadership skills for the implementation of the project…"*
>
> (Antony *et al*, 2007)

On the other hand there may be a negative correlation between the exploitation of this type of instruments and the use of formal procedures or quantitative indicators in the selection of projects, such as financial.
The use of management tools and project management skills is a very important practice that positively influence the effective implementation of most of the information regarding the mode of selection of projects and their management (Akpolat, 2004; George, 2003; Antony , 2006). At this regard, Antony (2006, p. 243) observes:

> *"…The selection of right projects in a Six Sigma program is a major factor in the early success and long-term acceptance within any organization. This factor becomes even more critical in a small and medium enterprise. If you do not have a rigorous and disciplined approach to selecting projects, there is a high probability that your efforts will flounder…"*
>
> (Antony, 2006)

Finally, the use of periodic reports during the NSD may be helpful in implementing procedures and objective in the selection of projects in the analysis of the risks involved (De Brentani, 1991).
In general, most of the interactions between these two areas depends on the tools of quality and the influence they have on meeting customer needs and application of formal procedures in the selection of projects.

Table 11.29: Correlations between the best practices of the aspects Methodology tools and Strategic project selection.

		STRATEGIC PROJECT SELECTION							
		Strong customer-focused project selection	Structured projects scoring system	Great importance of indicators such as financial impact, financial risk and ROI for project selection	The firm conducts periodical and detailed formal study of the market	Projects selection is clearly linked to the corporate strategy	Consistency with other Six Sigma projects in the company	Projects must be approved and supported by senior management	Thorough risk analysis of NSD project
METHODOLOGY TOOLS	Greater use of qualitative tools rather than statistical and quantitative tools	VV	X	X					
	Great importance of Change Management tools (e.g. CAP)	VV	X	X					
	Great importance of VOC analysis tools	VV	X	X					
	Joint use of Six Sigma and Lean Management tools	V							
	Use of Project Management tools and skills			V	V	V	V	V	
	Use of periodical reports during NSD		V						V
	Use of different management tools	V							
	The firm monitors service performance using a clear set of Key Performance Indicators	V						V	

11.3.3 Methodology implementation - Strategic project selection

From the intersection of the best practices of these two areas seems to be a negative correlation between the high priority of the needs of customers in the selection of projects and almost all the practices related to the implementation of the methodology, often referring to structured, formal and measurable procedures. This link is related to the difficulty of defining in a clear, organic and simple goals and metrics of projects, having to respond to demands by their very nature are often complex and heterogeneous.

In line with this guidance we can also assume a positive correlation between the use of formal procedures for ranking and selection of projects and the same practices on the implementation of the methodology (Antony, 2006; Antony *et al*, 2009).
Antony *et al* (2009, p. 671) look as formal procedures for selecting projects positively affect a Six Sigma program:

> *"…Survey findings also showed that the existence of formal project selection processes, process documentation, and rigorous requirements for project approval are all elements of a highly successful program…"*
>
> (Antony *et al.*, 2009)

Table 11.30: Correlations between the best practices of the aspects Methodology implementation and Strategic project selection.

		STRATEGIC PROJECT SELECTION							
		Strong customer-focused project selection	Structured projects scoring system	Great importance of indicators such as financial impact, financial risk and ROI for project selection	The firm conducts periodical and detailed formal study of the market	Projects selection is clearly linked to the corporate strategy	Consistency with other Six Sigma projects in the company	Projects must be approved and supported by senior management	Thorough risk analysis of NSD project
METHODOLOGY IMPLEMENTATION	Problem setting and clear formulation of project purposes	**X**	**V**	**V**	**V**	**V**	**V**		**V**
	The firm conducts a long post launch review and documentation after the new service launch								**V**
	Project results are consolidated over the years	**X**		**V**		**V**		**V**	
	Trade-off between results and project duration	**X**					**V**		
	Performance metrics and measurements based on project purposes	**X**	**V**	**V**		**V**	**V**		
	Pre-launch tests of the service process before actual launch are performed	**X**							
	Use of formal procedures for NSD projects selection	**X**	**VV**						
	The project objectives must be measurable	**X**	**V**	**V**		**V**	**V**		**V**

Instead a clear formulation of the problem and the objectives to be achieved in the projects and the selection of metrics and measurable objectives, have a positive correlation with all the practices related to project selection (Goldstein, 2001; Van Iwaarden *et al,* 2008; Antony, 2004). As mentioned previously, Antony (2004, p. 1011), summarizes this concept with the following statement:

> *"…Project objectives must be clear, succinct, specific, achievable, realistic and measurable…"*
>
> (Antony, 2004)

The prolonged review and documentation in response to the introduction of the new service can help analyze the risks associated with the project (De Brentani, 1991). Finally, to help focus on the sustainability of the improvements such improvements sshould be consistent with corporate strategy, supported by top management and based on sound financial conditions (Anand *et al*, 2009; Bañuelas and Antony, 2002).
In general, there is a close relationship between these two areas, which deals with the rules and procedures for the implementation of the methodology and the selection of projects, in addition to influences exerted by the same customers.

11.3.4 Culture and intangible assets – Methodology tools

From the intersection of the best practices of these two areas would appear especially strong positive correlation between the various aspects of customer focus, the proactivity, creativity and change in corporate culture and the use of different types of qualitative tools. In fact, in general, qualitative tools allow more flexibility and fits perfectly with the aspects of corporate culture necessary for the creation and development of new ideas, or allowing to adapt adequately to the needs of clients (George, 2003; Akpolat , 2004; Antony et al, 2007).
George (2003, p. 47), emphasizes in this regard as the focus on customer needs is ubiquitous in the Six Sigma.

> *"…Six Sigma prescribes numerous places in improvement methods where the voices of customers and suppliers must be included. It uses customer CTQ as a key metric and requires a means of capturing the VOC in the Define phase of DMAIC. Simply put, the customer is not front and center in Lean, yet is ever-present in Six Sigma work…"*
>
> (George, 2003)

The typical flexibility of the qualitative tools can also help extend the methodology across the supply chain to customers and suppliers (Bañuelas and Antony, 2002; Pande *et al*, 2000; Antony, 2006).
The correlations between these two aspects are related particularly on the positive influence that flexibility of the qualitative tools has to achieve certain objectives which the organizational culture has set.

Table 11.31: Correlations between the best practices of the aspects Culture and intangible assets and Methodology tools.

		CULTURE AND INTANGIBLE ASSETS							
		Company-wide Six Sigma knowledge	Customer-focused vision	Boosting innovation and creativity of employees	Widespread culture of change	Eliminate internal resistance factors	Senior managers strong support for NSD	Top Management long term commitment	The firm aims to extend the methodology awareness along the supply chain
METHODOLOGY TOOLS	Greater use of qualitative tools rather than statistical and quantitative tools		**VV**	**VV**	**VV**				**V**
	Great importance of Change Management tools (e.g. CAP)		**V**	**VV**	**VV**				**V**
	Great importance of VOC analysis tools		**VV**	**VV**	**V**				**V**
	Joint use of Six Sigma and Lean Management tools	**V**	**V**	**V**					
	Use of Project Management tools and skills								
	Use of periodical reports during NSD								
	Use of different management tools	**V**	**V**	**V**					
	The firm monitors service performance using a clear set of Key Performance Indicators								

11.3.5 Strategic project selection – Actors and organizational structure

From the intersection between the two aspects Strategic project selection and Actors and organizational structure is noted first that the presence of customers in the project team can help to pursue the customer focus project selection. However, this might not help scoring the projects in a structured way. Facilitators can definitely improve the long-term vision of the project and their consistency with other Six Sigma projects, because they help employees to understand the main points of the methodology and see the bigger picture.
Antony *et al.*(2007, p. 307), outlines this concept in this part:

> *"There is one challenge shared by all the type of industry, i.e. to present their recommendations and improvement report using the business language rather than the statistical language as only few*

managers have a statistical background. Sharing results in a language understood by employees will enhance their motivation and their perception about the efficacy of a six sigma business strategy."

(Antony *et al.*, 2007)

Furthermore, the facilitators in the organization could sustain the strong customer-vision of the company.
In summary, the interactions between these two aspects stay around three four concepts, namely the presence of customers in the project team, the importance of facilitators, the project selection link to the corporate strategy and finally the need to extend the awareness in the organization as much as the company can.

Table 11.32: Correlations between the best practices of the aspects Actors and organizational structure and Strategic project selection.

		STRATEGIC PROJECT SELECTION							
		Strong customer-focused project selection	Structured projects scoring system	Great importance of indicators such as financial impact, financial risk and ROI for project selection	The firm conducts periodical and detailed formal study of the market	Projects selection is clearly linked to the corporate strategy	Consistency with other Six Sigma projects in the company	Projects must be approved and supported by senior management	Thorough risk analysis of NSD project
ACTORS AND ORGANIZATIONAL STRUCTURE	Internal training for Six Sigma certification of human resources								
	Great importance of facilitators	**V**				**V**	**V**		
	Involvement of the process owner within the project team								
	The firm involves customers within the project team	**VV**	**X**						
	Widespread presence of Master and Black Belts in the organizational functions								
	Six Sigma awareness for all human resources in the company	**V**							
	Project teams are composed by HR from different functional areas in order to broaden the skills								
	Manage organization by processes								

11.3.6 Culture and intangible assets – Actors and organizational structure

Analyzing the intersection between the best practices of these two aspects, we can assume a strong positive correlation between the wide dissemination of the basic concepts of the methodology in the company and the majority of practices within the organizational aspects, in particular a structured training for HR Six Sigma certification and the objective of extending a minimum of awareness on the methodology to all resources (Ingle and Roe, 2001; Bañuelas and Antony, 2002; Henderson and Evans, 2000).
A strong and pervasive presence of certified resources can in fact help spread the concepts of the methodology and the formation of a shared mentality.
Moreover, the presence of customers in the project team could bring a positive correlation with the various aspects of customer focus, the proactivity, creativity and change in corporate culture, and of course the extension of the methodology along the supply chain (Bañuelas Antony, 2002; Pande *et al*, 2000; Antony, 2006; De Jong and Vermeulen, 2003; Kelly and Storey, 2000).
Kelly and Storey (2000, p.46) noted that it is necessary an organizational mechanism that encourages the creativity of employees in service industries:

> *"…In service firms, given the physical and psychological proximity of customer contact personnel to customers, steps should be taken to establish a mechanism to solicit and reward new service ideas from contact personnel…"*
>
> (Kelly and Storey, 2000)

The reduction of internal resistance factors comes through the involvement of customers and process owners in the project team but mostly there is the need for good facilitators to complete this process (Conti and De Risi, 2002; Van Iwaarden *et al*, 2008; Antony *et al*, 2007).
The support and commitment of top and senior management are essential in order to have a dense network of certified resources in each business function and extend to all Human Resources a minimum level of awareness about the methodology (Goldstein, 2001; Henderson and Evans, 2000 ; Chakrabarty and Tan, 2007; Van Iwaarden *et al*, 2008; Ingle and Roe, 2001). Henderson and Evans (2000, p.270) highlight the commitment required to develop an organizational structure suitable to apply broadly Six Sigma:

> *"…Conversion to a Six Sigma culture is an enormous undertaking. Many people have to be directly involved, and many support systems have to be in place to make it all work smoothly. Attaining Six Sigma quality levels requires total commitment from every department and active participation of every member of the company team. Employees with specific roles and responsibilities are important in deploying Six Sigma…"*
>
> (Henderson and Evans, 2000)

In conclusion we can say that the link between these two areas is based primarily on the dissemination of the methodology throughout the company and the presence of customers in project teams.

Table 11.33: Correlations between the best practices of the aspects Culture and intangible assets and Actors and organizational structure.

		CULTURE AND INTANGIBLE ASSETS							
		Company-wide Six Sigma knowledge	Customer-focused vision	Boosting innovation and creativity of employees	Widespread culture of change	Eliminate internal resistance factors	Senior managers strong support for NSD	Top Management long term commitment	The firm aims to extend the methodology awareness along the supply chain
ACTORS AND ORGANIZATIONAL STRUCTURE	Internal training for Six Sigma certification of human resources	**VV**							
	Great importance of facilitators		**V**			**VV**			**V**
	Involvement of the process owner within the project team	**V**				**V**			
	The firm involves customers within the project team	**V**	**VV**	**V**		**V**			**VV**
	Widespread presence of Master and Black Belts in the organizational functions	**V**					**V**	**V**	
	Six Sigma awareness for all human resources in the company	**VV**					**V**	**V**	
	Project teams are composed by HR from different functional areas in order to broaden the skills	**V**							
	Manage organization by processes								

11.3.7 Culture and intangible assets – Methodology implementation

Analyzing the intersection between the best practices of these two aspects, we could assume a negative correlation between the various aspects of customer focus, the proactivity, creativity and change in corporate culture and the use of formal procedures in NSD. In fact, practices such as those described require greater flexibility and freedom of movement and could possibly suffer from a too rigorous and structured approach, in particular those related to customer focus.

Table 11.34: Correlations between the best practices of the aspects Culture and intangible assets and Methodology implementation.

METHODOLOGY IMPLEMENTATION	CULTURE AND INTANGIBLE ASSETS: Company-wide Six Sigma knowledge	Customer-focused vision	Boosting innovation and creativity of employees	Widespread culture of change	Eliminate internal resistance factors	Senior managers strong support for NSD	Top Management long term commitment	The firm aims to extend the methodology awareness along the supply chain
Problem setting and clear formulation of project purposes	**V**					**V**	**V**	
The firm conducts a long post launch review and documentation after the new service launch								
Project results are consolidated over the years								
Trade-off between results and project duration						**V**	**V**	
Performance metrics and measurements based on project	**V**					**V**	**V**	
Pre-launch tests of the service process before actual launch are performed								
Use of formal procedures for NSD projects selection	**V**	**XX**	**X**	**X**	**X**			
The project objectives must be measurable	**V**					**V**	**V**	

There seems to be rather a positive correlation between the wide dissemination of the concepts of the methodology in the company and the more structured aspects of the implementation of the methodology itself (Fitzsimmons and Fitzsimmons, 2010; Vermeulen, 2004; Kelly and Storey, 2000; De Brentani, 1991). In fact prepared and competent resources make it a simple application of a formal and rigorous approach.

In addition, the support and commitment of top and senior management certainly has a positive effect in the terms and choice of targets and metrics, given the value they can bring in

terms of skills, experience and available resources (Antony, 2006; Pande *et al*, 2000; Goldstein, 2001; Sehwall and DeYong, 2003; Bañuelas and Antony, 2002, Henderson and Evans, 2000; Chakrabarty and Tan, 2007).
At this regard, Goldstein (2001, p. 37) notes:

> *"…If we were visiting a company where management was actively participating in the program, what behaviors would we observe? Clear goals will have been established to define the cost reduction targets, defect reduction target and timing to achieve the targets. The entire employee population will have received clear communications on a frequent basis describing the program, what the objectives are, progress reports and how each employee can participate and contribute…"*
>
> (Goldstein, 2001)

In general, relations between these two areas have focused precisely on the influence that has a positive and proactive management in this phase of project definition, in addition to the difficulty of applying formal procedures in this changing environment and with strong personal interactions.

11.3.8 Methodology implementation – Actors and organizational structure

From the intersection of the best practices of these two areas could be assumed negative correlation between the presence of customers in project teams and almost all the practices related to the implementation of the method referring to structured, formal and measurable procedure. Indeed, the presence of clients requires the most flexibility and freedom of action, which does not allow the use of excessively stringent procedures.
Instead, the involvement of process owners in the project team has a positive correlation with many of the practical implementation, especially with those related to the formulation of problems and objectives and the definition of metrics (Sehwall and DeYong, 2003; Goh, 2002; Antony, 2006; Akpolat, 2004; Heckl *et al*, 2010). In fact, the best indications are those provided directly by the people in close contact with the issues under consideration.
At this regard, Heckl *et al* (2010, p.453) stress the importance of clearly defining the goals of the projects:

> *"…The cornerstone of a successful optimization project is the existence of a clearly outlined project definition and project organization that are evident to the project leader, project staff, and project sponsor. This entails having clearly defined goals, milestones, timelines, and budgets…"*
>
> (Heckl *et al.*, 2010)

The presence of figures from different functional areas in the project team can have a positive influence in the process of goal setting and review of the project, which is useful to have contributions and diverse points of view.
Finally, the use of formal procedures in the NSD can be facilitated by the widespread presence of MBB, BB and GB in each department, as the proper facilitators and knowledge of a minimum level of methodology by every corporate resources (Van Iwaarden *et al,* 2008; Ingle and Roe, 2001; Henderson and Evans, 2000; Antony *et al,* 2007).
In general, the relations between these two areas are mainly concentrated on the influence that the composition of the meso-structure and the effect of the skills of resources on some key stages of the implementation of the methodology.

Table 11.35: Correlations between the best practices of the aspects Methodology implementation and Actors and organizational structure.

	METHODOLOGY IMPLEMENTATION							
ACTORS AND ORGANIZATIONAL STRUCTURE	Problem setting and clear formulation of project purposes	The firm conducts a long post launch review and documentation after the new service launch	Project results are consolidated over the years	Trade-off between results and project duration	Performance metrics and measurements based on project purposes	Pre-launch tests of the service process before actual launch are performed	Use of formal procedures for NSD projects selection	The project objectives must be measurable
Internal training for Six Sigma certification of human resources								
Great importance of facilitators							**V**	
Involvement of the process owner within the project team	**VV**		**V**	**V**	**VV**			
The firm involves customers within the project team	**X**		**X**	**X**	**X**		**X**	**X**
Widespread presence of Master and Black Belts in the organizational functions							**V**	
Six Sigma awareness for all human resources in the company							**V**	
Project teams are composed by HR from different functional areas in order to broaden the skills	**V**		**V**	**V**				
Manage organization by processes								

11.3.9 Methodology implementation – Methodology tools

Analyzing the intersection between the best practices of these two aspects, there seems to be a positive correlation between the majority of operational practices and a clear formulation of the problem and the objectives to be achieved. They are correlated to an extended review and documentation of the service introduced, as well. In fact, these practices are facilitated by the use of a diverse bundle of instruments, as well as the effective collection of VOC. Furthermore, having a set of key performance indicators and reporting regularly, it certainly helps the formulation stage of the objectives is the review one (George, 2003; Akpolat, 2004;

De Brentani, 1991; Stevens and Dimitriadis, 2005; Antony, 2004; Pande *et al*, 2000; Goldstein, 2001; Antony, 2006).
In addition, in line with the connections between the other aspects, we can assume a slight negative correlation between the use of formal procedures in NSD and practices regarding the use of qualitative tools. In fact, the application of formal procedures suggests a higher use of quantitative tools and could be influenced by less objective than qualitative. In this sense it is more difficult the definition of simple metrics, given the difficult applicability to purely qualitative data.
Finally, the use of periodic reports is positively correlated with the test process and the use of formal procedures in NSD (Fitzsimmons and Fitzsimmons, 2010; George, 2003; Akpolat, 2004; De Brentani, 1991; Stevens and Dimitriadis, 2005).
As mentioned earlier, Stevens and Dimitriadis (2005, pp.184-185) describe the importance of testing services to be introduced with customers:

> *"…Faced with the uncertainty of the NSD, the actors used a variety of action rules and behaviours…The team implements a solution in order to analyze the reactions of its adopters. Most often this trial results in adjustment of the solutions…"*
>
> (Stevens and Dimitriadis, 2005)

Overall, between the practices of these two areas there are not many interactions, and most regard the relationship between the bundle of instruments available and the phases of implementation and revision of the methodology. We notice the negative relationship between qualitative tools and formal procedures.

Table 11.36: Correlations between the best practices of the aspects Methodology implementation and Methodology tools.

		METHODOLOGY IMPLEMENTATION							
		Problem setting and clear formulation of project purposes	The firm conducts a long post launch review and documentation after the new service launch	Project results are consolidated over the years	Trade-off between results and project duration	Performance metrics and measurements based on project purposes	Pre-launch tests of the service process before actual launch are performed	Use of formal procedures for NSD projects selection	The project objectives must be measurable
METHODOLOGY TOOLS	Greater use of qualitative tools rather than statistical and quantitative tools					**X**		**X**	
	Great importance of Change Management tools (e.g. CAP)							**X**	
	Great importance of VOC analysis tools	**V**	**V**					**X**	
	Joint use of Six Sigma and Lean Management tools	**V**	**V**						
	Use of Project Management tools and skills	**V**	**V**						
	Use of periodical reports during NSD	**V**	**V**				**V**	**V**	
	Use of different management tools	**V**	**V**						
	The firm monitors service performance using a clear set of Key Performance Indicators	**V**	**V**						

11.3.10 Methodology tools – Actors and organizational structure

From the intersection of the best practices of these two areas it can be assumed that the presence of customers within the project team in a particularly positive influence practices the operational aspects of the instruments focus on qualitative, specifically those related to the management change and the collection of VOC (George, 2003; Akpolat, 2004; Antony *et al*, 2007).

Furthermore, the possibility of being able to utilize a bigger bundle of instruments, can be helpful in managing some external human resource in the project team. It even can help the structured training of internal resources and, in general, the spread of the methodology along the organization (Hayler Nichols, 2006; Hensley and Dobie, 2005; Delgado *et al*, 2010; Spedding and Pepper, 2010; Fitzsimmons and Fitzsimmons, 2010).

In general, between these two areas very few correlations emerge, which are more focused on the relationship between the presence of customers in project teams and the diversity of tools available to those using the methodology.

Table 11.37: Correlations between the best practices of the aspects Methodology tools and Actors and organizational structure.

		METHODOLOGY TOOLS							
		Greater use of qualitative tools rather than statistical and quantitative tools	Great importance of Change Management tools (e.g. CAP)	Great importance of VOC analysis tools	Joint use of Six Sigma and Lean Management tools	Use of Project Management tools and skills	Use of periodical reports during NSD	Use of different management tools	The firm monitors service performance using a clear set of Key Performance Indicators
ACTORS AND ORGANIZATIONAL STRUCTURE	Internal training for Six Sigma certification of human resources				**V**			**V**	
	Great importance of facilitators								
	Involvement of the process owner within the project team						**V**		
	The firm involves customers within the project team	**V**	**VV**	**VV**	**V**			**V**	
	Widespread presence of Master and Black Belts in the organizational functions								
	Six Sigma awareness for all human resources in the company				**V**			**V**	
	Project teams are composed by HR from different functional areas in order to broaden the skills								
	Manage organization by processes								

10.4 Analysis of the Best Practice connections in the same aspect (Intra-Aspect)

In this final section, best practices will be analyzed through an internal perspective for each of the five aspects of the methodology.
Specifically, these connections occur between the best practices proposed within the same aspect, following the logic described in the previous legend used for the inter-aspect analysis.

10.4.1 Correlations in the Methodology implementation aspect

Observing the relationship between the best practices within the Methodology implementation aspect, we can notice that the practices related to the definition of goals and metrics, have a greater importance, if compared to all other practices. Setting the process in a logical, simple and structured way, in fact, positively influences the subsequent implementation phases of a project (Sehwall DeYong, 2003; Antony, 2004; Pande *et al*, 2000; Goldstein, 2001; Heckl *et al* , 2010). Heckl *et al*, (2010, p. 453) illustrate the importance of such practices:

> *"…The cornerstone of a successful optimization project is the existence of a clearly outlined project definition and project organization that are evident to the project leader, project staff, and project sponsor. This entails having clearly defined goals, milestones, timelines, and budgets…"*
>
> (Heckl *et al.*, 2010)

Moreover, the testing process before the actual launch, helps to define the balance between quality, cost and speed, increasing the sustainability of the improvements (De Brentani, 1991; Stevens and Dimitriadis, 2005).
Furthermore, in order to achieve this, it would be very useful to have a long post launch review and documentation after the new service launch (Stevens and Dimitriadis, 2005; Heckl *et al.*, 2010).

Table 11.38: Correlations between the best practices in the Methodology implementation aspect.

METHODOLOGY IMPLEMENTATION	Problem setting and clear formulation of project purposes	The firm conducts a long post launch review and documentation after the new service launch	Project results are consolidated over the years	Trade-off between results and project duration	Performance metrics and measurements based on project purposes	Pre-launch tests of the service process before actual launch are performed	Use of formal procedures for NSD projects selection	The project objectives must be measurable
Problem setting and clear formulation of project purposes								
The firm conducts a long post launch review and documentation after the new service launch								
Project results are consolidated over the years	**V**	**V**						
Trade-off between results and project duration	**V**		**V**					
Performance metrics and measurements based on project purposes	**VV**			**VV**				
Pre-launch tests of the service process before actual launch are performed	**V**		**V**	**V**				
Use of formal procedures for NSD projects selection	**V**	**V**						
The project objectives must be measurable	**VV**		**V**	**V**	**VV**			

10.4.2 Correlations in the Methodology tools aspect

Observing the relationship between the best practices of the Methodology tools aspect, it seems that the use of disparate tools, from different areas and belonging to both the Lean and Six Sigma, exerts a positive influence to most of the other practices, but the use of periodic reports.

We noted a strong correlation, as expected, among other practices referring to qualitative tools, especially for change management (CAP) and the collection of VOC. In fact, as noted by several authors (George, 2003; Akpolat 2004; Antony *et al*, 2007), tools for the collection of VOCs are the most useful and used among the quality tools.

As previously reported, George (2003, pp. 366-367) emphasizes the importance of these tools:

"…The key objective of the Measure phase is to understand the Voice of the customer (VOC), and to translate the customer feedback into measurable design requirements…While customers needs play a central role in shaping priorities in a DMAIC project, here, a good understanding of customer needs is the single most important determinant of success…"

(George, 2003)

Table 11.39: Correlations between the best practices in the Methodology tools aspect.

METHODOLOGY TOOLS	Greater use of qualitative tools rather than statistical and quantitative tools	Great importance of Change Management tools (e.g. CAP)	Great importance of VOC analysis tools	Joint use of Six Sigma and Lean Management tools	Use of Project Management tools and skills	Use of periodical reports during NSD	Use of different management tools	The firm monitors service performance using a clear set of Key Performance Indicators
Greater use of qualitative tools rather than statistical and quantitative tools								
Great importance of Change Management tools (e.g. CAP)	VV							
Great importance of VOC analysis tools	VV							
Joint use of Six Sigma and Lean Management tools	V	V	V					
Use of Project Management tools and skills			V	V				
Use of periodical reports during NSD								
Use of different management tools	V	V	V	VV	V			
The firm monitors service performance using a clear set of Key Performance Indicators				V			V	

10.4.3 Correlations in the Culture and intangible assets aspect

Looking at the potential relationship between best practices in the aspect of Culture and intangible assets, it emerges that the spread of the basic concepts of the methodology, as well as the objective of extending the methodology along the supply chain are of particular importance and allow an easier implementation of many of the other practices in this area.
In fact, knowledge of the methodology facilitates the work of support from the senior and top management, and helps develop a culture focused on continuous improvement (Goldstein, 2001; Bañuelas and Antony, 2002).
In addition, significant weight is also associated with the diminishing of internal resistance factors, given the positive influence exerted on most other practices. In fact, the objective of arriving at a common mentality helps to align the efforts of all human resources towards their goals (Conti and De Risi, 2002).
The widespread culture of change is absolutely necessary to ensure a flexible and responsive organization, which is necessary in a changing and difficult to control environment such as the service sector, especially if characterized by high personal interactions (Firka, 2010).
Firka (2010, p.425), asserting the need for a culture change in the methodology states:

> *"…The concept of incorporating Six Sigma into the DNA of the organization was referred to by three companies, showing how Six Sigma changes and evolves as knowledge and experience accumulate within the organization. According to this view, Six Sigma cannot be seen as a static object that can be implemented once and forever…"*
>
> Firka (2010)

Finally, there is clearly a strong link between customer focus and a strong creativity and proactivity of employees, so they can best meet the needs of the client.

Table 11.40: Correlations between the best practices in the Culture and intangible assets aspect.

CULTURE AND INTANGIBLE ASSETS	Company-wide Six Sigma knowledge	Customer-focused vision	Boosting innovation and creativity of employees	Widespread culture of change	Eliminate internal resistance factors	Senior managers strong support for NSD	Top Management long term commitment	The firm aims to extend the methodology awareness along the supply chain
Company-wide Six Sigma knowledge								
Customer-focused vision	V							
Boosting innovation and creativity of employees		VV						
Widespread culture of change	V	V	V					
Eliminate internal resistance factors	V	V	V	V				
Senior managers strong support for NSD	VV				V			
Top Management long term commitment	VV				V	VV		
The firm aims to extend the methodology awareness along the supply chain	V	VV		V		V	V	

10.4.4 Correlations in the Actors and organizational structure aspect

Observing the relationship between the best practices of the aspect Actors and organizational structure, it could appear that the involvement of process owners in project teams is of great importance, since they bring a positive effect on all the practical implementation of this methodology and in particular they facilitate managing the organization by processes. The possibility to have consistent information from whom is in direct contact with the process (i.e. the process owner) allows driving the organizational efforts on projects and activities more appropriate (Akpolat, 2004; Bañuelas and Antony, 2002; Van Iwaarden *et al*, 2008).
At this regard, we claim again what has been observed by Van Iwaarden *et al* (2008, p.6751), regarding the benefits of involving the process owner:

> *"…Positive benefits from projects, management commitment, getting process owners involved, getting employees who are trained involved, and communication about overall progress with the Six Sigma approach are in the top five…"*
>
> (Van Iwaarden *et al*, 2008)

Moreover, the presence of figures from different functional areas, resulting in the heterogeneity of skills is very important in influencing positive especially regarding HR practices (Anand *et al*, 2009; Antony *et al.*, 2005; Henderson and Evans; 2000).
Finally, the extension of the training methodology and internal HR seem to exert a very positive influence on other practices, especially by facilitating the widespread presence of

certified resources in the company (Henderson and Evans, 2000; Goldstein, 2001; Ingle and Roe; 2001). The internal training of human resources can reduce costs, even the process of training is more focused on the needs of the organization, allowing you to insert the prepared resources in areas where there is greater need.
Ingle and Roe (2001, p. 276) illustrate the benefits of having resources within the corporate organization prepared in the methodology:

> *“…These, and other firms, are using Black Belt trained employees to assist in measuring how well their present business strategies are meeting company objectives, as well as developing strategies to reduce costs, cycle times and defects while increasing profitability and competitive advantage…”*
>
> (Ingle and Roe, 2001)

Table 11.41: Correlations between the best practices in the Actors and organizational structure aspect.

ACTORS AND ORGANIZATIONAL STRUCTURE	Internal training for Six Sigma certification of human resources	Great importance of facilitators	Involvement of the process owner within the project team	The firm involves customers within the project team	Widespread presence of Master and Black Belts in the organizational functions	Six Sigma awareness for all human resources in the company	Project teams are composed by HR from different functional areas in order to broaden the skills	Manage organization by processes
Internal training for Six Sigma certification of human resources								
Great importance of facilitators								
Involvement of the process owner within the project team	**V**	**V**						
The firm involves customers within the project team			**V**					
Widespread presence of Master and Black Belts in the organizational functions	**VV**		**V**					
Six Sigma awareness for all human resources in the company	**V**		**V**		**VV**			
Project teams are composed by HR from different functional areas in order to broaden the skills	**V**	**V**	**VV**		**V**	**VV**		
Manage organization by processes			**VV**				**V**	

ACTORS AND ORGANIZATIONAL STRUCTURE

10.4.5 Correlations in the Strategic project selection aspect

Observing the relationship between the best practices of the aspect strategic project selection we suggest that high priority for the needs of the customers could adversely affect the formal and rigorous selection procedures (Sehwall DeYong, 2003).
Sehwall and DeYong (2003, p.2), to this point explains the difficulty of managing the great variability of responses of clients with a formal approach:

> *"…For many service companies, Six Sigma applies to customer service metrics. As a result, response differences (and defects), cannot be segmented individually due to greater variability of responses…"*
>
> (Sehwall and DeYong, 2003)

On the other hand, such a statement could find benefit from the elaboration of market studies and detailed regularly in order to capture customers' preferences (De Brentani, 1991; Akpolat, 2004). Akpolat (2004, p.45) outlines the importance of collecting customer information to identify areas for improvement:

> *"…As part of project selection process, preliminary data must be collected and analyzed to identify an improvement area. Data don't always have to be numeric but they should be specific and quantifiable. Most organizations collect data in some form about their customers, staff and suppliers…"*
>
> (Akpolat, 2004)

Instead, the importance associated with financial indicators such as ROI positively influence the most other practices in this area, particularly linking the projects with the organization's strategy and the detailed risk assessment, (Goh, 2002; Goldstein, 2001; Sehwall and DeYong, 2003; Antony, 2006).
To connect the new projects with the business strategy and assess their compatibility with the previous ones, it is absolutely necessary the approval and support of senior management. Even including the use of formal procedures for ranking and selection can be a useful aid (Antony *et al*, 2009).
Antony *et al* (2009, p.671), stress the importance of a formal process for selecting projects:

> *"…Survey findings also showed that the existence of formal project selection processes, process documentation, and rigorous requirements for project approval are all elements of a highly successful program…"*
>
> (Antony *et al.*, 2009)

Table 11.42: Correlations between the best practices in the Strategic project selection aspect.

STRATEGIC PROJECT SELECTION	Strong customer-focused project selection	Structured projects scoring system	Great importance of indicators such as financial impact, financial risk and ROI for project selection	The firm conducts periodical and detailed formal study of the market	Projects selection is clearly linked to the corporate strategy	Consistency with other Six Sigma projects in the company	Projects must be approved and supported by senior management	Thorough risk analysis of NSD project
Strong customer-focused project selection								
Structured projects scoring system	**XX**							
Great importance of indicators such as financial impact, financial risk and ROI for project selection	**X**	**VV**						
The firm conducts periodical and detailed formal study of the market	**V**							
Projects selection is clearly linked to the corporate strategy	**X**	**V**	**VV**					
Consistency with other Six Sigma projects in the company	**X**	**V**	**V**		**V**			
Projects must be approved and supported by senior management					**VV**	**V**		
Thorough risk analysis of NSD project			**VV**		**V**		**V**	

STRATEGIC PROJECT SELECTION

Chapter 12 -SYNTHESIS OF DFFS MODELS FOR SERVICES

12.1 Introduction to the model for service process classification

In the previous chapter the first part of the empirical study if this thesis has been carried out, responding to the second research question:

> **“What are the best practices that firms must own to successfully implement DFSS to different typologies of service process?”**

Beyond the research gap in the Six Sigma literature, the origin of this research question was due mainly to the heterogeneity of services. The purpose was to find the common procedures that every kind of company with that purpose should adopt. For this reason, thanks to data analysis and confirmatory literature review, we outlined 40 best practices, eight for each of the five aspects of the methodology explained before.
However, these best practices should represent only the beginning for organizations willing to apply the methodology, because in order to apply more effectively DFSS to services, they should focus on different strengths or weaknesses of the methodology, related to the specific typologies of service process they want to design or redesign.
In other words, the third research question is:

> **“What are the models to effectively manage the aspects of DFSS in the case of different typologies of service processes?”**

We start from the service classification model we have discussed previously. Such classification groups service processes by the *interface* of the service, i.e. some people (organic interface) or a technological device (mechanistic) and by the *contact time*, i.e. the percentage of time spent by the customer in the area of service deployment compared to the total time of service deployment.
We already explained the model in the previous chapters. Here below, an example of the model referred to an airline:

Table 12.1: Example of service classification model in the case of an airline.

		How is the service deployed?	
		People	**Technology**
Extension of contact	**High**	*On board services*	*Flight activity*
	Low	*Call center reservations*	*Internet Booking*

The purpose is develop a specification of this for every of the five aspects of the methodology, starting from the analysis of the best practices found and on the basis of the data obtained from the four case studies Motorola, GE Oil & Gas, GE Capital and UniCredit.

12.2 Proposal of the five models

12.2.1 Methodology implementation model

First, the applicability of best practices in this field to the various types of services will be commented on the basis of the data available, as summarized in the following table:

Table 12.2: General applicability of best practice of Methodology implementation.

METHODOLOGY IMPLEMENTATION	
BEST PRACTICE	**APPLICABILITY**
Problem setting and clear formulation of project purposes	Variable, depending on service typology
Use of formal procedures for NSD projects selection	Variable, depending on service typology
The project objectives must be measurable	Transversal to every service typology
Performance metrics and measurements based on project purposes	Transversal to every service typology
Trade-off between results and project duration	Transversal to every service typology
Project results are consolidated over the years	Variable, depending on service typology
The firm conducts a long post launch review and documentation after the new service launch	Transversal to every service typology
Pre-launch tests of the service process before actual launch are performed	Variable, depending on service typology

Specifically, for those which have a transversal applicability, we report these levels (Very high-High-Average-Low-Very low):

Table 12.3: Degree of applicability of transversal best practices for Methodology implementation.

METHODOLOGY IMPLEMENTATION	
TRANSVERSAL BEST PRACTICE	**DEGREE OF APPLICABILITY**
The project objectives must be measurable	High
Performance metrics and measurements based on project purposes	High
Trade-off between results and project duration	High
The firm conducts a long post launch review and documentation after the new service launch	High

Furthermore, referring to the best practice with variable applicability depending on the typology of service process, we report the following levels (Very high-High-Average-Low-Very low) for every of the four service typologies:

Table 12.4: Variable degree of applicability depending on service typology of best practices for Methodology implementation.

BEST PRACTICE	SERVICE TYPOLOGY			
	High contact/ Organic	**Low contact/ Organic**	**High contact/ Mechanistic**	**Low contact/ Mechanistic**
Problem setting and clear formulation of project purposes	High	Very high	Average	Average
Project results are consolidated over the years	Very high	High	Average	Average
Pre-launch tests of the service process before actual launch are performed	Average	High	High	Very high
Use of formal procedures for NSD projects selection	Average	High	Very high	Very high

The analysis of case studies summarized in the tables, brought out some transversal best practices in methodology implementation aspect, thus common to all types of service. In particular, the simple definition of metrics for measuring the goals and the fact that they are easily measurable aspects are universally recognized as vital to the success of the methodology. Furthermore, the level of importance given by respondents of the case studies to the balance between quality, cost and speed of projects, let us believe that this practice is applicable across all types of services.
An analysis of best practices with variable applicability and the observations from the four case studies showed that in services with a strong extension of the contact and the presence of people, activities and tools related to the Analyze and Verify phases of the DMADV cycle are of great importance. In these cases it would be much worse to begin to design or redesign new services with some defective characteristics. In fact, given their high visibility, the same would be much more perceived negatively by customers. The only way to reduce these defects is to give emphasis to the Analyze phase, in order to take into account all critical to quality and eventualities in advance. It is also particularly important to test accurately the solution proposed in the Verify phase, because the physical presence of the customer, and especially the great length of time during service delivery, could lead to problems and unexpected events unwanted by the organization, hence the need for very thorough control of results.
In the case of services characterized by the presence of people but a lower extension of the contact, the Analyze phase is particularly important, although the phase of Verify is less significant, given the lack of customers in the physical environment of the delivery. These observations are confirmed by the importance given in the evaluations of respondents to the focus on time sustainability of the improvements, which in literature is reflected in Anand *et*

al. (2009). The importance given by respondents to the clear formulation of the problem and the objectives to be achieved in projects helps to further confirm such observations. In literature, this practice is reflected in Pande *et al.*, (2000), Goldstein (2001) and Van Iwaarden *et al.* (2008).
In the case of high-tech services with a high extension of the contact, the design is very important when you need to change the technology. In these cases, the phase of Verify is still important even if you have less relevance than whether there is a strong presence of people, because of the absence of long relations between the customer and people. Finally, in services with high technological content but with a low level of contact, the stage of design is important. The Verify phase is less important compared to the situation of high contact, for the same reasons previously quoted. For example, with regard to ATM, or ticket machines, which are characterized by a high-tech and management of sensitive data, the design phase turns out to be crucial. In fact, in these cases already in the design phase should be defined, with the highest level of detail, control parameters, and simulations of the operation, in order to minimize the variability and problems during delivery.
Starting from the observations reported previously we therefore propose the following model of classification of services in relation to the methodology implementation aspect:

Table 12.5: Methodology implementation model.

		How is the service deployed?	
		People	**Technology**
Extension of contact	**High**	*DM**A**D**V***	*DMA**DV***
	Low	*DM**A**DV*	*DMA**D**V*

In order to validate the model two quadrants will be commented, testing them on the basis of information from each of the four case studies under review.
The first quadrant is selected as one characterized by a high extent of contact and a mode of service delivery based on people. According to the model it provides a very important phase of Analyze and Verify.
GE Capital Customer Advisory Boards are attended by Leader of the GE and people with important business relationships with customers. By involving these boards in a panel of major customers, GE understands what is good, the areas in which needs to improve and is committed to undertake specific projects for improvement.
These indications seem to confirm the importance of control over the implemented solutions and services of the preliminary analysis of high contact and with a strong presence of people.
Again, GE believe that the Value Stream Map is the best tool to map a process and a clear view of the steps that comprise it, as well as systems and resources involved in each step. This tool is very useful in the Analyze phase of the cycle. It is very effective especially in high-extension of contact and with a strong presence of technology.
The second quadrant is characterized by a low extent of contact and a mode of service delivery based on people. According to the model it provides great importance overall on the Design phase.
In UniCredit, great importance is given to best practices regarding the knowledge of the methodology and tools. In particular, it refers to tools such as Kanban or 5 S, which are primarily used in the design phase of the cycle DMADV.

In the OTR processes, with high technology and low level of contact, there is a very sharp focus on the design activity. For example, one of the objectives in the design phase of a new process was to develop a mistake proof system, to limit the need for internal controls and improve efficiency.

12.2.2 Methodology tools model

First, the applicability of best practices in this field to the various types of services will be commented on the basis of the data available, as summarized in the following table:

Table 12.6: General applicability of best practice of methodology tools.

METHODOLOGY TOOLS	
BEST PRACTICE	**APPLICABILITY**
The firm monitors service performance using a clear set of Key Performance Indicators	Variable, depending on service typology
Great importance of VOC analysis tools	Variable, depending on service typology
Use of Project Management tools and skills	Transversal to every service typology
Greater use of qualitative tools rather than statistical and quantitative tools	Variable, depending on service typology
Great importance of Change Management tools (e.g. CAP)	Variable, depending on service typology
Joint use of Six Sigma and Lean Management tools	Transversal to every service typology
Use of periodical reports during NSD	Transversal to every service typology
Use of different management tools	Transversal to every service typology

Specifically, for those which have a transversal applicability, we report these levels (Very high-High-Average-Low-Very low):

Table 12.7: Degree of applicability of transversal best practices for methodology tools.

METHODOLOGY TOOLS	
TRANSVERSAL BEST PRACTICE	**DEGREE OF APPLICABILITY**
Use of Project Management tools and skills	Very high
Joint use of Six Sigma and Lean Management tools	Very high
Use of periodical reports during NSD	Average
Use of different management tools	High

Furthermore, referring to the best practice with variable applicability depending on the typology of service process, we report the following levels (Very high-High-Average-Low-Very low) for every of the four service typologies:

Table 12.8: Variable degree of applicability depending on service typology of best practices for methodology tools.

BEST PRACTICE	SERVICE TYPOLOGY			
	High contact/ Organic	**Low contact/ Organic**	**High contact/ Mechanistic**	**Low contact/ Mechanistic**
Great importance of Change Management tools (e.g. CAP)	Very high	High	Average	Average
Great importance of VOC analysis tools	Very high	High	Average	Average
Greater use of qualitative tools rather than statistical and quantitative tools	Very high	High	Average	Average
The firm monitors service performance using a clear set of Key Performance Indicators	Average	Average	High	Very high

The analysis of best practices summarized in the tables, suggests that the combined use of Six Sigma and Lean tools have applicability across the different types of service. In fact, the choice of appropriate systems to the resolution of certain issues, drawing on a common bundle of tools or Lean or Six Sigma, it is imperative for the success of any Six Sigma project, and in general for the implementation of the methodology. In this sense, the use of management tools and project management skills is a practice whose value is high across each type of service, as well as the use of periodic reports during the NSD.
The increased use of quality tools with respect to statistical tools is a common feature of the methodology in transactional environment, but there are nuances within the specific nature of the service. Indeed, the focus on increased use of qualitative tools can have different degrees of intensity, depending on the type of service to which you refer. It has been observed in fact, particularly in GE Capital and UniCredit, which services characterized by high intensity of contact and where the human component has an important place, there is a strong use of qualitative tools. In the specific tools for the collection of VOC and innovation tools, are primarily used precisely in this type of service, as evidenced by the great importance attached by respondents to the relevant best practices of these two organizations. These indications are based in literature, in particular Antony *et al.* (2007) and George (2003) refer to the importance of using quality tools for the collection of VOC and change management.
However, in services characterized by a lower extension of contact, but where the human component is still of major importance, the use of tools of quality was more frequent, even if with a lower level of intensity. For example, reference is made to process mapping tools such as value stream mapping or the use of checklists for the construction of the same workflow. It was also noted that in the case of services where the technology component has a

predominant aspect, the use of statistical tools is growing, with an intensity inversely proportional to the extension of the contact. In both case studies was in fact found a higher use of statistical tools in processes that require more technology and automation. To confirm these observations, there is a common high level of importance towards statistical and quantitative tools in dealing with OTR and ITO processes, in the high-tech. The use of statistical and quantitative tools requires a good understanding of themselves and of the methodology, as reported by Antony and Banuelas (2002).
Starting from the observations reported previously we therefore propose the following model of classification of services in relation to the scope of the tools:

Table 12.9: Methodology tools model.

		How is the service deployed?	
		People	**Technology**
Extension of contact	**High**	*Strong use of qualitative tools*	*Use of statistical tools*
	Low	*Use of qualitative tools*	*Strong use of statistical tools*

Validation of the model

In order to validate the model, two quadrants will be chosen, which will then be analyzed and tested on the basis of information from the case studies of reference.
The first quadrant is the one characterized by a high extent of contact and a mode of service delivery based on people. According to the model it provides for the use of high quality instruments.
In GE Capital and UniCredit for example, there is an extensive use in the concept phase of the core services of the business, like finance or fleet management, of a toolkit for innovation in order to facilitate the generation of new ideas and improve their quality.
In both companies, many activities to collect the voice of the customer are performed; in particular Capital is using a tool called IPSEN promoter score, a gauge of satisfaction that can be applied to both the product and service. This tool provides a score on customer satisfaction and indicate the potential areas of work and improvement.
On the other side, especially in GE Oil & Gas, there are required courses in change management, known as CAP. This instrument, with the purpose of explaining to employees the importance of change, is of particular relevance in its services where human presence is strong and the contact high. For example, maintenance services and field support provided by global service.
Motorola and GE Oil & Gas give much importance in this type of service process, to the tool of brainstorming. This is because in situations of high uncertainty, such as high contact and presence of people, the experience is more important than observation. This technique is widely used in the field, such as monitoring and diagnostic facilities, to ensure peak performance.
It should be emphasized that the use of such instruments with qualitative connotation, is highly concentrated in the phases of the methodology Verify and Measure. In fact, given the considerable influence dictated by perceptions of customer service in high-contact, a clear

definition of quality requirements and effective monitoring, through such tools for the collection of VOCs, are a prerequisite for a correct design of the service.
The second quadrant is the one characterized by a low extent of contact and a mode of service delivery based on the technology. According to the model it provides for the use of powerful statistical tools.
GE Capital and other financial institutions, there are many initiatives, where possible, to digitize the interface with the customer. For example the request for quotations, until the approval of the credit or the creation of documentation, is increasingly supposed to be done through e-document. It also seeks to implement, where ever possible, an electronic signature, or to reduce the billing invoices with manual and replace it with EDI (Electronic Data Interchange) and similar technologies. These practices allow processes and services designed getting simpler and less intensive as possible in order to facilitate both the personal and the end customer.

12.2.3 Culture and intangible assets model

First, the applicability of best practices in this field to the various types of services will be commented on the basis of the data available, as summarized in the following table:

Table 12.10: General applicability of best practice of Culture and intangible assets.

CULTURE AND INTANGIBLE ASSETS	
BEST PRACTICE	**APPLICABILITY**
Top Management long term commitment	Transversal to every service typology
Senior managers strong support for NSD	Transversal to every service typology
Customer-focused vision	Transversal to every service typology
Company-wide Six Sigma knowledge	Variable, depending on service typology
The firm aims to extend the methodology awareness along the supply chain (customers and suppliers)	Variable, depending on service typology
Widespread culture of change	Variable, depending on service typology
Eliminate internal resistance factors	Transversal to every service typology
Boosting innovation and creativity of employees	Variable, depending on service typology

Specifically, for those which have a transversal applicability, we report these levels (Very high-High-Average-Low-Very low):

Table 12.11: Degree of applicability of transversal best practices for culture and intangible assets.

CULTURE AND INTANGIBLE ASSETS	
TRANSVERSAL BEST PRACTICE	**DEGREE OF APPLICABILITY**
Eliminate internal resistance factors	High
Senior managers strong support for NSD	Very high
Top Management long term commitment	Very high
Customer-focused vision	High

Furthermore, referring to the best practice with variable applicability depending on the typology of service process, we report the following levels (Very high-High-Average-Low-Very low) for every of the four service typologies:

Table 12.12: Variable degree of applicability depending on service typology of best practices for culture and intangible assets.

BEST PRACTICE	SERVICE TYPOLOGY			
	High contact/ Organic	**Low contact/ Organic**	**High contact/ Mechanistic**	**Low contact/ Mechanistic**
Company-wide Six Sigma knowledge	Average	Very high	Average	Average
Boosting innovation and creativity of employees	Very high	Average	Average	Average
Widespread culture of change	Very high	Average	Average	Average
The firm aims to extend the methodology awareness along the supply chain (customers and suppliers)	Average	High	Very high	High

The new analysis of the four case studies summarized in the tables, has highlighted some best practices in the cultural and intangible aspects that are transversal to all types of service process. In particular, the spread of quality culture throughout the company and the commitment of top and senior management are not only common to all services, but are necessary prerequisites for the implementation of Six Sigma methodology in general. The customer focus is a distinguishing feature of all services, and is therefore also considered as a transversal practice.

An analysis of best practices with applicability variable and the observations from the four case studies showed that in services with a strong extension of the contact and presence of people, the behavioral aspects of the service supply are of great importance. With behavioral aspects are understood as the ways in which service provision meets the other party in order to ensure a better service. As an example we can quote the flexibility, openness, commitment and availability. Unlike the case of services where, against a strong presence of people, there is a rather low level of contact. In these cases there was a trend towards standardization, in line with those expectations may be related to the type of service. About this point, i.e. the aim of extending knowledge of the methodology to more business resources possible, even in literature is reflected its great importance, e.g. Banuelas and Antony (2002), and Anand *et al.* (2009).
In the case of services with high technological content, the most important intangible asset is surely to be the corporate brand, with its wealth of messages, meanings, and culture. For GE, the vision, "bring better things to life", and the brand of a multinational company with more than a century old, seem to be a very important asset in the acquisition of customers, especially when the service is characterized by poor presence of people from limited contact. Schmenner (1986), commenting on his Service Process Matrix asserts that one of the biggest challenges in this type of services is in the marketing function, and then consequently also in enhancing the corporate brand.
Starting from the observations reported previously we therefore propose the following model of classification of services in relation to the field of culture and intangible aspects:

Table 12.13: Culture and intangible assets model.

		How is the service deployed?	
		People	**Technology**
Extension of contact	**High**	*Behavioral aspects*	*Strong brand*
	Low	*Standardization*	*Very strong brand*

Validation of the model

In order to validate the model, three quadrants will be chosen, which will then be tested on the basis of information from the case studies under review.
The first quadrant is selected as one characterized by a high extent of contact and a mode of service delivery based on people. According to the model it provides the focus on the behavioral aspects of the service delivery.
GE Capital's vision, particularly suited to the core services of the company, says: *"That Provide financial solutions enable companies to build Stronger and better future, connect with people that understand your industry and your need."*. GE Capital is proposed to help build the future of their own customers and, through a team of people who know the customer's products and their industry. From this message it seems clear a strong commitment to meeting the specific needs of the client, through a flexible and open collaboration.
One service of this typology offered by GE Oil & Gas and Motorola is called CSA, which stands for Contractual service agreements. These agreements are usually twenty years long, signed with the most loyal customers, for the duration of which the company guarantees the availability or performance of the machine at the peak of its possibilities. In this type of

service, where you plan consistent with the external customer interface, are very important social skills, reassurance, and readiness in responding to the needs of the customer.
The second quadrant is the one characterized by a low extent of contact and a mode of service delivery based on people. According to the model it provides the focus on standardization. One of the most important concepts in the culture of GE Capital on the optimization of internal processes characterized by low extent of contact is as follows: *"align employee effort with business and customer success."*. In practice, the launch of a project should be clearly defined by the business case methodology, the vision and the expected benefits to allow you to align the efforts of staff towards the goals.
A signal that characterizes the quest for standardization is certainly the importance towards the extension of the methodology to the largest possible number of corporate resources to ensure service of process as much as possible uniform and standardized.
The third quadrant represents the services characterized by a low extent of contact and a mode of service delivery based on the technology. According to the model it provides a great importance of the brand.
One of the strengths of GE Capital is the presence in all continents, with a policy of regionalization, which provides strong recognition and identification of the brand in each geographic outpost.
In the quotation process, characterized by low contact time and by high technology, the strong characterization of a brand such as GE, can often make the difference in the acquisition of a contract. In particular, initiatives such as "quote in a day", is advancing the company's goal to complete the estimates in the shortest possible time, helping to create a strong corporate image, very important in this type of service.

12.2.4 Actors and organizational structure model

First, the applicability of best practices in this field to the various types of services will be commented on the basis of the data available, as summarized in the following table:

Table 12.14: General applicability of best practice of Actors and organizational structure.

ACTORS AND ORGANIZATIONAL STRUCTURE	
BEST PRACTICE	**APPLICABILITY**
Manage organization by processes	Transversal to every service typology
Project teams are composed by HR from different functional areas in order to broaden the skills	Variable, depending on service typology
Internal training for Six Sigma certification of human resources	Transversal to every service typology
Involvement of the process owner within the project team	Transversal to every service typology
Six Sigma awareness for all human resources in the company	Variable, depending on service typology
Great importance of facilitators	Variable, depending on service typology
Widespread presence of Master and Black Belts in the organizational functions	Transversal to every service typology
The firm involves customers within the project team	Variable, depending on service typology

Specifically, for those which have a transversal applicability, we report these levels (Very high-High-Average-Low-Very low):

Table 12.15: Degree of applicability of transversal best practices for Actors and organizational structure.

ACTORS AND ORGANIZATIONAL STRUCTURE	
TRANSVERSAL BEST PRACTICE	**DEGREE OF APPLICABILITY**
Manage organization by processes	High
Involvement of the process owner within the project team	High
Widespread presence of Master and Black Belts in the organizational functions	Average
Internal training for Six Sigma certification of human resources	Very high

Furthermore, referring to the best practice with variable applicability depending on the typology of service process, we report the following levels (Very high-High-Average-Low-Very low) for every of the four service typologies:

Table 12.16: Variable degree of applicability depending on service typology of best practices for Actors and organizational structure.

BEST PRACTICE	SERVICE TYPOLOGY			
	High contact/ Organic	**Low contact/ Organic**	**High contact/ Mechanistic**	**Low contact/ Mechanistic**
Great importance of facilitators	High	Very high	High	Very high
The firm involves customers within the project team	Very high	Average	Average	Average
Six Sigma awareness for all human resources in the company	Average	Very high	High	High
Project teams are composed by HR from different functional areas in order to broaden the skills	High	Very high	Average	Average

The analysis of case studies summarized in the tables, brought out some best practices within the organization, transversal to all types of service. In particular, a meso-structure characterized by the presence of Master Black Belts, Black Belts and Green in each business function is a common practice to apply to each type of service. In addition to internal training

resources through a structured training methodology and the presence of process owners in the project team practices are valued very highly by the respondents in each of the four case studies, and also seems applicable to each type of service.
Finally, as noted in Motorola and UniCredit, the presence of a flexible and responsive organizational structure, and a system of rewards and professional growth based on the results of Six Sigma projects are characteristics of all types of services, and generally a prerequisite for the implementation of the methodology.
Thanks to the analysis of best practices with variable applicability and the observations from the case studies allowed outlining that in services with a strong extension of the contact and the presence of people, contact staff is particularly important. This view is reinforced by indications from the case studies and best practices greatly influenced by the front office staff. Specifically it refers to the presence of customers in project teams, a practice seen in particular from Motorola. In addition, both GE Oil & Gas and GE Capital, refer to the objective of extending the knowledge of the methodology along the supply chain, from customers and suppliers. A claim for extension of the methodology along the supply chain has a counterpart in literature Banuelas and Antony (2002) and Goldstein (2001).
Edvardsson and Olson (1996) have instead proposed a number of observations regarding the role of the customer in developing services. In fact, given the large number of interactions that characterize this type of process, people are most stressed and influential customers. In the case of services with the presence of people but with little extension of contact, the observations from case studies show rather greater importance given to the back office staff. In this Den Hertog (2000), proposes to consider four-dimensional analysis of service innovation, called the size of the new service concept, the size of the new interface with the customer, size of the new system of service delivery and size technological options. In particular, about the size of the service delivery system, it provides changes for internal organization, in order to enable the back office staff to carry out properly the tasks and to develop and offer innovative services.
A demonstration of this claim is stressed by the best practices greatly influenced by the back office staff, as the diversity of skills in project teams, or the need for great facilitators in this type of service. In literature, the diversity of skills in project teams is reflected in Anand *et al.* (2009) and Henderson and Evans (2000).
Over the years the distinction between goods and services is becoming increasingly blurred, particularly the phenomenon of integration of products and services in the most recent literature is called "servitization" (Wilkinson *et al.* 2009). In reference to the activities of front office and back office, the authors note that the integrated supply of products and services requires a significant transformation in the structure of firms, leading to the establishment of specialized units in the activities of front end and back end .
In the case of services from high-tech, ICT (Information and Communication Technology) is obviously particularly important. We can notice that, the computational capacity is a more critical aspect in high-contact services, and issues relating to telecommunications services are more important in low-contact. A classic example of the influence of technology in the way of service delivery is undoubtedly linked to the advent of self service. According to Fitzsimmons (2003), the services are migrating from a purely human interaction to one characterized by a high proportion of machinery or, more generally, purely technological. For example, the technology vendors to help keep track of spending habits of customers and provide special promotional offers. By definition, high-touch services are less influenced by self-service, but some of its uses are observed. For example, a patient at home at home could use a machine to measure the pressure and then send the results to the doctor's office.

Even the E-Commerce and E-Business, are closely related to technological development and communication technologies and at this regard Weill and Vitale (2001) have proposed eight generic models for E-Business involving different sectors and types of services. Starting from the observations reported previously we therefore propose the following model of classification of services in relation to the Actors and organizational structure aspect:

Table 12.17: Actors and organizational structure model.

<table>
<tr><th colspan="2"></th><th colspan="2">How is the service deployed?</th></tr>
<tr><th colspan="2"></th><th>People</th><th>Technology</th></tr>
<tr><th rowspan="2">Extension of contact</th><th>High</th><td>Involve the front office people</td><td>ICT</td></tr>
<tr><th>Low</th><td>Involve the back office people</td><td>ICT</td></tr>
</table>

Validation of the model

In order to validate the model three quadrants will be commented, testing them on the basis of information of the case studies under review.
The first quadrant is characterized by a high extent of contact and a mode of service delivery based on people. According to the model it provides for substantial involvement of the front office staff.
In some projects, concerning financial services typically offered by GE Capital and UniCredit, it happens to be working on processes that involve both the company and its customers. At this regard, the firm consequently gives some knowledge of the methodology to customers, demonstrating the importance of the front office staff, in close contact with the customer in this type of services.
Furthermore, in some projects, it can happen even to include within the project team also customers, overall in Motorola. For example promoters may be responsible for relations with Motorola for the customer. This practice allows the sharing of knowledge and skills in order to achieve effective implementation of the methodology.
Some services offered by GE's global service, are characterized by a continuous interface with external customers such as CSA (Contractual service agreements). Such services require a very significant focus on front office staff, again to facilitate the sharing of knowledge and facilitate the application of the methodology.
The second quadrant shows a low extent of contact and a mode of service delivery based on people. According to the model it provides a strong back office staff involvement.
The optimization and standardization of internal processes, characterized by a low extent of contact with customers and a strong presence of staff, require a certain level of knowledge of the methodology. In order to improve the competence of the staff back office on Six Sigma, UniCredit and GE aim to expand to as many employees as possible at a minimum level of awareness on the methodology.
According to the vision of GE Oil & Gas. the ingredients of success for the improvement of internal processes, are the employees contributions. However, such employees must be in close contact with these processes, relying on their knowledge and expertise. These opening words and suggestions are very important in the Measure and Analyze phases of the cycle DMADV.

Another feature of the service process inside a low extent of contact is the need of excellent facilitators in the early stages of projects, this in order to manage conflicts between the back office staff in a constructive manner. In particular, these figures are very important during the Measure and partly in the Analyze phase of DMADV cycle.
The third quadrant is characterized by a low extent of contact and a mode of service interface based on the technology. According to the model it provides a main focus on computational aspects of ICT.
At GE Capital but even in UniCredit, in fact, there are many initiatives to digitize as much as possible interface with the customer in high-tech services. For example, the processes relating to quotations shall try to do as much as possible through the use of e-document.
A common practice, especially in the ITO where the technology is strong, is the use of tools to verify the possibility of separating the population data collected in two different samples. If the tests are OK, then the processes are created with structures that allow you to efficiently and effectively manage different types of transactions.

12.2.5 Strategic project selection model

First, the applicability of best practices in this field to the various types of services will be commented on the basis of the data available, as summarized in the following table:

Table 12.18: General applicability of best practice of Strategic project selection.

STRATEGIC PROJECT SELECTION	
BEST PRACTICE	**APPLICABILITY**
Projects must be approved and supported by senior management	Transversal to every service typology
Strong customer-focused project selection	Variable, depending on service typology
Structured projects scoring system	Variable, depending on service typology
Projects selection is clearly linked to the corporate strategy	Transversal to every service typology
Great importance of indicators such as financial impact, financial risk and ROI for project selection	Transversal to every service typology
Thorough risk analysis of NSD project	Transversal to every service typology
Consistency with other Six Sigma projects in the company	Transversal to every service typology
The firm conducts periodical and detailed formal study of the market	Variable, depending on service typology

Specifically, for those which have a transversal applicability, we report these levels (Very high-High-Average-Low-Very low):

Table 12.19: Degree of applicability of transversal best practices for Strategic project selection.

STRATEGIC PROJECT SELECTION	
TRANSVERSAL BEST PRACTICE	**DEGREE OF APPLICABILITY**
Great importance of indicators such as financial impact, financial risk and ROI for project selection	High
Projects selection is clearly linked to the corporate strategy	Very high
Consistency with other Six Sigma projects in the company	High
Projects must be approved and supported by senior management	Very high
Thorough risk analysis of NSD project	High

Furthermore, referring to the best practice with variable applicability depending on the typology of service process, we report the following levels (Very high-High-Average-Low-Very low) for every of the four service typologies:

Table 12.20: Variable degree of applicability depending on service typology of best practices for Strategic project selection.

BEST PRACTICE	SERVICE TYPOLOGY			
	High contact/ Organic	**Low contact/ Organic**	**High contact/ Mechanistic**	**Low contact/ Mechanistic**
Strong customer-focused project selection	Very high	High	Average	Average
The firm conducts periodical and detailed formal study of the market	High	High	Average	Average
Structured projects scoring system	Average	Average	High	Very high

The analysis of case studies summarized in the tables, suggests that consistency with business objectives and other initiatives in the company are transversal practices to each type of service for the selection of Six Sigma projects. Almost the same is done for the approval and support of senior management as to the importance of financial indicators in project selection. In fact, except in cases of statutory compliance, the ultimate goal of Six Sigma projects always leads to an improvement in the financial results of the company. Finally, in all projects of NSD is imperative a thorough analysis of the risks associated with each.
An analysis of best practices and observations emerged from the four case studies showed that for high contact services with a considerable amount of staff, the influence of external customers is very important for the selection of improvement projects. This observation is linked to the fact that in these cases there is a predominance of front office processes, or those

in close contact with the end customer. In these cases it is preferable to use the DMAIC cycle, because, given the large presence of staff and clients, the changes must be incremental and not radical. In the literature, we find the reference to the importance of the information of customers on the origin of the projects in Antony and Ferguson (2004) and Goldstein (2001).
Similar considerations apply to the case of services with high contribution of people but by the low level of contact, which are also being developed through the use of DMAIC methodology. The observations arising from the cases, however, show a greater influence of internal customers in the selection of projects from these types of services, often with the aim of improving efficiency. Therefore, in these cases, there is a prevalence of back office processes, overall involving process owners and general internal customers.
When the Six Sigma projects are about service processes with limited degree of contact and a strong technology component, it makes more sense to use the cycle DMADV, especially suitable for situations that require radical improvements. An example is the use of multi-generational project plans, which are used in Motorola George (2003). A multi-generational project plan is a tool for project managers to manage projects quickly and easily use. Specifically, this tool helps managers define the objectives of a project going beyond the boundaries thereof, providing a better base on which to make operational decisions. In fact, with this tool are also considered possible future developments in the project analysis, both from the point of view of long-term goals and technology to use.
When there is a high-tech service, but combined with a high level of contact, there applies similar reasoning, however, there is a greater focus on the technologies of contact. Frohele and Roth (2004), have provided a model that illustrates the ways in which technology affects the delivery of service. In particular, as described in the model refers to the case where customer and organic provider of services are not in direct contact. In such situations, the technology of contact, such as technical assistance provided by a help desk or a call center at a distance, are particularly important.
In literature there are several studies and proposals for innovation in services, whether radical or incremental. In particular, Oke (2007), investigated the prerequisites needed to excel both in incremental innovation and radical one, in various industries including financial, transportation and telecommunications. The study involved five independent variables strategy calls for innovation, human resource management, creativity and ideas management, selection and project management, implementation. The author states that these five success factors are particularly significant in the case of radical innovation, while less importance is given to them in case of incremental innovation.
Starting from the observations reported previously we therefore propose the following model of classification of services in relation to the aspect of strategic project selection:

Table 12.21: Strategic project selection model.

<table>
<tr><th colspan="2"></th><th colspan="2">How is the service deployed?</th></tr>
<tr><th colspan="2"></th><th>People</th><th>Technology</th></tr>
<tr><th rowspan="2">Extension of contact</th><th>High</th><td>On the front office processes. Normally DMAIC</td><td>On the technology of contact. Normally DMADV</td></tr>
<tr><th>Low</th><td>On the back office processes. Normally DMAIC</td><td>On the technology of remote connection. Normally DMADV</td></tr>
</table>

Validation of the model

In order to validate the model two quadrants will be analyzed and commented on the basis of information from each of the two four case studies under review.
The first quadrant is selected as one characterized by a high extent of contact and a mode of service delivery based on people. According to the model it provides for the prevalence of front office processes, with incremental improvements usually applied through the DMAIC cycle.
In the financial services offered by GE Capital, where performance is repeated and repetitive over time, there is a big importance of the *"in life"*, the next contact with the customer. For example, in fleet management services, there is a portion of funding, for which the customer is directed to GE Capital, related to the acquisition of the machine and re-hire, and a series of additional services after the sale. These services involve a daily relationship with the customer, for example, find the location where the car be repaired, the quality of the same, the need for a replacement vehicle, all interactions between the service provider and the customer. Given the high complexity of the service, the result of continuous and constant interaction with the customer in such cases is preferable to use the DMAIC cycle, suitable to the introduction of incremental improvements.
Both in Motorola and GE Oil & Gas, the global service function, which interfaces with the external customer constantly in welfare services in the field, absolutely must take account of their needs, that become a priority. So in this sense, the front office processes become very important. Furthermore, the improvements are purely incremental, and introduced through the use of the DMAIC cycle.
The second quadrant is the one characterized by a low extent of contact and a mode of service delivery based on the technology. According to the model it provides for the prevalence of dial-up technologies with radical improvements normally applied through the DMADV cycle.
In UniCredit, certain processes ITO (Inquiry To Order), where there is a strong push towards the automation and increasing use of technology such as e-document or EDI, you need a total redesign of processes, with the help of step methodology similar to the cycle DMADV. At the same time in Motorola, in certain processes typically OTR (Order to Remittance), where again there is a strong need for automation and there is a high technological content, it is often used to utilize multi-generational project plans (MGPP), very useful in planning the future innovation. In particular, this tool is very helpful in the Measure and Analyze phases of the methodology.
In projects involving the redesign of internal processes, particularly those with high technological content and lack of contact as the quotations, are often used methodological steps typical of the DMADV cycle.

12.3 References in the Service and Six Sigma literature

The following summary tables are given the references in the literature used to validate the models on the five aspects of the methodology listed in the previous pages.

Table 12.22: Summary of authors and concepts for service process typology (1).

	SERVICE PROCESS TYPOLOGY			
AUTHORS AND MAIN CONCEPTS	High contact/ Organic	Low contact/ Organic	High contact/ Mechanistic	Low contact/ Mechanistic
George (2003), VOC and MGGP tools	✓	✓	✓	✓
Antony et al. (2007), qualitative tools like CAP and Brainstorming; project team with facilitators	✓	✓		
Anand et al. (2009), extend awareness to all HR; heterogeneity of skills in project teams; aim of long term improvements	✓	✓		
Bañuelas and Antony (2002), extend awareness to all HR; extend methodology in the supply chain; high knowledge of the methodology	✓	✓		✓
Schmenner (1986), Service Process Matrix	✓	✓	✓	✓
Antony and Ferguson (2004), customer focused project selection	✓			
Goldstein (2001), customer focused project selection; extend the methodology in the supply chain	✓	✓		
Henderson and Evans (2000), heterogeneity of skills in project teams		✓		
Pande *et al.* (2000), thorough problem and purpose setting	✓	✓		
Van Iwaarden et al. (2008), thorough problem and purpose setting	✓	✓		
Haynes (1990), Service Transaction Analysis Model			✓	✓
Berry et al. (1995), connection between the service technological content and perceived customer service			✓	✓
Chase (1981), Customer Contact Model	✓	✓	✓	✓
Fitzsimmons and Sullivan (1982), connection between productivity in services, level of customization and technological content	✓	✓	✓	✓

Table 12.23: Summary of authors and concepts for service process typology (2).

		SERVICE PROCESS TYPOLOGY			
		High contact/ Organic	**Low contact/ Organic**	**High contact/ Mechanistic**	**Low contact/ Mechanistic**
AUTHORS AND MAIN CONCEPTS	Fitzgeral et al. (1992), service classification and characteristics of contact extension	✓	✓	✓	✓
	Thomas (1975), differences between organic and mechanistic interface	✓	✓	✓	✓
	Kotler (1980), differences between organic and mechanistic interface	✓	✓	✓	✓
	Maister and Lovelock (1983), service classification based on customization	✓	✓	✓	✓
	Frohele and Roth (2004), Technological contributions to service delivery			✓	✓
	Wilkinson et al. (2009), notes on servitization	✓	✓		
	Fitzsimmons (2003), technology and self-service			✓	✓
	Collier (1983), service autonomation			✓	✓
	Soete and Miozzo (1989, 2001), service classification based on technology	✓	✓	✓	✓
	Evardsson and Olson (1996), customers' role for service development	✓			
	Van Hertong (2000), model on service innovation	✓	✓	✓	✓
	Oke (2007), Critical succes factors on radical/incremental innovation on services	✓	✓	✓	✓
	Weill and Vitale (2001), e-Business models			✓	✓

12.4 Conclusion about the models

In this section we summarize, reporting in a table in the end of the section, the characteristics that distinguish the five aspects of the methodology in each of the four types of service process identified in the service classification model we chose. In particular, the focus will primarily deal with the different service types, while in the previous sections, the aim was to fully characterize each of the five areas under a variety of perspectives.

12.4.1 High contact services with organic interface

This type of service is characterized by a high number of personal interactions and consequently it results difficult to control the processes of this typology.
Consequently, from the point of view of the methodology tools aspect, there seems to be a strong use of quality tools in the design approach, with particular relevance to those used in the VOC analysis. These observations are reinforced by what emerged from the case studies addressed, particularly in GE Capital, and especially during Measure and Verify, which is essential for proper design of the service. Moreover, indications are based in literature, specifically George (2003) and Akpolat (2004), refer to the importance of instruments for the collection of VOC.
With regard to culture and intangible assets aspect, in this kind of services are most important behavioral aspects of the service, or the ways in which the regulator seeks to match the needs of the customer in order to provide a better service. For example, characteristics such as availability, flexibility and open-mindedness are essential when the client's presence is

massive and long while the service is delivered. For example, in the CSA (Contractual service agreements), as described previously and provided by Global Services of Motorola, there is a constant contact with the external customer and therefore these characteristics appear to be fundamental.

In terms of project selection, the high contact services with a strong presence of people have seen a great importance attached to the front office processes, or those where there is close contact with the end customer. Also in this type of cases it is preferable to use the DMAIC cycle, in order to introduce incremental changes and not too drastic. From this point of view, we find in the literature regarding the importance of the information of customers on the origin of the projects, (Antony and Ferguson, 2004; Goldstein, 2001). For example, a fleet management service as that offered by UniCredit, which is characterized by continuous and constant interaction with the client, the role of front office staff is essential, as it is better to use the DMAIC cycle, more suitable for the introduction of incremental changes. Also concerning the organizational aspects of the methodology it was observed that for this type of services have a strong involvement of the front office staff. For example in financial services or insurance, where there is a strong component of customization which leads to a high extent of contact; for this reason responsibility and social skills of frontline staff are essential. The indication of the need to extend the methodology across the supply chain is also stressed (Bañuelas and Antony, 2002; Goldstein 2001).

Finally, for methodology implementation, it was observed that in this type of service phases of the cycle DMADV, Analyze and Verify are of particular importance. In fact, given the great visibility related to the presence of people that distinguishes these services is key to start the implementation of change with the least possible number of defects, taking into account all possible eventualities in advance. In addition, the physical presence of the customer and especially prolonged contact will require a very fine control of the result. For example, in most of the cases a key tool in the early stages of an improvement project is the Value Stream Map, used to map the processes and to have a clear view of the steps that compose them, as well as the resources and the systems involved.

12.4.2 Low contact services with organic interface

This type of service is characterized by a high number of personal interactions, but the limited size of the contact shifts the focus of the service on the optimization of internal processes, which are essential for successful delivery. From the methodology tools point of view is observed, as in the previous case, a prevalence in the use of qualitative tools, although at a lower level of intensity for the lower extension of the contact. This observation is confirmed by indications from the literature (Anthony *et al*., 2007). For example, Motorola is often much referenced to the process mapping tools such as value stream mapping or the use of checklists for the design of the same.

With regard to culture and intangible assets, there was a strong trend towards standardization, aimed precisely to optimize internal processes. In this sense it is significant for example, the objective of extending the knowledge of the methodology to the largest possible number of corporate resources (Bañuelas and Antony, 2002, Anand *et al*., 2099). This is to provide services consistent and standardized as possible. This objective is obviously to reach for the lower extension of the contact, which reduces the complexity of many personal interactions. The strategic issues related to the selection of projects are characterized by a predominance of back office processes, with strong involvement of process owners and internal customers (Van Iwaarden *et al*, 2008). This is linked to the increased importance given to the indications of internal customers in the improvement projects of this type, aimed primarily at improving

efficiency. However, even in this case, the presence of personal interactions suggests the introduction of incremental improvements through the DMAIC cycle.
Even the organizational aspects are linked to this main focus, with a significant importance given to the back office staff in this type of service. In this sense, aspects such as the diversity of competencies in project teams, or the presence of excellent facilitators within them are important (Antony *et al*. 2007; Anand *et al.*, 2009). Furthermore, the organization should facilitate the back-office staff to carry out activities related to service delivery.
From the point of view of the methodology implementation, in this type of service is particularly important to the Analyze phase as in the previous case, however, the phase of Verify is less relevant, given the lesser extent of contact with the customer during the delivery of service. In confirmation of this observation is the importance given in the case studies of the clear formulation of problems and objectives to be achieved in the projects (Antony, 2004; Pande *et al*, 2000; Goldstein, 2001).

12.4.3 High contact services with mechanistic interface

This type of service is characterized by a strong technology that improves the efficiency during delivery, however, there is a high extension of the contact, which implies a more complex context and more difficult to control by the supplier.
From the tools point of view, there has been a growing use of quantitative tools and statistical data in this type of service, although the limited extension of the contact can limits that. In fact, the physical presence of the customer during delivery increases the variability and makes it harder to extend the use of them.
From the perspective of corporate culture in these types of services, it emerges with particular relevance the importance of the brand, which should be properly advertised and promoted. A strong corporate brand, with its own set of content, it can be important when the service is delivered not by an individual but by a technological device, an aspect which is also observed in the case studies discussed in this thesis, such as the slogan "Imagination at work ", which makes GE known around the world.
Strategic aspects regarding this type of service point out the introduction of more drastic improvement systems through the cycle DMADV. In particular for services with high extension of contact, the new contact technologies are fundamental, making it possible to assist and facilitate the interaction between the customer and the service provider. At this regard Frohele and Roth (2004), in their model of interaction between technology and service provision, also refer to the case where the customer and service provider are not in direct contact. In such situation, the technologies of contact, such as a help desk or call center, are of particular importance.
Regarding the organizational aspects, ICT services are definitely important in services with high technological interface; especially the computational power is something more critical in those with high extension of contact. For example, we stress as GE Capital uses an always more digitized interface with the customer, using e-document and e-communications. Moreover, according to Fitzsimmons (2003), the services are migrating from a purely human interaction to one characterized by a high proportion of machinery or, more generally, purely technological.
Finally, within the methodology implementation for this type of service, the design phase is very important because you need to change the technology. Also the Verify phase is very important, even if less relevant, if compared with those with a strong presence of people, due to the lack of direct relations between the customer and the organization personnel.

12.4.4 Low contact services with mechanistic interface

This type of service is characterized by a strong technological content and a low level of interaction with the customer during the delivery. This involves a very thorough focus on optimization; the technology also simplifies the delivery environment, enhancing control by the supplier.

From a methodology implementation point of view, it is noted that this type of service is made strong use of statistical tools, especially in higher-technology interfaced processes and automation. The use of statistical tools requires a good understanding of themselves and of the methodology. In GE Oil & Gas, for example, we can observe that ITO processes use statistical measurements to assess whether the data have a normal distribution. Using this type of instruments, however, requires a good understanding of statistics and the methodology (Bañuelas and Antony, 2002; Antony, 2006).

For the culture and intangible assets aspects, services with high technological interface and low contact time, stress again the great importance of corporate brand. For example, the vision of GE "Bring better things to life" joins the brand of a multinational company with great tradition and helps the customer acquisition and retention, especially in the case of this service typology. Schmenner (1986) at this regard, said that one of the most important challenges in this type of service is right in the marketing function, in order to enhance the corporate brand.

As we said for the service with high contact and mechanistic interface, the strategic topics point out the better introduction of more drastic improvements through the cycle DMADV. An example is the use of multi-generational project plans, which are used in GE Oil & Gas and illustrated by George (2003).

In addition, for services with a low extension, are fundamental technologies for remote connection, when client and provider of human services are not in direct contact. With regard to organizational aspects, in the case of high-tech interface services, ICT are of great importance. In particular, aspects relating to telecommunications services are particularly relevant in low-contact. For example, Weill and Vitale (2001) have shown how E-Commerce and E-Business are aspects related to communication technologies, and in this sense they might help manufacturers keep track of consumer habits of customers, improving the supply .

Finally, about the methodology implementation aspect, there is in this kind of services very marked importance of the design phase, having seen a strong involvement of the technology. At the same time, the Verify phase takes less importance, given the lack of interaction between customer and supplier, resulting from the lower extension of the contact. An example, regarding the ATM machines, i.e. a high technological interface service, is the importance of the Design phase in the DFSS project in UniCredit launched to redesign such service process.

The following page contains a table summarizing the most important topics in design or redesign different types of service processes, in relation to the five aspects of the methodology.

Table 12.24: Summary of the models.

		SERVICE TYPOLOGY			
		High contact/ Organic	**Low contact/ Organic**	**High contact/ Mechanistic**	**Low contact/ Mechanistic**
ASPECT	**Methodology implementation**	*DM**A**D**V***	*DM**A**DV*	*DMA**DV***	*DMA**D**V*
	Methodology tools	*Strong use of qualitative tools*	*Use of qualitative tools*	*Use of statistical tools*	*Strong use of statistical tools*
	Culture and intangible assets	*Behavioral aspects*	*Standardization*	*Strong brand*	*Very strong brand*
	Actors and organizational structure	*Involve the front office people*	*Involve the back office people*	***I**CT*	*I**C**T*
	Strategic project selection	*On the front office processes. Normally DMAIC*	*On the back office processes. Normally DMAIC*	*On the technology of contact. Normally DMADV*	*On the technology of remote connection. Normally DMADV*

CONCLUSIONS

In this thesis three research questions have been analyzed. After a thorough systematic literature review on the Six Sigma topic, an exploratory case study was launched. This pilot helped to find out response to the first research question about the aspects that organizations should manage to implement DFSS to design or redesign new service processes.
These aspects are five, belonging to the three decision levels, i.e. strategic, organizational and operational:

1. *Methodology implementation*, dealing with the models that organizations can use to apply the methodology and the procedures for its application (Operational level);

2. *Methodology tools*, dealing with the best tools that organizations can use in the model to improve its implementation (Operational level);

3. *Culture and intangible assets*, dealing with values, knowledge and Six Sigma training throughout the company (Organizational level);

4. *Actors and organizational structure*, dealing with the meso-structure of Six Sigma organization and the people involved in the project teams (Organizational level);

5. *Strategic project selection*, dealing with the ability of the company to connect corporate strategy to Six Sigma project selection (Strategic level).

Afterwards, to respond to the second research question and find the best practices among different kinds of services, a multiple case study has been launched, comparing the results in four different organizations that have applied the Six Sigma methodology in order to design or redesign their service processes.
Empirical results emerged in these case studies have been gathered and translated into forty best practices, in the form of statements, and grouped by the five aspects above mentioned.
These Best Practices are:

1. *Methodology implementation*:
    - Problem setting and clear formulation of project purposes;
    - Use of formal procedures for NSD projects selection;
    - The project objectives must be measurable;
    - Performance metrics and measurements based on project purposes;
    - Trade-off between results and project duration;
    - Project results are consolidated over the years;
    - The firm conducts a long post launch review and documentation after the new service launch;
    - Pre-launch tests of the service process before actual launch are performed.

2. *Methodology tools*:
    - The firm monitors service performance using a clear set of Key Performance Indicators;

- Great importance of VOC analysis tools;
- Use of Project Management tools and skills;
- Greater use of qualitative tools rather than statistical and quantitative tools;
- Great importance of Change Management tools (e.g. CAP);
- Joint use of Six Sigma and Lean Management tools;
- Use of periodical reports during NSD;
- Use of different management tools.

3. *Culture and intangible assets*:
   - Top Management long term commitment;
   - Senior managers strong support for NSD;
   - Customer-focused vision;
   - Company-wide Six Sigma knowledge;
   - The firm aims to extend the methodology awareness along the supply chain (customers and suppliers);
   - Widespread culture of change;
   - Eliminate internal resistance factors;
   - Boosting innovation and creativity of employees;

4. *Actors and organizational structure*:
   - Manage organization by processes;
   - Project teams are composed by HR from different functional areas in order to broaden the skills;
   - Internal training for Six Sigma certification of human resources;
   - Involvement of the process owner within the project team;
   - Six Sigma awareness for all human resources in the company;
   - Great importance of facilitators;
   - Widespread presence of Master and Black Belts in the organizational functions;
   - The firm involves customers within the project team.

5. *Strategic project selection*:
   - Projects must be approved and supported by senior management;
   - Strong customer-focused project selection;
   - Structured projects scoring system;
   - Projects selection is clearly linked to the corporate strategy;
   - Great importance of indicators such as financial impact, financial risk and ROI for project selection;
   - Thorough risk analysis of NSD project;
   - Consistency with other Six Sigma projects in the company;
   - The firm conducts periodical and detailed formal study of the market.

As regards the methodology implementation aspect, i.e. the operational level, the best practices point out several hints to successfully manage a Six Sigma project, both before the launch, during its development, and after its conclusion. Likewise, the methodology tools best practices suggest the use of new and various tools, e.g. lean management tools and innovation tools.

About the organizational level, the best practices regard culture and intangible aspects, and actors and organizational structure. The former outlines the purpose not to keep the methodology for few people, but try to extend to the whole organization the core Six Sigma values; the latter suggest mainly a series of improvement for Six Sigma teams and new directions for training.
Finally, as regards the strategic project selection aspect, i.e. strategic level, the best practices stress that the choice of Six Sigma projects connects the corporate strategy to customer needs. Furthermore, they outline other information, e.g. where the ideas for Six Sigma projects come from, how they are evaluated and eventually chosen, and who should approve and authorize their launch.
In response to the third and last research question, afterwards we carried out the comparative analysis of the case studies to find similarities and differences between the best practices, and extrapolate the results, finding how the best practices fit with different classes of service process defined previously.
On the basis of previous studies, we decided to classify service processes by two criteria: extent of contact time and interface of delivery. The former is about the contact time (Chase, 1981), i.e. the duration of the physical presence of the customer in the location where the service is deployed. The latter is about how the service is delivered and allows to distinguish services whose interface is represented by people, e.g. the waiter in a restaurant and those represented by technology, e.g. an ATM of a bank.
Crossing the two criteria, four different classes of service processes are emerged, but some questions raise:

- There is a continuum rather than a pigeonhole of organization into any one of the four classes;

- The specific organizations involved in service deployment can offer services classifiable in different typologies.

As a final result, the data analysis from the case studies and the confirmatory literature review allowed us to identify five models, corresponding to the five Six Sigma aspects mentioned earlier, which show us how organizations should differ Six Sigma application for each kind of new service process to design or redesign.
Service organizations should implement the methodology implementation aspect (Operational level) in different ways in case of different class of service processes. In the case of service deployed mainly by people with a high contact with the customers, the Analysis and Verify phases are particularly important. In this case, it would be very bad to start the implementation of the new services with defects. They would be highly visible and negatively perceived by customers, and hence impact on the success of the new services. The only way to reduce such defects is to give emphasis to the Analyze phase in order to take into account all the possible events in advance. It is important also testing very thoroughly the solution in the Verify phase, since the physical presence of the customers in the premises of the organizations could more easily lead to unexpected problems. Besides, in the case of services deployed through people with a low extension of the contact, the Analysis phase is still particularly important, while the Verify phase is less important on respect to the case of high contact due to the absence of the customers in the premises of the organization. Thus, the Analysis phase is important to take into account of all possible events, while testing (and hence the Verify phase) is also important but less so since the customer has a low contact with the organization. In the case of services mainly deployed through technology with a high

extension of the contact, Design is important since it will be necessary to modify the technology. In this case, the Verify phase is also important once again due to the presence of the customers in the premises of the organization and hence the need to reduce any defect at the start up of the new service. Finally, when services are mainly deployed through the technology but with a low level of contact with the customers, the Design phase remains important. The Verify phase is less important if compared to the situation of high contact, due to the lack of direct contact with the customers.

Empirical evidence suggests for the methodology tools aspect (Operational level) that organizations should better use different tools by the service process to create. In the case of service deployed mainly by people, even if the contact with the customers is low, the use of qualitative tools, in order to better identify the customer needs and the CTQs is effective: the higher the contact with the customers, the more important is the use of qualitative tools. At the same time, in the case of services mainly deployed through technology and with high contact with the customers, the use of statistical tools is more important. In this case, there is the need of processing a larger amount of available data in order to identify constraints and key variables to design a better service process: the lower the contact with the customers, the more important is the use of statistical tools.

About the culture and intangible assets aspect, dealing with values, knowledge and Six Sigma training throughout the company (Organizational level), there are different priorities according to the class of services. So for instance in the case of service deployed mainly through people and with a high extension of the contact, the behavioral aspects derived from the culture of the organization, with a strong set of values are very important. In the case of services, deployed by people but with a low contact, standardization is important since the customer remotely expect a well specified and standard type of service. Finally, in the case of services deployed through technology, the relevant intangible asset is the brand, particularly important in the case of low contact.

About the actors and organizational structure aspect, dealing with the meso-structure of Six Sigma organization and the people involved in the project teams (Organizational level), the type of people or facilities more critical to the success of the NSD initiatives are different according to the class of services. So for instance in the case of services mainly deployed through people and with a high extension of the contact, the front office people are particularly important. They should be part of project team to share the wealth of their knowledge of the customers. In the case of services deployed by people but with low contact, the back office persons are relevant, due to the remoteness of the customer. Information and Communication Technology (ICT) is relevant in the case of services deployed through technology. The processing side is more relevant in the case of high contact, while the telecommunication side is more relevant if contact with the customer is low, since the network connection offers greater opportunities.

Finally, the Strategic project selection should be oriented towards critical aspects of the organization. Similarly, there will be a difference in the use of the DMAIC model, based on the sequence of phases Define, Measure, Analyze, Improve and Control, more suitable for continuous small improvements, versus the DMADV model, based on the sequence Define, Measure, Analyze, Design and Verify; the latter is more suitable for radical improvements. In the case of services mainly deployed through people and with a high level of contact with the customers, the priority should be given to the front office processes for their criticality in the delivery of the services. DMAIC is used rather than DMADV, since when there is a physical presence of a large number of personnel and customers, and changes must be soft rather than radical. Similar considerations are valid for the case of services deployed through people but with a low contact, whose reference cycle should still be DMAIC. In this latter case, however,

the best service processes to improve should deal with the back office processes. The selection would be different in the case of services delivered by a technological interface. In this case, when contact with the customer is high, priority is normally given on the technology of contact. When contact is low, priority should be given to the remote connection technology. In the case of technology-based services, DMADV makes much more sense, since investments are definitely addressed to the technology, and efforts are stronlgy justified only in presence of radical improvements.
As a matter of fact, there is a continuum and a combination regarding how services vary. Such variation is connected with the interface of service delivery and the extension of contact with the customer. As a consequence, in applying the model, organizations should take into accounts these aspects in order to adapt to specific situations.
In summary, main results of this study have been twofold. By an academic point of view, since empirical research on DFSS applications in service processes is totally lacking, this study fills an important gap in scientific literature on Six Sigma. Furthermore, important managerial implications have been developed:

- The five main aspects that organizations should manage to successfully implement DFSS to design or redesign new service processes have been identified;

- A series of Best Practices common to the different service processes have been stated in order to manage these five aspects of the methodology;

- Five models have been proposed, one for each aspect, in order to successfully adapt the methodology to different service processes and maximize the results.

Limits of the research and future recommendations

The main research limitation of this study is associated with the number of organizations studied. In order to increase its validity the priority should be extend the study to much more organizations, in a theory building perspective.
Furthermore, the study used a selection of large enterprises; a future research might be the adaptation of the framework in the context of Small and Medium Enterprises (SMEs) to test if the results would be similar.
About research methods, future directions of research should include surveys and other quantitative methods. In this way it would be possible to test the best practices and the models with a method that would definitely reinforce the theory obtained in this thesis.
Finally, according to table 9.4, it could be interesting to extend the study also to the processes to manage DFSS in an inter-organizational context. This study, indeed, defined no best practices for that area, but since the common vision is to extend Six Sigma culture and training along the supply chain, also reflected in this study, further detailed research on the topic would be interesting. As a matter of fact it is expected that in the future more and more considerations would be given to inter-organizational processes from which there are potential high level of benefits.
In general, the results obtained with this study have been several; the purpose is to keep on carrying on this research, to offer a continuous critical discussion and shape new questions that open future research directions.

PART IV – APPENDIX

APPENDIX A: Research centers

Centre for Research in Six Sigma and Process Excellence

This is the first research center in the area of Six Sigma in Europe, based at Strathclyde, University of Glasgow, United Kingdom. The center was founded in June 2004 by Professor Jiju Antony, one of the authors of reference on Six Sigma in the world. Its primary objectives are the promotion of the Six Sigma strategy, Lean, as well as methods for quality management and improvement of business processes. In addition, the center's objective is to conduct academic research on Six Sigma and related topics, as well as build a foundation for the local business community through a wide range of international conferences and workshops.

Six Sigma Academy & Company

SSA & Company is a consulting firm in the field of operations that has helped hundreds of companies around the world improve their ways of working. Founded in 1994 under the name Six Sigma Academy by Harry and Schroeder, the creators of Lean Six Sigma methodology, it is located in the United States, Asia and Europe and so far has allowed saving billions of dollars to its customers.

Six Sigma Management Institute (SSMI)

The SSMI was founded by Harry in 2003 with the aim to explore new and innovative ways of implementing Six Sigma. One of the main objectives of the SSMI was to research and develop effective delivery systems to ensure that training costs could be reduced, making Six Sigma the prerogative of individuals and business of all sizes. This goal was achieved through the launch of MindPro, a web-based platform for methodology training, highly flexible and therefore suitable for enterprises of all sizes.

Motorola University

The Motorola University began as an internal program for employees with courses on a wide range of subjects to improve their technical skills. With the proliferation of Six Sigma, originally developed at Motorola, the Motorola University began to provide solutions in Six Sigma quality and also to customers, suppliers and partners.

Lean Sigma Institute

The LSI was founded in 2004 by a group of Lean Six Sigma professionals with a strong passion for this methodology. Some of them are considered as the pioneers of the first wave of the methodology, associated with birth in Motorola during the eighties. LSI is one of the first consulting firms in Asia in the supervision of Lean Six Sigma programs for non-manufacturing companies, combining the thought of Toyota and the Lean Six Sigma in Motorola.

APPENDIX A

American Society for Quality (ASQ)

ASQ is a global community of experts and is the leading scientific authority on quality, with the aim to promote and develop the tools, principles and practices regarding this topic. The center, founded in 1946 in Milwaukee, USA, now has over 85,000 members worldwide, and consists of 25 divisions that deal with various issues concerning the issues of quality, including one devoted entirely to the Six Sigma methodology. Since 1991, ASQ, which is now deployed in 15 locations along all the U.S. is the sole director of the Malcolm Baldrige National Quality Award Program.

QFD Institute

The QFD Institute was founded in 1993 by Dr. Yoji Akao and is based in Ann Arbor, Michigan, USA. It is the only advanced research center in the world dedicated to training on QFD, the state of the art technology and tools associated with it. The QFD Institute is a nonprofit organization formed for the most part, by volunteers.

Centro Ricerche Qualità

The Centro Ricerche Qualità was born in Genoa in 1992 and during these years has carried out research on the methodology of Total Quality Certification, developed programs and quality processes, products and services, and extended its powers to the environmental certification and safety plans in the workplace.
CRQ have set up a company specializing in consulting for public administration, whose areas of activity are: the development of systems of work organization, management controls and the introduction of the principles of quality and environmental protection in the performance of public administration.

Union of Japanese Scientistics and Engineers (JUSE)

JUSE was founded in May 1946 in Tokyo, following the encouragement by the Japanese government to the formation of industrial organizations to help the post-war recovery. This association brings together leaders and experts from all major Japanese companies wishing to share their best practices with the aim of revitalizing the country's economy, eliminate waste and improve quality.
The objective of JUSE is to promote systematic studies needed for the advancement of science and technology contributing to the development of culture and industry. JUSE which also managed the Deming Prize, also carries out training courses relating to the management of quality, Quality Circles, reliability engineering, DOE and much more.

Deming Institute

The W. Edwards Deming Institute was founded in 1993 by Deming. The institute, based in Washington DC, is a non-profit organization that provides educational services via conferences and seminars on the teachings of Guru Deming. The purpose of the institute is to increase the understanding of issues relating to quality management in furtherance of trade, peace and prosperity.

APPENDIX A

Centre of Quality Excellence

The Centre of Quality Excellence was founded in 2002, at the University of Leicester, on the basis of the Quality Excellence Group, active in Leicester since 1998. It has the aim of further developing the study of these issues, in particular, the center houses the Master in Quality and Excellence in Customer Service Management. The first Master was developed through the sponsorship of Rolls-Royce and now, thanks to the spread of teleconferencing is open to students from all over the world.

APPENDIX B: Classification of books

In the following appendix there are various classification of the books quoted in this thesis.

B1: Classification books per topic

AREA	TOPIC	Italian	English (Not translated)	English (Translated)	Totale stranieri	Total
Quality and Six Sigma	Quality Management	1	2	1	2	4
	Six Sigma	1	4	0	4	5
	Design For Six Sigma	0	1	0	1	1
	Six Sigma for service	0	3	0	3	3
	TQM	0	0	1	1	1
	Lean	0	0	1	1	1
Service	Service Management	0	8	0	8	8
	Service Marketing	0	4	1	5	5
	New Service Development	0	2	0	2	2
	Service Quality	0	2	0	0	2
	eBusiness	0	1	0	1	1
Methodology	Case study	0	0	1	1	1
	Qualitative research	1	3	0	3	4
		Tot. Italian	**English (Not translated)**	**30**		**Total**
		3	**English (Translated)**	**5**		**38**

B2: List of authors of books

<table>
<tr><th rowspan="2">AREA</th><th rowspan="2">TOPIC</th><th rowspan="2">Italian</th><th colspan="2">English (Not translated)</th><th rowspan="2">Total</th></tr>
<tr><th colspan="2">English (Translated)</th></tr>
<tr><td rowspan="12">Quality and Six Sigma</td><td rowspan="2">Quality Management</td><td rowspan="2">Conti and De Risi (2002)</td><td colspan="2">Hoerl and Snee (2002), Taylor</td><td rowspan="2">4</td></tr>
<tr><td colspan="2">Ishikawa (1992)</td></tr>
<tr><td rowspan="2">Six Sigma</td><td rowspan="2">Gibertoni (2008)</td><td colspan="2">Pandé et al (2000), Eckes (2001), Harry and Schroeder (2000), Breyfogle et al. (2001)</td><td rowspan="2">5</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td rowspan="2">Design For Six Sigma</td><td rowspan="2">-</td><td colspan="2">Staudter et al (2008)</td><td rowspan="2">1</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td rowspan="2">Six Sigma for service</td><td rowspan="2">-</td><td colspan="2">Hayler and Nichols (2006), Akpolat (2004), George (2003)</td><td rowspan="2">3</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td rowspan="2">TQM</td><td rowspan="2">-</td><td colspan="2">-</td><td rowspan="2">1</td></tr>
<tr><td colspan="2">Feigenbaum (1987)</td></tr>
<tr><td rowspan="2">Lean</td><td rowspan="2">-</td><td colspan="2">-</td><td rowspan="2">1</td></tr>
<tr><td colspan="2">Womack and Jones (1991)</td></tr>
<tr><td rowspan="10">Service</td><td rowspan="2">Service Management</td><td rowspan="2">-</td><td colspan="2">Fitzsimmons and Fitzsimmons (2010), Fitzsimmons and Sullivan (1982), Clark (1957), Roth and van der Velde (1992), Johnston and Clark (2001), Sasser et al. (1978), Heskett (1986), Mintzberg (1979)</td><td rowspan="2">8</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td rowspan="2">Service Marketing</td><td rowspan="2">-</td><td colspan="2">Kotler (1980), Zeitaml and Bitner (2000), Grönroos (1982), Clancy and Shulman (1991)</td><td rowspan="2">5</td></tr>
<tr><td colspan="2">Grönroos (2002)</td></tr>
<tr><td rowspan="2">New Service Development</td><td rowspan="2">-</td><td colspan="2">Fitzsimmons and Fitzsimmons (2000), Edvardsson et al. (2000)</td><td rowspan="2">2</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td rowspan="2">Service Quality</td><td rowspan="2">-</td><td colspan="2">Zeithaml et al. (1990), Collier (1994)</td><td rowspan="2">2</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td rowspan="2">eBusiness</td><td rowspan="2">-</td><td colspan="2">Weill and Vitale (2001)</td><td rowspan="2">1</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td rowspan="4">Methodology</td><td rowspan="2">Case study</td><td rowspan="2">-</td><td colspan="2">-</td><td rowspan="2">1</td></tr>
<tr><td colspan="2">Yin (2005)</td></tr>
<tr><td rowspan="2">Qualitative research</td><td rowspan="2">Cardano (2003)</td><td colspan="2">Miles and Hubermann (1994), Glaser and Strauss (1967), Patton M.Q. (1990)</td><td rowspan="2">4</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Tot. Italian</td><td>English (Not translated)</td><td>30</td><td>Total</td></tr>
<tr><td>3</td><td>English (Translated)</td><td>5</td><td>38</td></tr>
</table>

B3: Main contributions of books

AREA	TOPIC	MAIN CONTRIBUTIONS	Total
Quality and Six Sigma	**Quality Management**	Conti and De Risi, *Manuale della qualità* (2002)	4
	Six Sigma	Gibertoni, *Sei Sigma e azienda snella. Una guida per perseguire l'eccellenza aziendale, ridurre i costi e incrementare il valore nei processi* (2008)	5
	Design For Six Sigma	Staudter *et al*, *Design for Six Sigma+lean toolset: implementing innovations successfully* (2008)	1
	Six Sigma for service	Akpolat, *Six Sigma in transactional and service environments* (2004)	3
	TQM	Feigenbaum, *Total quality control* (1987)	1
	Lean	Womack and Jones, *La macchina che ha cambiato il mondo* (1991)	1
Service	**Service Management**	Fitzsimmons and Fitzsimmons, *Service Management, Operations, Strategy, Information Technology* (2010)	8
	Service Marketing	Grönroos, *Management e Marketing dei servizi* (2002)	5
	New Service Development	Fitzsimmons and Fitzsimmons, *New service development: creating memorabile exeperiences* (2000)	2
	Service Quality	Zeithaml *et al.*, *Delivering quality service: balancing customer perceptions and expectations* (1990)	2
	eBusiness	Weil and Vitale, *Place to space: migrating to eBusiness models* (2001)	1
Methodology	**Case study**	Yin, *Lo studio di caso nella ricerca scientifica* (2005)	1
	Qualitative research	Cardano, *Tecniche di ricerca qualitativa* (2003)	4
Total books			38

B4: Books evaluation

In the following tables the books in the bibliography are classified and evaluated. For each book are given some information as the authors, title, and the language. In addition, an assessment is given on a scale of 1 to 5, where the book was completely read (R), partially read (PR) or just consulted (C).

N.	Authors	Year	Title	Editor	Language	Topic	Evaluation	Read
1	Akpolat, H.	2004	Six Sigma in transactional and service environments	Gower	English	Six Sigma for service	4	R
2	Cardano, M.	2003	Tecniche di ricerca qualitativa	Carocci Editore	Italian	Qualitativ e research	3	PR
3	Clark, C.	1957	The Conditions of Economic Progress	MacMill an Co.	English	Service managem ent	1	C
4	Collier, D.A.	1994	The Service /Quality Solution: using service management to gain Competitive advantage	Irvin	English	Service quality	2	C
5	Conti, T. and DeRisi, P.	2002	Manuale della qualità	Il sole 24 ore	Italian	Quality managem ent	4	C
6	Eckes, G.	2001	The Six Sigma revolution: how General Electric and others turned process into profits	Wiley	English	Six Sigma	3	C
7	Edvardsson *et al*	2000	New service development and innovation in the New Economy	Studenlit teratur	English	New service developm ent	2	C
8	Feigenbaum A.V.	1987	Total quality control	Mc Graw Hill	Italian	Total quality managem ent	3	C
9	Fitzsimmons, J.A. & Fitzsimmons, M.	2010	Service Management, Operations, Strategy, Information Technology	Mc Graw Hill	English	Service managem ent	5	PR

N.	Authors	Year	Title	Editor	Language	Topic	Evaluation	Read
10	Fitzsimmons, J.A. and Fitzsimmons, M.	2000	New service development: creating memorabile exeperiences	Sage Pubblications	English	New service development	3	C
11	Fitzsimmons, J.A. and Sullivan, R.A.	1982	Service Operations Management	Mc Graw Hill	English	Service management	2	C
12	George, M.L.	2003	Lean Six Sigma for Service	Mc Graw Hill	English	Six sigma for services	4	R
13	Gibertoni, M.	2008	Sei Sigma e azienda snella. Una guida per perseguire l'eccellenza aziendale, ridurre i costi e incrementare il valore nei processi.	Il sole 24 ore	Italian	Six sigma	5	R
14	Glaser, B.G and Strauss, A. L.	1967	The Discovery of Grounded Theory: Strategies for Qualitative Research.	Aldine De Gruyter	English	Qualitative research	2	C
15	Grönroos, C.	2002	Management e Marketing dei servizi	ISEDI	Italian	Service marketing	4	PR
16	Grönroos, C.	1982	Strategic Management and Marketing in the Service Sector	Swedish School of economics	English	Service marketing	2	C
17	Harry, M.J. and Schroeder, R.	2000	Six Sigma: the breakthrough management strategy revoluzionizing the world's top corporations	Currency	English	Six Sigma	3	C
18	Hayler, R. and Nichols, M.	2006	Six Sigma for financial services: How Leading Companies Are Driving Results Using Lean Six Sigma and Process Management	Mc Graw Hill	English	Six sigma for services	3	C

N.	Authors	Year	Title	Editor	Language	Topic	Evaluation	Read
19	Hoerl, R and Snee, R.D.	2002	Statistical thinking: improving business performance	Duxury-Thomson Learning	English	Quality management	2	C
20	Ishikawa, K.	1992	Che cos'è la qualità totale. Il modello Giapponese	Il sole 24 ore	Italian	Quality management	4	C
21	Johnston, R. Clark, G.	2001	Service Operations Management	Prentice-Hall	English	Service management	3	C
22	Kotler, P.	1980	Principles of Marketing	Prentice-Hall	English	Service marketing	1	C
23	Miles, H. and Huberman, M.	1994	Qualitative Data Analysis: A Sourcebook.	Sage Pubblications	English	Qualitative research	3	C
24	Pandé *et al*	2000	The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing their Performance	Mc Graw Hill	English	Six Sigma	3	C
25	Roth, A. V. and van der Velde, M.	1992	World Class Banking: Benchmarking the strategies of retail bankng leaders.	Chicago: Bank Administration institute	English	Service management	1	C
26	Staudter *et al*	2008	Design for Six Sigma+lean toolset: implementing innovations successfully	Springler	English	Design For Six Sigma	3	C
27	Taylor, F.W.	1911	The principles of scientific management	Forgotten books	English	Quality management	5	C
28	Weil, P.and Vitale, M.R.	2001	Place to space: migrating to eBusiness models	Harvard Business School Press	English	eBusiness	2	C

N.	Authors	Year	Title	Editor	Language	Topic	Evaluation	Read
29	Womack, J.P. and Jones, D. T.	1991	La macchina che ha cambiato il mondo	Rizzoli	Italian	Lean	4	C
30	Yin, R.K.	2005	Lo studio di caso nella ricerca scientifica	Armando Editore	Italian	Case study	5	R
31	Zeithaml *et al*	1990	Delivering quality service: balancing customer perceptions and expectations	Simon and Schuster	English	Service quality	3	C
32	Zeithaml, V.A. and Bitner M.J.	2000	Service Marketing. Integrating Customer Focus Across the firm	Mc Graw Hill	English	Service marketing	3	C
33	Clancy, K.J. and Shulman, R.S.	1991	The marketing revolution	Harper Business, NY	English	Service marketing	3	C
34	Sasser *et al*	1978	Management of Service Operations	Allyn & Bacon	English	Service Management	3	C
35	Heskett, J.L.	1986	Managing in the Service Economy	Harvard Business School Press	English	Service Management	2	C
36	Mintzberg, H.	1979	The Structuring of Organizations	Prentice-Hall, Inc., London	English	Service Management	4	C
37	Patton, M.Q.	1990	Qualitative Evaluation and Research Methods	Second edition, Sage Publications, Newbury Park, London	English	Qualitative research	4	PR
38	Breyfogle, F.W.I., Cupello, J.M. and Meadows, B.	2001	Managing Six Sigma: A practical guide to understanding, assessing, and implementing the strategy that yields bottom line success	Wiley, New York, NY	English	Six Sigma	3	C

B5: Best references of books

Books on quality management

Conti T. and De Risi, P., 2002, *Manuale della Qualità*. This book addresses the need to sort and collect the diverse and growing body of knowledge relating to this discipline, marking the stages of its evolution. The book itself as a valuable reference: an effective tool and a useful guide for many companies, governments, cultures. The book is divided into 40 chapters that address a wide variety of topics related to quality management: from the tools and methodologies to the state of the art in different sectors and countries.

Books on Six Sigma

Gibertoni M., 2008, *Six Sigma, come snellire l'azienda, raggiungere l'eccellenza, ridurre i costi e incrementare il valore nei processi*. This book examines all aspects peculiar to the Six Sigma methodology, offering an historical overview, metrics and statistical aspects, and the instruments used. This is a real guide, set for every kind of user. It is structured into chapters, each addressed to a specific issue: the tools, human resources, project selection and so on. A perfect book for approaching the topic of Six Sigma for the first time.

Books on Design For Six Sigma

Staudter C., J. Mollenhauer, R. Meran, and Roenpage, O., 2008, *Design for Six Sigma + Lean toolset: Implementing innovations successfully*. This book examines in detail the methodology of DFSS using the DMADV approach. After an introductory chapter which explains the basics of the methodology, the similarities and differences with the classic DMAIC approach, there is a series of chapters, each devoted to a specific phase of the cycle DMADV. For each phase are illustrated in detail, activities to be undertaken and instruments used. This is a very specific and thorough book, suitable for advanced users who wish to apply in practice the methodology.

Books on Six Sigma for services

Akpolat H., 2004, *Six Sigma in transactional and service environments*. This book deals with the application of Six Sigma in the service sector, through an intuitive and simple but effective approach. After a general overview on Six Sigma methodology, we move to a specific focus on the application of the same to services, the importance given to the voice of the customer, the selection of projects and the most appropriate tools to use in this sector. In the second part of the book real examples of application of the methodology are offered, for different types of service firms. In general this is a book easy to use, ideal for understanding the basics of Six Sigma in the service sector.

George M.L., 2003, *Lean Six Sigma for service*. This book addresses two issues, primarily the joint application of the Six Sigma approach with Lean Management, and secondly, the application of the same in the service sector. The book has a strong practice and is full of examples of practical application of this method to real cases, mainly in the U.S. public sector. The volume highlighted the importance of VOC analysis, as well as the use of appropriate tools to develop in this sector specific improvement programs.

APPENDIX B

Books on service management

J. Fitzsimmons and M. Fitzsimmons, 2010, *Service Management, Operations, Strategy, Information Technology*. The book offers an expansive approach to the matter, considering all aspects and facets, a general understanding of the sector, the design issues relating to the purposes of organizations and quality and strategy of service operations. This book is very easy to read and very didactic. It could be used easily in some university courses, thanks to a fine combination of clarity and completeness of the information available.

Books on service marketing

Grönroos C., 2002, *Management e Marketing dei servizi*. The volume is the work of one of the authors of reference in the service management. The author offers a 360-degree view of the topic, starting with a characterization of the industry and dealing with reference models in great detail. This is a very useful book for the first approaches to these issues.

Books on qualitative research

Cardano M., 2003, *Tecniche di ricerca qualitativa*. The book sketches a map of the area of social sciences and focuses on three main techniques of qualitative research: participant observation, interview and focus group. The author proceeds to a critical presentation, paying special attention to the issue of validity of the knowledge that these techniques can capture. It also provides the steps to follow to engage in qualitative research and the different options, stating the pros and cons of each choice. This is a very useful book in planning the stages of the interviews to be carried out to develop a case study.

Books on case study research

Yin, R.K., 2005, *studio di caso nella ricerca scientifica*. This book is a complete and comprehensive discussion of the case study written by a Guru of the case study methodology. It deals with the definition of the research project, data collection, analysis and elaboration in the report stage. This book stresses the advantages of this method applied to a wide range of disciplines, e.g. sociology, psychology and management. The book provides the theoretical tools, as well as numerous examples and exercises.

APPENDIX C: Classification of papers

In the following appendix there are various classification of the papers quoted in this thesis.

C1: Classification papers per journal

Papers from International Journals	**N. Papers**
Journal of Operations Management	10
The TQM Journal	9
International Journal of Quality and Reliability Management	5
Managing Service Quality	4
International Journal of Operations & Production Management	4
Business Process Management Journal	4
Administrative Science Quarterly	3
International Journal of Service Industry Management	3
Harvard Business Review	3
European Journal of Marketing	3
Journal of Product Innovation Management	3
Journal of Services Marketing	3
International Journal of Management Reviews	2
Sloan Management Review	2
Int. Journal Production Economics	2
Service Industries Journal	2
Managerial auditing journal	2
International Journal of Productivity and Performance Management	2
International Journal of Production Research	2
Journal of Service Management	2
Journal of Manufacturing Technology Management	2
Journal of retailing	2
Int. J. of Six Sigma and competitive advantage	1
Strategic Management Journal	1
Technovation	1
International Journal of Lean Six Sigma	1
Journal of Marketing	1
The Business Review, Cambridge	1
Quality & Reliability Engineering International	1
European Management Journal	1
Academy of Management Review	1
Organisation Science	1
Other 28 International Journals with 1 reference each	
Total of papers from International Journals	112
Papers from other sources	
International conference	3
Workshop	1
Total papers from other sources	4
Total papers	116

C2: Classification papers per topic

<table>
<tr><th>AREA</th><th>TOPIC</th><th>N. of reference *</th><th colspan="2">Total</th></tr>
<tr><td rowspan="4">Quality and Six Sigma</td><td>Six Sigma</td><td>1, 5, 8, 9, 10, 26, 30, 31, 35, 37, 39, 51, 52,56, 60, 62, 67, 75, 77, 81, 84, 85, 86, 92, 93, 94, 100, 103, 105, 107, 116</td><td>31</td><td rowspan="4">56</td></tr>
<tr><td>Six Sigma for services</td><td>4, 6, 7, 13, 21, 23, 36, 38, 64, 95, 99, 102</td><td>12</td></tr>
<tr><td>Design For Six Sigma</td><td>3, 11, 12, 78, 90, 104</td><td>6</td></tr>
<tr><td>Quality Management</td><td>2, 97, 98, 101, 106, 108, 115</td><td>7</td></tr>
<tr><td rowspan="5">Service</td><td>Service Management</td><td>14, 27, 28, 40, 58, 71, 76, 79, 87, 88, 111, 113</td><td>12</td><td rowspan="5">47</td></tr>
<tr><td>Service Marketing</td><td>33, 83</td><td>2</td></tr>
<tr><td>Classification of service models</td><td>15, 29, 34, 46, 47, 49, 50, 61, 65, 69</td><td>10</td></tr>
<tr><td>New Service Development</td><td>17,18, 19, 20, 22, 24,32, 41, 42 ,43, 54, 63, 68, 72, 80, 82, 109, 110, 112, 114</td><td>20</td></tr>
<tr><td>Service Quality</td><td>55, 89, 91</td><td>3</td></tr>
<tr><td rowspan="2">Methodology</td><td>Case study</td><td>25, 44, 48, 57, 73, 74, 96</td><td>7</td><td rowspan="2">13</td></tr>
<tr><td>Systematic literature review</td><td>16, 45, 53, 59, 66 70</td><td>6</td></tr>
<tr><td colspan="3">Total papers</td><td colspan="2">116</td></tr>
</table>

* The N. of reference is related to appendix C3

C3: Evaluation of papers

The items in the references are classified and evaluated in the following tables. For each item are given some information e.g. the authors, year, title, topic and keywords. In addition, an assessment is given on a scale of 1 to 5, and a letter is set if the article was fully read (R) or if only the abstract was read (A).

APPENDIX C

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
1	Anand *et al*	2009	Dynamic capabilities through continuous improvement structure	Journal of Operations Management	Continuous improvement, Dynamic capabilities, Lean management, Operations strategy, Six Sigma, TQM	Six Sigma	R	4
2	Andersson *et al*	2006	Similarities and differences between TQM, Six Sigma and Lean	The TQM Journal	Quality management, quality improvement, TQM, Lean, Six Sigma	Quality Management	R	4
3	Antony	2002	Design for Six Sigma: a breakthrough business improvement strategy for achieving competitive advantage	Work Study	Quality, competitive advantage, business strategy	Design For Six Sigma	R	3
4	Antony	2004	Sigma in the UK service organisations: results from a pilot survey	Managerial Auditing Journal	Statistical process control, Critical success factors, Service operations	Six Sigma for services	R	3
5	Antony *et al*	2005	Six Sigma in small-and medium-sized UK manufacturing enterprises	International Journal of Quality & Reliability Management	Quality programmes, Small to medium-sized enterprises, Critical success factors, United Kingdom	Six Sigma	R	3
6	Antony	2006	Sigma for service processes	Business Process Management Journal	Six sigma, Customer services quality, Quality improvement, Service industries	Six Sigma for services	R	5
7	Antony et al	2007	Six sigma in service organisations. Benefits, challenges and difficulties, common myths, empirical observations and success factors	International Journal of Quality & Reliability Management	Six sigma, Services, Critical success factors, Quality, United Kingdom	Six Sigma for services	R	4

APPENDIX C

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
8	Antony and Ferguson	2004	Six Sigma in the software industry: results from a pilot study	Managerial Auditing Journal	Statistical process control, Critical success factors, Computer software	Six Sigma	R	3
9	Antony *et al*	2009	Project selection and its impact on the successful deployment of Six Sigma	Business Process Management Journal	Six Sigma, Analytical hierarchy process, Project planning	Six Sigma	R	4
10	Bañuelas and Antony	2002	Critical success factors for the successful implementation of six sigma projects in organizations	The TQM Journal	Quality,management, methods	Six Sigma	R	5
11	Bañuelas and Antony	2003	Going from Six Sigma to Design for Six Sigma: an exploratory study using analytic hierarchy process	The TQM Journal	DFSS, process management, business process re-engineering	Design For Six Sigma	R	4
12	Bañuelas and Antony	2004	Six Sigma or Design for Six Sigma?	The TQM Journal	Quality programmes, Analytical hierarchy process, Research	Design For Six Sigma	R	3
13	Chakrabarty and Tan	2007	The current state of six sigma application in services	Managing Service Quality	Six sigma, Services, Critical success factors, Performance measures	Six Sigma for services	R	3
14	Chase	1981	The Customer Contact Approach to Services: Theoretical Bases and Practical Extensions	Operations Research	Service, customer contact, approach	Service Management	A	4

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
15	Collier	1983	The service sector revolution: the automation of services	Long range planning	Service, sector, autonomation	Classification of service models	A	2
16	Collins and Fauser	2005	Balancing the strengths of systematic and narrative reviews	Human Reproduction Update	Systematic, narrative, review, methodology	Systematic literature review	A	3
17	Cooper *et al*	1994	What distinguishes top performing new products in financial services	Journal of Product Innovation Management	Financial, service, performance, NSD	New Service Development	A	2
18	De Brentani	1991	Factors in Developing New Business Services	European Journal of Marketing	New service development, factors, business	New Service Development	R	4
19	De Brentani	2001	Innovative versus incremental new business services: different keys for achieving success	Journal of Product Innovation Management	New service development,incremental, service, business, improvement	New Service Development	R	3
20	Den Hertog	2000	Knowledge-intensive business services as co-producers of innovation	International Journal of Innovation Management	New service development, knowledge, business, services, innovation	New Service Development	A	3
21	De Koning *et al*	2008	Lean Six Sigma in financial services	Int. J. Six Sigma and Competitive Advantage	Lean, Six Sigma, services, financial, case study	Six Sigma for services	R	3

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
22	De Jong and Vermeulen	2003	Organizing successful new service development: a literature review	Management decision	New service development, service, literature review	New Service Development	R	3
23	Delgado *et al*	2010	The implementation of Lean Six Sigma in financial services organizations	Journal of Manufacturing Technology Management	Lean, Six Sigma, services, financial, case study	Six Sigma for services	R	3
24	Edvardsson and Olsson	1996	Key concepts in new service development	Service Industries Journal	New service development, concepts,	New Service Development	R	4
25	Eisenhardt	1989	Building theory from case study research	Academy of Management Review	Theory, building, case study, research	Case study	R	5
26	Firka	2010	Six Sigma: an evolutionary analysis through case studies.	The TQM Journal	Six Sigma, Case studies, Design and development, Argentina	Six Sigma	R	4
27	Fitzsimmons	2003	Is self service the future of services?	Managing Service Quality	Self-service, services, management	Service Management	A	3
28	Foote and Hatt	1953	Social Mobility and Economic Advancement	American Economic Review	Service industry, social, mobility, economy, employment	Service Management	A	2

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
29	Frohele and Roth	2004	New measurement scales for evaluating perceptions of the technology-mediated customer service experience	Journal of Operations Management	Customer service, technology, services, measurement	Classification of service models	R	3
30	Goh	2002	A strategic assessment of Six Sigma	Quality & Reliability Engineering International	Six Sigma, quality management, knowledge management	Six Sigma	R	3
31	Goldstein	2001	Six Sigma program success factors	Six Sigma Forum Magazine	Six Sigma, success, factors, quality management	Six Sigma	R	3
32	Goldstein *et al*	2002	The service concept: the missing link in service design research?	Journal of Operations Management	Service concept, Service design planning, Service recovery design	New Service Development	R	4
33	Gummesson	1987	Lip services-A neglected Area in Services Marketing	Journal of Services Marketing	Service marketing, development, definitons	Service Marketing	A	3
34	Haynes	1990	Service typologies: A transaction modelling approach	International Journal of Service Industry Management	Service delivery, model, classification, service typoligies	Classification of service models	R	5
35	Hatch and Dyer	2004	Human capital and learning as a source of sustainable competitive advantage	Strategic Management Journal	Human capital, competitive advantage, quality management	Six Sigma	R	3

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
36	Heckl *et al*	2010	Uptake and success factors of Six Sigma in the financial services industry	Business Process Management Journal	Process management, Service improvements, Six sigma, Financial services, Europe	Six Sigma for services	R	3
37	Henderson and Evans	2000	Successful implementation of Six Sigma: benchmarking General Electric Company	Benchmarking: An International Journal	Kaizen, Electronics industry, Benchmarking	Six Sigma	R	4
38	Hensley and Dobie	2005	Assessing readiness for six sigma in a service setting	Managing Service Quality	Customer services quality, Quality programmes, Organizational planning	Six Sigma for services	R	3
39	Ingle and Roe	2001	Six Sigma Black Belt implementation	The TQM Journal	Kaizen, Electronics industry, TQM	Six Sigma	R	4
40	Johnston and Jones	2004	Service productivity - Towards understanding the relationship between operational and customer productivity	International Journal of Productivity and Performance Management	Service, productivity, customer, organizations	Service Management	A	2
41	Karmarkar and Apte	2007	Operations Management in the Information Economy: Information, Products, Processes, and Chains	Journal of Operations Management	New service development, Information technology, services, processes	New Service Development	A	3
42	Kindström and Kowalkowski	2009	Development of industrial service offerings: a process framework	Journal of Service Management	Manufacturing industries, Services, Service levels, Innovation	New Service Development	R	3

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
43	Kelly and Storey	2000	New Service Development: initiation strategies	International Journal of Service Industry Management	New product development, Idea generation, Service operations	New Service Development	R	3
44	Leonard-Barton	1990	A dual methodology for case studies: synergistic use of a longitudinal single site with replicated multiple sites	Organisation Science	Case study, multiple sites, methodology	Case study	A	2
45	Leseure *et al*	2004	Adoption of promising practices: a systematic review of the evidence	International Journal of Management Reviews	Systematic, rewiev, practices, methodology	Systematic literature review	A	2
46	Lovelock	1983	Classifying Services to Gain Strategic Marketing Insights	Journal of Marketing	Classification, services, service marketing	Classification of service models	R	4
47	Maister and Lovelock	1982	Managing Facilitator Services	Sloan Management Review	Classification, services, service marketing	Classification of service models	R	4
48	Mintzberg	1979	An emerging strategy of "direct" re-search	Administrative Science Quarterly	Case study, research, methodology	Case study	A	2
49	Miozzo and Soete	2001	Internationalization of services: a technological perspective	Technological Forecasting and Social Change	Service, internationalization, technology, business	Classification of service models	A	2

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
50	Miozzo and Soete	1989	Trade and development in services: a technological perspective	Working paper N. 89-031, Merit, Maastricht	Service, technology, trade	Classification of service models	A	3
51	Montgomery	2010	A modern framework for achieving enterprise excellence	International Journal of Lean Six Sigma	Six sigma, Process management, Quality management, Lean production	Six Sigma	R	4
52	Montgomery and Woodall	2008	An overview of Six Sigma	International Statistical Review	Designed experimentation, measurement systems analysis, process capability, quality control, variability reduction	Six Sigma	R	5
53	Mulrow	1994	Systematic Reviews: Rationale for systematic reviews	BMJ	Systematic review, methodology, rationale	Systematic literature review	A	3
54	Oke	2007	Innovation types and innovation management practices in service organizations	International Journal of Operations & Production Management,	Sevice innovation, services, management, organizations	New Service Development	A	2
55	Parasuraman *et al*	1988	SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality	Journal of Retailing	Service quality, consumer perception, measure, instrument	Service Quality	R	3
56	Pepper and Spedding	2010	The evolution of Lean Six Sigma	International Journal of Quality & Reliability Management	Lean production, Six sigma	Six Sigma	R	3

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
57	Pettigrew	1988	Longitudinal field research on change: Theory and practice	NSF Conference on Longitudinal Research Methods in Organizations	Case Study, research methods, organizations	Case study	A	2
58	Pine and Gilmore	1998	Welcome to the Experience Economy	Harvard Business Review	Services, experience economy, customer, environment	Service Management	R	3
59	Pittway *et al*	2004	Networking and innovation: a systematic review of the evidence	Industrial Journal of Management Reviews	Systematic review, innovation, networking	Systematic literature review	A	2
60	Raisinghani *et al*	2005	Sigma: concepts, tools, and applications	Industrial Management & Data Systems	Quality improvement, Quality awards, ISO 9000 series, Quality programmes	Six Sigma	R	3
61	Schmenner	1986	How can service Businesses Survive and Prosper?	Sloan Management Review	Classification, services, labor intensity, customer	Classification of service models	R	5
62	Schroeder *et al*	2008	Six Sigma: Definition and underlying theory	Journal of Operations Management	Quality management, Six Sigma, Organizational issues, Case/field study	Six Sigma	R	3
63	Schostack	1984	Designing Services That Deliver	Harvard Business Review	New service development, design, services	New Service Development	A	2

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
64	Sehwail and DeYong	2003	Six sigma in health care	International Journal of Health Care Quality Assurance	Health service sector, process management, Hospital, quality systems	Six Sigma for services	R	3
65	Silvestro *et al*	1992	Towards a Classification of Service Processes	International Journal of Service Industry Management	Classification, services, customer contact, industry	Classification of service models	R	4
66	Slavin	1986	Best-Evidence Synthesis: An Alternative to Meta-Analytic and Traditional Reviews	Educational Researcher	Literature review, Meta-Analytic, methodolgy	Systematic literature review	A	2
67	Snee and Rodebaugh	2002	The project selection process	Quality Progress	Six Sigma, projetc selection, quality management	Six Sigma	R	3
68	Stevens and Dimitriadis	2005	Managing the new service development process: towards a systemic model	European Journal of Marketing	Financial services, Retailing, Innovation, Learning, Learning organizations, Research	New Service Development	R	3
69	Thomas	1975	Strategy is Different in Service Businesses	Harward Business Reivew	Service, business, technology, strategy	Classification of service models	A	3
70	Tranfield *et al*	2003	Factors characterising the maturity of BPR programmes	International Journal of Operations & Production Management	Business process reengineering, systematic, review	Systematic literature review	A	2

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
71	Van Iwaarden *et al*	2008	The Six Sigma improvement approach: a transnational comparison	International Journal of Production Research	Six Sigma, Quality management, Improvement approaches	Six Sigma	R	3
72	Vermeulen	2004	Managing Product Innovation in Financial Services	European Management Journal	Product innovation, Financial services, Barriers, Innovation process	New Service Development	R	3
73	Voss *et al*	2002	Case research in operations management	International Journal of Operations & Production Management	Operations management, Research, Methodology, Case studies	Case study	R	4
74	Yin	1981	The case study crisis: Some answers	Administrative Science Quarterly	Case study, methodology, crisis	Case study	A	2
75	Ying-Ching *et al*	2008	An empirical study of key success factors for Six Sigma Green Belt projects at an Asian MRO company	Journal of Air Transport Management	Six Sigma, Green Belt project, Key success factors	Six Sigma	R	3
76	Wilkinson *et al*	2009	Changing times and changing timescales: the servitization of manufacturing	International Journal of Operations & Production Management	Services, servitization, manufacturing, management	Service Management	R	2
77	Zu *et al*	2010	Mapping the critical links between organizational culture and TQM/Six Sigma practices	Int. Journal Production Economics	Six Sigma, Total quality management, Organizational culture	Six Sigma	R	3

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
78	Campanerut, M. & Nicoletti, B.	2010	Best Practices for DFSS in the Development of New Services: Evidence from a Multiple Case Study	The Business Review, Cambridge	Best practice, case study, Six Sigma, DFSS, NSD	Design For Six Sigma	R	5
79	Heineke, J. and Davis, M.M.	2007	The emergence of service operations management as an academic discipline	Journal of Operations Management	service, operations management	Service Management	R	5
80	Johne, A., Storey, C.	1998	New service development: a review of literature and annotated bibliography	European Journal of Marketing	Literature review, NSD	New Service Development	R	5
81	Kwak, Y.H. and Anbari, F.T.	2006	Benefits, obstacles, and future of six sigma approach	Technovation	Six Sigma, CSF	Six Sigma	PR	4
82	Menor, L.J., Tatikonda, M.V. and Sampson, S.E.	2002	New service development: areas for exploitation and exploration	Journal of Operations Management	NSD, New research areas	New Service Development	R	5
83	Alam, I. and Perry, C.	2002	A customer-oriented new service development process	Journal of Service Marketing	Customer focus, New service	Service Marketing	PR	4
84	Chakravorty, S.S.	2009	Sigma programs: An implementation model	International Journal of Production Economics	Implementation, Six Sigma	Six Sigma	PR	4

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#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
85	Goel, S. and Chen, V.	2008	Integrating the global enterprise using Six Sigma: Business process reengineering at General Electric Wind Energy	International Journal of Production Economics	GE, BPR, Six Sigma	Six Sigma	PR	3
86	Savolainen, T. and Haikonen, A.	2007	Dynamics of organizational learning and continuous improvement in Six Sigma implementation	The TQM Magazine	Continuous improvement, Six Sigma, Organizational learning	Six Sigma	R	4
87	Edgett, S.J. and Jones, S.	1991	New Product Development in the Financial Service Industry - A Case Study	Journal of Marketing Management	NPD, Finance, Case study	Service Management	A	2
88	Blois	1984	Productivity and Effectiveness in Service Firms	Service Industries Journal	Service operations, customer participation, service firms	Service Management	A	2
89	Berry, L.L., Zeithaml, V.A. & Parasuraman	1985	A Quality Counts in Services Too	Business Horizons	Service, quality, industry	Service Quality	A	2
90	Campanerut, M. & De Toni, A.F.	2010	Managing DFSS in New Service Development: an exploratory case study	Proceedings from the 17th International Product Development Management Conference	Case study, DFSS, NSD	Design For Six Sigma	R	5

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#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
91	Setijono D. and Dahlgaard J.J.	2007	Customer value as a key performance indicator (KPI) and a key improvement indicator (KII)	*Measuring Business Excellence*	Customer value, KPI	Service quality	R	4
92	Hoerl, R. W., Montgomery, D. C., Lawson, C., Molnau, W. E., Elias, R.	2001	Six Sigma Black Belts: What do they need to know?	*Journal of Quality Technology*	Belts, team, Six Sigma	Six Sigma	A	3
93	Byrne G., Lubowe D. Blitz A.	2007	Using a Lean Six Sigma approach to drive innovation	Strategy & Leadership	Innovation, Lean, Six Sigma	Six Sigma	PR	3
94	Pandey A.	2007	Strategically focused training in Six Sigma way: a case study	Journal of European Industrial Training	Training, Six Sigma, Case study	Six Sigma	A	2
95	Jenicke L.O., Kumar A., Holmes M.C.	2008	A framework for applying six sigma improvement methodology in an academic environment	The TQM Journal	Academia, Six Sigma	Six Sigma for services	A	3
96	Meredith, J.	1998	Building operations management theory through case and field research	Journal of Operations Management	Field research, case study	Case study	R	4
97	Kumar M., Antony J., Madu C.N., Montgomery D.C., Park S.H.	2008	Common myths of Six Sigma demystified	International Journal of Quality and Reliability Management	Comparison, quality management	Quality Management	PR	3

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
98	Näslund, D.	2008	Lean, six sigma and lean sigma: fads or real process improvement methods?	Business Process Management Journal	Fad, myth, lean, six sigma	Quality Management	PR	3
99	Nakhai, B. and Neves, J.S.	2009	The challenges of six sigma in improving service quality	International Journal of Quality and Reliability Management	service, improvement six sigma	Six Sigma for services	PR	3
100	Brady, J.E. and Allen, T.T.	2006	Six Sigma Literature: A Review and Agenda for Future Research	Quality and Reliability Engineering International	literature review, six sigma	Six Sigma	R	4
101	Sousa, R. and Voss, C.	2002	Quality management re-visited: A reflective review and agenda for future research	Journal of Operations Management	quality management, review	Quality Management	R	5
102	Johannsen, F. and Leist, S.	2009	A Six Sigma approach for integrated solutions	Managing Service Quality	service, six sigma, quality	Six Sigma for Services	A	2
103	Buch K.K. and Tolentino A.	2006	Employee perceptions of the rewards associated with six sigma	Journal of Organizational Change Management	Human resource, Six Sigma	Six Sigma	A	2

#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
104	Gourdarzlou A. and Tan Kay C.	2008	Using Six Sigma in New Service Development	Management of Engineering & Technology	NSD, DFSS	DFSS	R	5
105	Haikonen A., Savolainen T. and Jarvainen P.	2004	Exploring Six Sigma and CI capability development: preliminary case study findings on management role	Journal of Manufacturing Technology Management	capability, case study	Six Sigma	R	4
106	Black K. and Revere L.	2006	Six Sigma arises from the ashes of TQM with a twist	*International Journal of Health Care Quality Assurance*	Six Sigma, TQM	Quality Management	PR	3
107	Bunce M.M., Wang L. and Bidanda B.	2008	Leveraging Six Sigma with industrial engineering tools in crateless retort production	International Journal of Production Research	Tools, Six Sigma	Six Sigma	A	3
108	Bendell T.	2006	A review and comparison of six sigma and the lean organisations	The TQM Journal	Review, Lean, Six Sigma	Quality Management	PR	3
109	Tax, S.S. and Stuart, I.	1997	Designing and implementing new services	Journal of Retailing	New services, design	New Service Development	A	3
110	Carbonell, P., Rodriguez-Escudero, A.I. and Pujari, D. (2009)	2009	Customer Involvement in New Service Development: An Examination of Antecedents and Outcomes	Journal of Product Innovation Management	Customer involvement, NSD	New Service Development	PR	4

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#	Authors	Year	Title	Source	Keywords	Topic	Read	Evaluation
111	Droege, H., Hildebrand, D. and Heras Forcada, M.A.	2009	Innovation in services: present findings, and future pathways	Journal of Service Management	Innovations, Services	Service Management	A	3
112	Dolfsma, W.	(2004)	The Process of New Service Development - Issue of Formalization and Approbriability.	International Journal of Innovation Management	NSD, process	New Service Development	PR	3
113	Nijssen, E.J., Hillebrand, B., Vermeulen, P.A.M. and Kemp, R.G.M.	2006	Exploring product and service innovation similarities and differences	International Journal of Research in Marketing	service innovation, product	Service Management	A	3
114	Scheuing, E.E. and Johnson, E.M.	1989	A Proposed Model for new Service Development	Journal of Service Marketing	Model, NSD	New Service Development	A	3
115	Joh, J.M. and Mayfield, M.	2009	The discipline of product discovery: identifying breakthrough business opportunities	Journal of Business Strategy	Product, innovation	Quality Management	A	2
116	Linderman, K., Schroeder, R.G., Zaheer, S., Choo, A.S.	2003	Six Sigma: a goal-theoretic perspective	Journal of Operations Management	Six Sigma, goals	Six Sigma	R	5

C4: Best references of papers

Quality Management

Andersson, R., Eriksson, H. H. and Torstensson, 2006, *Similarities and Differences Between TQM, Six Sigma and Lean*. The TQM Journal.
The authors of this paper investigate the similarities and differences between the three main approaches for quality management: Six Sigma, TQM and Lean. This study was carried out through the approach of case study, with interviews and a review of relevant literature. The article concludes that Lean and Six Sigma methodologies are a reference to be used alone or in combination, within a TQM approach.

Six Sigma

Montgomery, D.C. and Woodall, W.H., 2008., *An Overview of Six Sigma*. International Statistical Review.
The authors propose an overview of Six Sigma methodology, both from a historical perspective and statistical. Starting from the contextualization of the same within the historical framework of methodologies for quality management, the authors illustrate in detail the characteristics of the methodology explaining how to implement it. In addition, they stress the future development of Six Sigma and DFSS approach.

Bañuelas, R. and Antony, J., 2002, *Critical success factors for the successful Implementation of six sigma projects in organizations*. The TQM Journal.
The authors propose a comprehensive overview of the key success factors that influence the implementation of Six Sigma in an organization. The factors are summarized by topic and range from cultural issues to those related to relations with customers and suppliers. This paper is in most of the references of articles related to Six Sigma methodology.

Henderson, K. and Evans, J., 2000, *Successful Implementation of Six Sigma: benchmarking General Electric Company*. Benchmarking: An International Journal.
The purpose of this article is to revisit the basic concepts of Six Sigma, its benefits, and approaches for a more effective implementation. In particular, they conduct a benchmark of the practices used in General Electric, one of the world leaders in implementing the innovation process. The authors conclude by identifying some key factors for effective implementation of the methodology.

Design For Six Sigma

Bañuelas, R. & Antony, J., 2003. *Going from Six Sigma to Design for Six Sigma: an exploratory study using analytic hierarchy process*. The TQM Journal.
The article aims to illustrate, by using a variety of sources in the literature the similarities and differences between Six Sigma and Design for Six Sigma. In addition, the authors try to explain what the conditions that justify the use of a methodology rather than the other. Finally, they refer to a technique to select the most appropriate methodology, i.e. the Analytic Hierarchy Process (AHP).

Bañuelas, R. & Antony, J., 2004, *Six Sigma or Design for Six Sigma?*. The TQM Journal.

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The article gives an effective presentation of the methodology of Design for Six Sigma, taking account of the fact that it may be more useful to design high level processes. In addition, the article tests a multiple criteria decision-making technique based on the process of hierarchical analysis, to decide whether to use Six Sigma or DFSS in two multinational companies.

Six Sigma for services

Antony, J., 2006, *Six Sigma for service processes*. Business Process Management Journal.
The article shows the basic features that identify Six Sigma, as well as guidelines for a simple application of the methodology to the service sector. The article also illustrates a set of tools and techniques, a set of key success factors and those to select the best process improvement methodology to be used in the service sector.

Antony, J., Kumar, M. and Byung, R.C., 2007, *Six Sigma in Service Organisations. Benefits, Challenges and Difficulties, common myths, empirical observations and success factors*. International Journal of Quality & Reliability Management.
This article presents some of the challenges and issues related to the application of Six Sigma in the service sector. In addition, the article discusses the benefits of using the methodology in this area, identifying the main tools and techniques to be used in addition to the key criteria for selecting the best improvement projects. The observations are supported by the results of a survey conducted on a sample of service companies in the United Kingdom.

Classification of service models

Haynes, RM, 1990, *Service typologies: A transaction modeling approach*. International Journal of Service Industry Management.
This article has been used extensively to prepare the chapter on service classification models. The author proposes from a thorough and extensive review of the literature, a model for classifying services based on the type of delivery. Specifically, the author identifies two dimensions of classification of services: technology and interface.

Schmenner, R.W., 1986. *How can Service Businesses Survive and Prosper?* Sloan Management Review.
In this article the author proposes the Service Process Matrix. In this matrix, the vertical axis measures the degree of work intensity, defined as the ratio between the cost of labor and capital costs. The horizontal axis measures instead the degree of interaction and customization, a marketing variable that describes the customer’s ability to directly influence the service provided. The four quadrants of the Service Process Matrix have names, as defined by the two dimensions to describe the nature of the services illustrated. This matrix has been used intensively in the service literature.

Silvestro, R., Fitzgerald, L. and R. Johnston (1992). *Towards a Classification of Service Processes*. International Journal of Service Industry Management.
The authors propose a classification of services from the concept of contact time, introduced by Chase, and six dimensions found in the literature on service operations. In particular, the authors state that there are three types of service processes: professional service, service shops and mass service. Each type of service can refer to the six dimensions defined above. Based

on evidence derived from case studies, the authors argue that the dimensions are correlated with the volume of customers processed by a production unit on a daily basis.

New Service Development

De Brentani, U., 1991, *Success Factors in Developing New Business Services*. European Journal of Marketing.
The author proposes a set of best practices to use in developing new services. Furthermore, the distinctive characteristics of services are highlighted and it is explained how those characteristics might affect the process of new service development from a practical point of view.

Goldstein, SM, Johnston, R., Duffy, J., and Rao, J., 2002. *The service concept: the missing link in service design research?* Journal of Operations Management.
In this paper the authors propose a definition of service concept and describe how the same may be used to generate a variety of service design processes. Furthermore, the authors apply the service concept to service design planning. The paper even shows that the use of the service concept can be considered an important driver for service design and raises a number of interesting research questions.

Case study

Eisenhardt, KM, 1989, Building *theory from case study research*. Academy of Management Review.
This article describes the process of theory building through case studies, from the specification of research questions to the results. Some features of the process, such as the definition of the problem or the validation of the constructs are similar to theory testing research. However, the logic of data analysis is specific to this research methodology. Overall, the process is described to be highly iterative and closely related to the data collected, especially suitable for new areas of research. This article is used as a basic reference for all researchers who undertake the case study as research methodology.

Voss, C., Tsikriktsis, N., & Frohlich, M., 2002, *Case research in operations management*. International Journal of Operations & Production Management.
The article explains the use of case study research methodology in Operations management for developing and testing theories. At this regard, the authors provide guidelines for researchers in the operations management area, who wish to design, develop and conduct research based on case study.

APPENDIX D: Main authors

Jiju Antony

Professor Jiju Antony is an authority in the field of Six Sigma and quality management and has worked in several projects concerning the quality and process improvement for many blue chip companies in the UK, including Nokia, Bosch, Rolls-Royce, GE, 3M and Siemens. Professor Antony works at the University of Strathclyde in Glasgow, where he is director of the famous Centre for Research in Six Sigma and Process Excellence (CRISSPE). In over 10 years as a researcher has published over 150 articles and five books, in the following areas: Reliability Engineering, Design of Experiments, Taguchi Methods, Six Sigma, Total Quality Management and Statistical Process Control. In August 2004 she successfully launched the First International Journal of Six Sigma and Competitive Advantage.

Roger Schroeder

Professor Emeritus Roger G. Schroeder holds the Chair in Operations Management at the Curtis L. Carlson School of Management, University of Minnesota. It is also the co-director of the Juran Center for quality. He graduated in Industrial Engineering with honors from the University of Minnesota, and got his Ph.D. from Northwestern University. Prior to joining the University of Minnesota, he taught at the U.S. Naval Postgraduate School in Monterey, California, and was an analyst for the Office of the Deputy Secretary of Defense. Professor Schroeder has received research grants from the Ford Foundation, the Exxon Education Foundation and the National Science Foundation. He was awarded with the Morse prize for teaching at the University of Minnesota.

Michael Harry

Dr. Harry has been cited in many publications as the principal architect of Six Sigma methodology. His book titled "*Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*" was listed as a best seller by the Wall Street Journal. Currently, Dr. Harry is President of Six Sigma Management Institute, founded after being the Six Sigma Academy CEO in 1994. He has carried out activities focused on improving product quality, performance, productivity and cost reduction in various multinational companies. Dr. Harry has obtained the Master of Science at Ball State University and a Ph.D. at Arizona State University.

Christian Grönroos

Christian Grönroos is Professor of Relationship Marketing at Hanken School of Economics, Finland and is director of the Center for Relationship Marketing and Service Management (CERS) affiliated to the university. Professor Grönroos is a pioneer in the field of marketing and service management.

Mario Gibertoni

Mario Gibertoni is Chairman of the *Management Consulting Company* group. After a long experience in multinational companies (e.g. Fiat, Iveco, Beretta arms) both within the organizational and technical areas and as top manager, he has entered the world of management consulting. He specializes in Japan with Masaaki Imai at the Kaizen Institute and the prestigious JUSE, studying the Toyota model. He teaches at the Sole 24 Ore Business School and he is Senior Member of the American Society for Quality.

Robert Yin

Robert K. Yin is the president of COSMOS Corporation, a research firm specializing in technology management and issues of social policy. As part of the company is engaged in individual projects, including those using the method of the case study. He also worked as a visiting scholar at the U.S. General Accounting Office in 1992-1993 in the areas of program evaluation and Methodology Division, as well as in the editorial boards of several journals and in the Committee of the National Academy of Sciences.

Michael George

Michael L. George is the founder and CEO of George Group, the largest Lean Six Sigma consulting company throughout the United States. George is the author of numerous books on the methodology, with a perspective on different aspects and sectors of industry.

James Fitzsimmons

James Fitzsimmons is Professor of Business at the University of Texas at Austin and is one of the leading figures in the field of service management. Professor Fitzsimmons has served as a consultant in many universities around the world and in some industrial huge groups like General Motors. In 2004 he received the IBM Faculty Award in recognition of his contribution to the field of service operations management. Prof. Fitzsimmons also plays a role in the editorial board of the Journal of Service Research, having published hundreds of articles and two important books on service management and New Service Development.

Douglas Montgomery

Douglas Montgomery is Professor of Industrial Engineering and Statistics at the Arizona State University. His research interests are in industrial statistics, where is the author of 16 books and over 180 technical articles. He has received numerous awards during his research and he is a member of the prestigious American Statistical Association and American Society for Quality Control.

Armand Feigenbaum

Armand Feigenbaum is one of the fathers of quality, having introduced the concept of Total Quality Control, also known as Total Quality Management. Feigenbaum received his Master of Science and Ph.D. from MIT. He was Director of Operations at General Electric and is now president and CEO of General Systems Company in Pittsfield, Massachusetts. Feigenbaum has written several books and was president of the American Society for Quality from 1961 to 1963.

APPENDIX D

Kathleen Eisenhardt

Kathleen Eisenhardt is a professor at Stanford University and co-director of the Stanford Technology Ventures Program. Professor Eisenhardt's work focuses on strategy and organization especially in companies with strong technological features and in areas of high development. He also worked extensively with a large bundle of companies, from telecommunications to solar energy. It was recently noted as the most cited author in the context of strategic organizational studies of the last 25 years. Professor Eisenhardt is also a consultant in the strategic and organizational area for a wide variety of global companies.

Chris Voss

Chris Voss is Professor Emeritus of Management Science and Operations at London Business School, where he also received his Degree and Ph.D. His research interests include service management, the internationalization of operations, benchmarking and operational improvement. He is the author of several important publications in management and research design.

Roger Schmenner

Roger W. Schmenner is Professor of Manufacturing Management and Associate Dean at the Kelley School of Business, Indiana University. He also held several conferences at the universities of Duke, Harvard, and Yale and was visiting faculty at IMD in Lausanne. Professor Schmenner holds a B.A. from Princeton University and a Ph.D. from Yale University, both in Economics. He was president of International Production and Operations Management Society in 1997. The research interests of Professor Schmenner are in the field of manufacturing strategies and choice of location for service companies. He has written over 100 papers published in some of the most important journals in the field of operations, such as Harvard Business Review, Sloan Management Review, Journal of Operations Management as well as numerous books on service management.

Christopher Lovelock

Christopher Lovelock is recognized worldwide as an authority in matters concerning service management. Professor Lovelock teaches at the Yale School of Management and is director of Lovelock Associates, through which he has worked for customers in many service sectors, e.g. finance, health, education, insurance, transportation. Earlier he distinguished for his academic career after teaching for eleven years at Harvard Business School, two years at IMD in Lausanne and given class at Berkeley, MIT and Stanford.

William Deming

William Deming can be considered a pioneer of quality management. In Japan, since 1950, he taught the top management how to improve the design, product quality and sales through various methods, including the application of statistics. In 1993, Deming founded the Deming Institute, based in Washington D.C. Deming received his Master’s Degree from the University of Colorado and a Ph.D. from Yale University. Afterwards, he worked at Bell Telephone Laboratories and for U.S. government.

APPENDIX E: Items of systematic literature review

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
1	International Journal	Aboelmaged M.A.	2010	Six Sigma quality: a structured review and implications for future research	International Journal of Quality & Reliability Management	27	3	4
2	International Journal	Ackermann C.S.	1993	Supplier improvement via SPC applications workshops	Semiconductor Manufacturing, IEEE Transactions on	6	2	1
3	International Journal	Ackermann C.S., Fabia J.M.	1993	Monitoring supplier quality at PPM levels	Semiconductor Manufacturing, IEEE Transactions on	6	2	1
4	International Journal	Agarwal R., Bajaj N.	2008	Managing outsourcing process: applying six sigma	Business Process Management Journal	14	6	3
5	International Journal	Al-Mishari S.T., Suliman S.	2008	Integrating Six-Sigma with other reliability improvement methods in equipment reliability and maintenance applications	Journal of Quality in Maintenance Engineering	14	1	2
6	Thesis	Anand G. J.	2006	Continuous improvement and operations strategy: focus on Six Sigma programs	_	_	_	2
7	International Journal	Anand G., P. T. Ward , M. V. Tatikonda, D.A. Schilling	2009	Dynamic capabilities through continuous improvement infrastructure	Journal of Operations Management	27	_	4

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
8	International Journal	Anand G., P. T. Ward , M.V. Tatikonda	2010	Role of explicit and tacit knowledge in Six Sigma projects: An empirical examination of differential project success	Journal of Operations Management	28	_	2
9	International Journal	Anand R.B., Shukla K.S., Ghorpade A., Tiwari M.K., Shankar R.	2007	Six sigma-based approach to optimize deep drawing operation variables	International Journal of Production Research	45	10	2
10	International Conference	Anbari F.T., Kwak Y.H.	2004	Success Factors in Managing Six Sigma Projects	2004 Project Management Institute Research Conference, London, UK, July 11-14, 2004	-	-	1
11	International Journal	Andersson R., Eriksson H., Torstensson H.	2006	Similarities and differences between TQM, six sigma and lean	The TQM Journal	18	3	5
12	International Conference	Anil R., Seshadri V., Chavala A., Vemuri M.	2004	A methodology for managing multidisciplinary programs with six sigma approach	Engineering Management Conference	_	_	1
13	International Journal	Kumar M., Antony J., Byung R.C.	2009	Project selection and its impact on the successful deployment of Six Sigma	Business Process Management Journal	15	5	4
14	International Conference	Antony J, , Kumar M.	2010	Feasibility study of Six Sigma in UK SMEs: Multiple-Case Study Analysis	_	_	_	3
15	International Journal	Antony J.	2006	Six sigma for service processes	Business Process Management Journal	12	2	4

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
16	International Journal	Antony J.	2008	Can Six Sigma be effectively implemented in SMEs?	International Journal of Productivity and Performance Management	57	5	3
17	International Journal	Antony J.	2009	Six Sigma vs TQM: some perspectives from leading practitioners and academics	International Journal of Productivity and Performance Management	58	3	4
18	International Journal	Antony J.	2008	What is the role of academic institutions for the future development of Six Sigma	International Journal of Productivity and Performance Management	57	1	2
19	International Journal	Antony J.	2004	Some pros and cons of six sigma: an academic perspective	The TQM Journal	16	4	4
20	International Journal	Antony J.	2002	Design for six sigma: a breakthrough business improvement strategy for achieving competitive advantage	Work Study	51	1	5
21	International Journal	Antony J.	2004	Six Sigma in the UK service organisations: results from a pilot survey	Managerial Auditing Journal	19	8	4
22	International Journal	Antony J.	2005	A perspective on the future [Analysis: Six Sigma]	Manufacturing Engineer	84	1	2
23	International Journal	Antony J. and Desai D.A.	2009	Assessing the status of six sigma implementation in the Indian industry Results from an exploratory empirical study	Management Research News	32	5	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
24	International Journal	Kumar M., Antony J., Douglas A.	2009	Does size matter for Six Sigma implementation? Findings from the survey in UK SMEs	The TQM Journal	21	6	3
25	International Journal	Antony J., Antony F., Kumar M.	2005	Statistical thinking and its role for industrial engineers and managers in the 21st century	Managerial Auditing Journal	20	4	2
26	International Journal	Antony J., Antony F.J., Kumar M., Cho B.R.	2007	Six sigma in service organisations Benefits, challenges and difficulties, common myths, empirical observations and success factors	International Journal of Quality & Reliability Management	24	3	4
27	International Journal	Antony J., Banuelas Coronado R.	2002	Design for Six Sigma	Manufacturing Engineer	81	1	4
28	International Journal	Antony J., Douglas A., Antony F.J.	2007	Determining the essential characteristics of Six Sigma Black Belts	The TQM Journal	19	3	4
29	International Journal	Antony J., Downey-Ennis K., Antony F, Seow C.	2007	Can Six Sigma be the “cure” for our “ailing” NHS?	Leadership in Health Services	20	4	4
30	International Journal	Antony J., Escamilla J.L., Caine P.	2003	Lean Sigma production and supply chain management	Manufacturing Engineer	82	1	2
31	International Journal	Antony J., Fergusson C.	2004	Six Sigma in the software industry: results from a pilot study	Managerial Auditing Journal	19	8	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
32	International Journal	Antony J., Kumar M., Madu C.N.	2005	Six sigma in small- and medium-sized UK manufacturing enterprises	International Journal of Quality & Reliability Management	22	8	2
33	International Conference	Arcidiacono G., Citti P., Antico P., Torricini S.	2006	A new management process to analyse the automotive components complaints through DMADV	Proceedings of ICAD2006 The Fourth International Conference on Axiomatic Design Firenze – June 13-16, 2006	–	–	3
34	International Conference	Arcidiacono G., Panichi C., Schurr S.)	2006	Applying QFD and DFSS to the design of the suspension of a formula SAE race car	–	–	–	3
35	International Journal	Arnheiter E.D., Maleyeff J.	2005	The integration of lean management and Six Sigma	The TQM Journal	17	1	3
36	International Journal	Ayad, A.	2010	Critical thinking and business process improvement	Journal of Management Development	29	6	2
37	International Journal	Bañuelas R., Antony J.	2004	Six sigma or design for six sigma?	The TQM Journal	16	4	4
38	International Journal	Bañuelas R., Antony J.	2002	Key ingredients for the effective implementation of Six Sigma	Measuring Business Excellence	6	4	3
39	International Journal	Bañuelas R., Antony J.	2003	Going from six sigma to design for six sigma: an exploratory study using analytic hierarchy process	The TQM Journal	15	5	4
40	International Journal	Bañuelas R., Antony J.	2002	Critical success factors for the successful implementation of six sigma projects in organisations	The TQM Journal	14	2	5

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
41	International Journal	Bañuelas R., Tennant C., Tuersley I.,Tang S.	2006	Selection of six sigma projects in the UK	The TQM Journal	18	5	3
42	International Conference	Baoduo L., Wang L.	2008	Six Sigma Management in China: Status and Strategy	Wireless Communications, Networking and Mobile Computing	–	–	2
43	International Journal	Barnes C. and Walker R.	2010	Improving corporate communications: Lean Six Sigma science has broad reach	Journal of Business Strategy	31	1	2
44	International Journal	Barnes, C., & Walker, R.	2010	Improving corporate communications: Lean Six Sigma science has broad reach	Journal of Business Strategy	31	1	2
45	Thesis	Bedal K.W.	2008	Systems Process Engineering for Renal Transplants at The University of Toledo Medical Center Utilizing the Six Sigma Approach	–	–	–	2
46	International Journal	Behara R.S., Austin S.F., Fontenot G.F., Gresham A.	1995	Customer satisfaction measurement and analysis using six sigma	International Journal of Quality & Reliability Management	12	3	4
47	International Journal	Bendell T.	2006	A review and comparison of six sigma and the lean organisations	The TQM Journal	18	3	3
48	International Conference	Bendell T.	2004	Managing engineering improvement by six sigma	Engineering Management Conference	–	–	1
49	International Journal	Berlowitz D.R.	2003	Striving for six sigma in pressure ulcer care	Journal Of The American Geriatrics Society	51	9	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
50	International Book	Bhote K.R.	2003	The Power of Ultimate Six Sigma	_	_	_	2
51	International Book	Bhote K.R.	2002	The Ultimate Six Sigma	_	_	_	2
52	International Journal	Bhuiyan N., Amit Baghel A., Wilson J.	2006	A sustainable continuous improvement methodology at an aerospace company	International Journal of Productivity and Performance Management	55	8	2
53	International Journal	Biehl R.E.	2004	Six sigma for software	Software, IEEE	21	2	2
54	International Journal	Black K., Revere L.	2006	Six Sigma arises from the ashes of TQM with a twist	International Journal of Health Care Quality Assurance	19	3	4
55	International Journal	Boarin Pinto S.H., Monteiro de Carvalho M., Lee Ho L.	2008	Main quality programs characteristics in large size Brazilian companies	International Journal of Quality & Reliability Management	25	3	2
56	International Journal	Bowser T.J.	2009	Statistical methods fos Six Sigma in R&D and manufacturing	Journal of Food Quality	27	5	1
57	International Journal	Brady J.E. and Allen T.T	2009	Six Sigma: A Review and Agenda For Future Research	Quality and Reliability Engineering International	22	3	3
58	Thesis	Brady, J.E.	2005	Six Sigma and the university: teaching, research and meso-analysis	_	_	_	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
59	International Book	Breyfogle F.W.	2003	Implementing Six Sigma	_	_	_	3
60	International Book	Breyfogle F.W.	2000	Implementing Six Sigma: Smarter Solutions Using Statistical Methods	_	_	_	3
61	International Journal	Buch K.K., Tolentino A.	2006	Employee perceptions of the rewards associated with six sigma	Journal of Organizational Change Management	19	3	2
62	International Journal	Buch K.K., Tolentino A.	2006	Employee expectancies for six sigma success	Leadership & Organization Developement Journal	27	1	2
63	International Journal	Bunce M.M., Wang L., Bidanda B.	2008	Leveraging Six Sigma with industrial engineering tools in crateless retort production	International Journal of Production Research	46	23	1
64	International Conference	Burge L., Garuba M., Brent C.	2004	Improving retention of minority freshmen in engineering by applying the six sigma methodology	Information Technology: Coding and Computing, 2004. Proceedings. ITCC 2004. International Conference on	_	_	1
65	International Journal	Burge R.	2008	Ready Set Change	Industrial Engineer	40	10	2
66	International Journal	Burge R.	2008	Lollipops for excellence	Industrial Engineer	40	8	2
67	International Conference	Bury A.J., Akiya N.	2005	Evaluating proposed capital and operational improvements at a marine terminal	Winter Simulation Conference, 2005 Proceedings of the	_	_	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
68	International Conference	Buss P., Ivey N.	2001	Dow Chemical design for Six Sigma rail delivery project	Simulation Conference, 2001. Proceedings of the Winter	–	–	1
69	International Journal	Byrne G., Lubowe D. Blitz A.	2007	Using a Lean Six Sigma approach to drive innovation	Strategy & Leadership	35	2	3
70	International Journal	Camgoz-Akdag H.	2007	Total quality management through six sigma benchmarking: A case study	Benchmarking: An International Journal	14	2	2
71	International Journal	Capelli-Schellpfeffer M.	2006	Six sigma safety	Industry Applications Magazine, IEEE	12	5	1
72	International Journal	Carleysmith S.W., Dufton A.M., Altria K.D.	2009	Implementing Lean Sigma in pharmaceutical research and developement : a review by practitioners	R&D Management	39	1	2
73	International Journal	Catherwood P.	2005	Champions of the cause [six sigma]	Manufacturing Engineer	84	1	2
74	International Journal	Catherwood P.	2002	What's different about Six Sigma?	Manufacturing Engineer	81	1	3
75	International Journal	Cauchick Miguel P.A., Andrietta J.M.	2009	Benchmarking Six Sigma application in Brazil	Benchmarking: An International Journal	16	1	2
76	International Journal	Caulcutt R.	2001	Why is Six Sigma so successful?	Journal of Applied Statistics	28	3	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
77	Thesis	Cavallini A.G.	2008	LSS as a source of competitive advantage	_	_	_	2
78	International Journal	Chakrabarty A., Tan K.C.	2007	The current state of six sigma application in services	Managing Service Quality	17	2	5
79	International Conference	Chakrabarty A., Tan K.C.	2008	Case Study Analysis of Six Sigma in Singapore Service Organizations	Service Systems and Service Management	_	_	3
80	International Conference	Chakrabarty A., Tan K.C.	2007	A survey on Six Sigma implementation in Singapore service industries	Industrial Engineering and Engineering Management	_	_	4
81	International Journal	Chakravorty S.	2009	Six Sigma programs :An implementation model	International Journal of Production Economics	117	1	2
82	International Journal	Chao-Ton S., Chia-Jen C.	2007	A systematic methodology for the creation of Six Sigma projects: A case study of semiconductor foundry	Expert Systems with Applications	34	1	1
83	International Journal	Chee-Cheng Chen	2009	Integration of quality function deployment and process management in the semiconductor industry	International Journal of Production Research	47	6	2
84	International Journal	Chen M. , Lyu J.	2009	A lean six sigma approach to touch panel quality improvement	Production Planning & Control	20	5	4
85	International Conference	Chinbat U., Takakuwa S.	2008	Using Operation Process Simulation for a Six Sigma project of Mining and Iron Production Factory	Simulation Conference, 2008. WSC 2008. Winter	_	_	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
86	International Journal	Chonghun H., Minjin K., Yoon E.S.	2008	A hierarchical decision procedure for productivity innovation in large-scale petrochemical processes	Computers & Chemical Engineering	32	–	2
87	International Journal	Chonghun H., Young-Hak L.	2002	Intelligent Integrated Plant Operation System For Six Sigma	Annual Reviews in Control	26	1	2
88	International Journal	Choo A.S., Lindermanb K.W., Schroeder R.G.	2007	Method and context perspectives on learning and knowledge creation in quality management	Journal of Operations Management	25	4	2
89	International Conference	Chookittikul J., Chookittikul W.	2008	Six sigma quality improvement methods for creating and revising computer science degree programs and curricula	Frontiers in Education Conference, 2008. FIE 2008. 38th Annual	–	–	2
90	International Conference	Chookittikul J., Chookittikul W.	2008	Information technology strategy for Six Sigma projects in a Thai University	Management of Engineering & Technology, 2008. PICMET 2008. Portland International Conference on	–	–	2
91	International Journal	Chow, A. F., Finney, T. G., & Woodford, K. C.	2010	Training design and transfer: contributions of Six Sigma	International Journal of Productivity and Performance Management	59	7	3
92	International Conference	Chunho K., Baldwin D.F.	2002	Design guidelines to implement Six Sigma in assembly process yield of area array solder interconnect packages	Electronic Components and Technology Conference, 2002. Proceedings. 52nd	–	–	1
93	International Journal	Clegg B. et. al.	2010	A study into the effectiveness of quality management training A focus on tools and critical success factors	The TQM Journal	22	2	2
94	International Journal	Coleman S.	2008	Six Sigma: an opportunity for statistics and for statisticians	Significance	5	2	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
95	National Journal	Connolly M.	2003	Six Sigma deployment at DuPont.	R&D Magazine	45	4	2
96	International Conference	Costello C., Molloy O., Lyons G., Duggan J.	2005	Using event-based process modelling to support six sigma quality	Database and Expert Systems Applications, 2005. Proceedings. Sixteenth International Workshop	_	_	2
97	International Journal	Cronemyr P. and Witell L.	2010	Changing from a product to a process perspective for service improvements in a manufacturing company	The TQM Journal	22	2	4
98	International Book	Cupello J., Meadows B.	2001	Managing Six Sigma	_	_	_	2
99	International Journal	Dahlgaard J.J., Dahlgaard-Park S.M.	2006	Lean production, six sigma quality, TQM and company culture	The TQM Journal	18	3	3
100	International Journal	Dale B.G., Williams R.T.,Van der Wiele T.	2000	Marginalisation of quality: is there a case to answer?	The TQM Journal	12	4	2
101	International Journal	De Koning H., De Mast J.	2006	A rational reconstruction of Six-Sigma's breakthrough cookbook	International Journal of Quality & Reliability Management	23	7	3
102	International Journal	de Koning, H., Does, R. and Bisgaard, S	2008	Lean Six Sigma in financial services	Int. J. Six Sigma and Competitive Advantage	4	1	4
103	International Journal	De Mast J.	2004	A methodological comparison of three strategies for quality improvement	International Journal of Quality & Reliability Management	21	2	2
104	International Journal	De Vore K.	2008	A six-sigma approach to stability testing	Journal of Pharmaceutical and Biomedical Analysis	47	1	1

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
105	International Journal	Deaves M.	2003	Mission improvement six sigma	Manufacturing Engineer	82	_	2
106	International Journal	DeFeo J.A.	1993	Six Sigma: perfection is possible in meet customer needs	Handbook of Business Strategy	1	1	3
107	International Journal	Delgado C., Ferreira M., Castelo Branco M.	2010	The implementation of lean Six Sigma in financial services organizations	Journal of Manufacturing Technology Management	21	4	4
108	International Conference	Desai T.N., Shrivastava R.L.	2008	Six Sigma: A Break through Business Improvement Strategy for Achieving Competitive Advantage A Case Study	Emerging Trends in Engineering and Technology, 2008. ICETET '08.	–	–	2
109	International Conference	Deshmukh S.V., Lakhe R.R.	2008	Six Sigma - an innovative approach for waste reduction: A case study of an Indian SME	Industrial Engineering and Engineering Management, 2008. IEEM 2008. IEEE International Conference on	–	–	2
110	International Journal	Dong-Suk K.	2010	Eliciting success factors of applying Six Sigma in an academic library A case study	Performance Measurement and Metrics	11	1	3
111	International Journal	Duen-Yian Y., Ching-Hsue C., Mei-Lin C.	2007	A modified two-tuple FLC model for evaluating the performance of SCM: By the Six Sigma DMAIC process	Applied Soft Computing	7	3	1
112	International Book	Eckes G.	2002	The Six Sigma Revolution	_	_	_	4
113	International Journal	Ehie I., Sheu C.	2005	Integrating six sigma and theory of constraints for continuous improvement: a case study	Journal of Manufacturing Technology Management	16	5	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
114	International Journal	Elder B. L.	2008	Six Sigma next term in the Microbiology Laboratory	Clinical Microbiology Newsletter	30	19	2
115	International Journal	Eldridge N.E., Woods S.S., Bonello R.S., Clutter K., Ellingson L.A., Harris M.A., Livingston B.K., Bagian J.P., Danko L.H., Dunn E.J., Parlier R.L., Pederson C., Reichling K.J., Roselle G.A., Wright S.M.	2006	Using the Six Sigma Process to Implement the Centers for Disease Control and Prevention Guideline for Hand Hygiene in 4 Intensive Care Units	Journal of General Internal Medicine	21	2	2
116	International Book	Elliott G.	2004	The journey to steps to Six Sigma	_	_	_	2
117	International Conference	Eng Hooi T., Fook Nyen C., Wei Tsun L.	2007	What's Next After Process Characterization	Electronic Manufacturing Technology Symposium, 2007. IEMT '07. 32nd IEEE/CPMT International	_	_	2
118	International Journal	Fairbanks C.B.	2007	Using Six Sigma and Lean Methodologies to Improve OR Throughput	AORN Journal	86	1	2
119	International Journal	Feng Q., Manuel C.M.	2008	Under the knife: a national survey of six sigma programs in US healthcare organizations	International Journal of Health Care Quality Assurance	21	6	2
120	International Conference	Ferrin D.M., Muthler D.	2002	Six Sigma and simulation, so what's the correlation?	Simulation Conference, 2002. Proceedings of the Winter	_	_	1
121	International Journal	Ferryanto L.	2007	Design for six sigma	Jurnal Teknik Industri	9	1	3

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
122	International Journal	Firka, D.	2010	Six Sigma: an evolutionary analysis through case studies	The TQM Journal	22	4	4
123	International Journal	Fisher N.I, Nair V.N.	2009	Quality management and quality practice: Perspectives on their history and their future	Applied Stochastic Models In Business And Industry	25	1	2
124	International Journal	Flott L.W.	2000	Six-Sigma Controversy	Metal Finishing	98	12	1
125	International Journal	Frankel H.L., Crede W.B., Topal J.E., Roumanis S.A., Devlin M.W., Foley A.B.	2005	Use of Corporate Six Sigma next term Performance-Improvement Strategies to Reduce Incidence of Catheter-Related Bloodstream Infections in a Surgical ICU	Journal of the American College of Surgeons	201	3	2
126	National Journal	Fraser N., Fraser J.	2009	LSS applied to a customer service process within a commercial finance organization	Management Service	_	_	4
127	International Journal	Freiesleben J.	2006	Communicating six sigma's benefits to top management	The TQM Journal	10	2	2
128	International Journal	Freiesleben J.	2008	A proposal for an economic quality loss function	International Journal of Production Economics	113	2	1
129	International Journal	Freiesleben J.	2010	Proposing a new approach to discussing economic effects of design quality	Int. J.ProductionEconomics	124	_	3
130	International Journal	French CM, Duplancic N	2006	Application of six sigma methods for improving the analytical data management process in the environmental industry	Ground Water Monitoring And Remediation	26	2	2
131	International Journal	Friday-Stroud S.S., Sutterfield J.S.	2007	A conceptual framework for integrating six-sigma and strategic management methodologies to quantify decision making	The TQM Journal	19	6	2
132	International Journal	Fulton G., Webster D.	2002	A business evolution	Manufacturing Engineer	81	1	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
133	International Journal	Garg D., Narahari Y., Viswanadham N.	2004	Design of six sigma supply chains	Automation Science and Engineering, IEEE Transactions on	1	1	1
134	International Journal	Goel S., Chen V.	2008	Integrating the global enterprise using Six Sigma: Business process reengineering at General Electric Wind Energy	International Journal of Production Economics	113	1	4
135	International Journal	Goel S., Chen V.	2008	Can business process reengineering lead to security vulnerabilities: analyzing the reengineered process	International Journal of Production Economics	115	1	2
136	International Journal	Goh T.N.	2002	A strategic assessment of six sigma	Quality & Reliability Engineering International,	18	_	4
137	International Journal	Goh T.N., Xie M.	2004	Improving on the six sigma paradigm	The TQM Journal	16	4	3
138	International Conference	Goldman L.I., Evans-Hilton E., Emmett H.	2003	Crystal Ball for Six Sigma Tutorial	Simulation Conference, 2003. Proceedings of the 2003 Winter	_	_	1
139	International Journal	Goldstein M., 2001	2001	Six Sigma program success factors	ASQ Six Sigma forum magazine	1	1	5
140	International Conference	Goncalves F.M.G.S., Moreira Bezerra C.I., Dias Belchior A., Carneireo Coelho C., Pires C.G.S.	2008	A Strategy for Identifying, Classifying and Prioritizing Improvement and Innovation Actions: A CMMI Level 5 and Six Sigma Approach	Software Engineering, 2008. ASWEC 2008. 19th Australian Conference on	_	_	2
141	International Book	Gordon M.J.	2003	Six Sigma Quality for Business & Manufacture	_	_	_	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
142	International Conference	Goudarzlou A., Tan Kay C.	2008	Using six sigma in new service development	Service Systems and Service Management, 2008 International Conference on	–	–	3
143	International Journal	Gowen C.R., Stockz G.N., Mcfadden K.L.	2008	Simultaneous implementation of Six Sigma and knowledge management in hospitals	International Journal of Production Research	46	23	2
144	International Journal	Gowen C.R., Tallon W.J.	2005	Effect of technological intensity on the relationships among Six Sigma design, electronic-business, and competitive advantage: A dynamic capabilities model study	Journal of High Technology Management Research	16	1	2
145	International Journal	Gras J.M., Philippe M.,	2007	Application of the Six Sigma concept in clinical laboratories: a review	Clinical Chemical Laboratory Medicine	45	6	2
146	International Conference	Gremyr I., Gustavsson S., Gideberg A.	2010	Design for Six Sigma in healthcare; the medication process	–	–	–	4
147	International Conference	Gupta S.M., Nukala S.	2006	A Six Sigma tolerancing approach for the design of an efficient closed-loop supply chain network	–	–	–	2
148	International Journal	Gutiérrez Gutiérrez L.J., Lloréns-Montes F.J., Bustinza Sánchez O.F.	2009	Six sigma: from a goal-theoretic perspective to shared-vision development	International Journal of Operations & Production Management	29	2	2
149	International Conference	Habib M., Ahmed S., Rehmat A., Khan M.J., Shamail, S.	2008	Blending Six Sigma and CMMI - an approach to accelerate process improvement in SMEs	Multitopic Conference, 2008. INMIC 2008. IEEE International	–	–	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
150	International Journal	Hagemeyer C., Gershenson J.K., Johnson D.M.	2006	Classification and application of problem solving quality tools: A manufacturing case study	The TQM Journal	18	5	3
151	International Journal	Hahn G., Hoerl R.	1998	Key challenges for statisticians in business and industry	Technometrics	40	3	2
152	International Journal	Hahn G.J., Hill W.J., Hoerl R.W., Zinkgraf S.A.	1999	The Impact of Six Sigma Improvement-A Glimpse into the Future of Statistics	American Statistician	53	3	1
153	International Journal	Haikonen A., Savolainen T., Jarvinen P.	2004	Exploring Six Sigma and CI capability development: preliminary case study findings on management role	Journal of Manufacturing Technology Management	15	4	2
154	International Journal	Hamza S.E.	2009	Monitoring and controlling design process using control charts and process sigma	Business Process Management Journal	15	3	2
155	International Journal	Harjac S.J., Atrens A., Moss C.J.	2008	Six Sigma review of root causes of corrosion incidents in hot potassium carbonate acid gas removal plant	Engineering Failure Analysis	15	5	1
156	International Book	Harry M., Schroeder R.	2001	Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations	_	_	_	4
157	International Book	Harry M.J., Lawson J.R.	1994	Six Sigma Producibility Analysis and Process Characterization	_	_	_	2
158	International Journal	Hart M.A.	2006	Service Design for Six Sigma: A Roadmap for Excellence	Journal of Product Innovation Management	23	5	1

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
159	International Conference	Hashmi S.I., Baik J.	2008	Quantitative Process Improvement in XP Using Six Sigma Tools	Computer and Information Science, 2008. ICIS 08. Seventh IEEE/ACIS	–	–	1
160	International Journal	Heckl, D., Moormann, J., & Rosemann, M.	2010	Uptake and success factors of Six Sigma in the financial services industry	Business Process Management Journal	16	3	4
161	International Journal	Henderson K.M., Evans J.R.	2000	Successful implementation of Six Sigma: benchmarking General Electric Company	Benchmarking: An International Journal	7	4	4
162	International Journal	Hensley R.L., Dobie K.	2005	Assessing readiness for six sigma in a service setting	Managing Service Quality	15	1	5
163	International Conference	Hoehn W.K.	1995	Robust designs through design to six sigma manufacturability	Engineering Management Conference, 1995. 'Global Engineering Management: Emerging Trends in the Asia Pacific'., Proceedings of 1995 IEEE Annual International	–	–	1
164	International Journal	Holtz R., Campbell P.	2004	Six Sigma: Its implementation in Ford's facility management and maintenance functions	Journal of Facilities Management	2	4	2
165	International Conference	Hon N., Fok W., Wong E., Zongwei L.	2006	Quality Management using RFID and Third Generation Mobile Communications Systems	e-Business Engineering, 2006. ICEBE '06. IEEE International Conference	–	–	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
166	International Journal	Hong G.Y., Goh T.N.	2003	Six Sigma in software quality	The TQM Journal	15	6	2
167	International Journal	Hong Mo Y., Byung Seok C., Jin Park H., Min Soo S., Bongsug C.	2007	Supply chain management six sigma: a management innovation methodology at the Samsung Group	Supply Chain Management: An International Journal	12	2	2
168	International Conference	Hongbo W.	2008	A Review of Six Sigma Approach: Methodology, Implementation and Future Research	Wireless Communications, Networking and Mobile Computing	–	–	2
169	International Conference	Horst R.L.	1999	Making the six sigma leap using SPC data [quality]	Electronics Manufacturing Technology Symposium, 1999. Twenty-Fourth IEEE/CPMT	–	–	1
170	International Journal	Hu G., Wang L., Fetch S., Bidanda B.	2008	A multi-objective model for project portfolio selection to implement lean and Six Sigma concepts	International Journal of Production Research	46	23	2
171	International Journal	Hwang Y.D.	2006	The practices of integrating manufacturing execution systems and Six Sigma methodology	The International Journal of Advanced Manufacturing Technology	31	1	1
172	International Conference	Hyuck Moo K., Min Koo L., Sung Hoon H., Do Whan C.	2008	Driving Strategic Issues as Champion Projects for Six Sigma	Innovative Computing Information and Control, 2008. ICICIC '08. 3rd International Conference on	–	–	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
173	International Journal	Ingle S., Roe W.	2001	Six sigma black belt implementation	The TQM Journal	13	4	4
174	International Journal	Isaacson G.	2008	Six Sigma tympanostomy tube insertion: Achieving the highest safety levels during residency training	Otolaryngology - Head and Neck Surgery	139	3	2
175	International Conference	Jalali S., Shafieezadeh M., Naiini M.	2008	Using Knowledge Management in DMAIC methodology of Six Sigma projects	Information Technology, 2008. IT 2008. 1st International Conference on	_	_	1
176	International Journal	Jenicke L.O., Kumar A., Holmes M.C.	2008	A framework for applying six sigma improvement methodology in an academic environment	The TQM Journal	20	5	3
177	Thesis	Jochem R.	2007	Quality Governance based on Enterprise Engineering Method and Six Sigma Approach	_	_	_	2
178	Thesis	Jochem R.	2007	Enterprise Engineering Method supporting Six Sigma Approach	_	_	_	1
179	International Journal	Johansen F. and Leist S.	2009	A Six Sigma approach for integrated solutions	Managing Service Quality	19	5	4
180	National Journal	Johnson A.	2002	Six Sigma in R&D	Research Technology Management	45	2	1
181	National Journal	Johnson A.	2006	Lession learned in Six Sigma in R&D	Research Technology Management	49	2	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
182	International Journal	Johnston A.B., Maguire L.P., McGinnity T.M.	2009	Downstream performance prediction for a manufacturing system using neural networks and six-sigma improvement techniques	Robotics and Computer-Integrated Manufacturing	25	3	2
183	International Journal	Johnston A.B., Maguire L.P., Mcginnity T.M.	2008	Disentangling causal relationships of a manufacturing process using genetic algorithms and six-sigma techniques	International Journal of Production Research	46	23	1
184	International Journal	Jung-Lang C.	2008	Implementing Six Sigma via TQM improvement: an empirical study in Taiwan	The TQM Journal	20	3	2
185	International Conference	Kai X., Sikdar C., Gardner M.	2006	Six Sigma Roles in Innovation	Management of Innovation and Technology, 2006 IEEE International Conference on	–	–	1
186	International Conference	Kanani Y.G.	2006	Study and analysis of control phase role for increasing the Success of six sigma projects	Management of Innovation and Technology	–	–	2
187	International Journal	Kang J.O., Kim M.H., Hong S.E., Jung J.H., Song M.J.	2005	The application of the six sigma program for the quality management of the PACS	American Journal Of Roentgenology	185	5	2
188	International Journal	Kang N., Kim J., Park Y.	2007	Integration of marketing domain and R&D domain in NPD design process	Industrial Management & Data Systems	107	6	2
189	International Conference	Kedar A.P., Lakhe R.R., Deshpande V.S., Washimkar P.V., Wakhare, M.V.	2008	A Comparative Review of TQM, TPM and Related Organisational Performance Improvement Programs	Emerging Trends in Engineering and Technology, 2008. ICETET '08. First International Conference on	–	–	1

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
190	International Journal	Klefsjo B., Bergquist B. , Garvare R.	2008	Quality management and business excellence, customers and stakeholders: Do we agree on what we are talking about, and does it matter?	The TQM Journal	20	2	4
191	International Journal	KlefsjoÈ B., Wiklund H., Edgeman R.L.	2001	Six Sigma seen as a methodology for total quality management	Measuring Business Excellence	5	1	3
192	International Journal	Knowles G., Johnson M., Warwood S.	2004	Medicated sweet variability: a six sigma application at a UK food manufacturer	The TQM Journal	16	4	2
193	National Journal	Kondio Ž., Dušak V.	2006	The role of ICT in Six Sigma approach implementation	Journal of Information and Organizational Sciences	30	1	2
194	International Journal	Kuei C.H., Madu C.N.	2003	Customer-centric six sigma quality and reliability management	International Journal of Quality & Reliability Management	20	8	2
195	International Journal	Kumar M., Antony J.	2008	Comparing the quality management practices in UK SMEs	Industrial Management & Data Systems	109	8	2
196	International Journal	Kumar M., Antony J., Madu C.N., Montgomery D.C., Park S.H.	2008	Common myths of Six Sigma demystified	International Journal of Quality & Reliability Management	25	8	4
197	International Journal	Kumar M., Antony J., Singh R.K., Tiwari M.K., Perry D.	2006	Implementing the Lean Sigma framework in an Indian SME: a case study	Production Planning & Control	17	4	2
198	International Journal	Kumar S. and Steinebach M.	2008	Eliminating US hospital medical errors	International Journal of Health Care Quality Assurance	21	5	3

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
199	International Journal	Kumar S., Dieveney E., Dieveney A.	2009	Reverse logistic process control measures for the pharmaceutical industry supply chain	International Journal of Productivity and Performance Management	58	2	2
200	International Journal	Kumar S., Sosnoski M.	2009	Using DMAIC Six Sigma to systematically improve shopfloor production quality and costs	International Journal of Productivity and Performance Management	58	3	2
201	International Journal	Kumar S., Strandlund E., Thomas D.	2008	Improved service system design using Six Sigma DMAIC for a major US consumer electronics and appliance retailer	International Journal of Quality & Reliability Management	36	12	2
202	International Journal	Kumar S., Wolfe A.D., Wolfe K.A.	2008	Using Six Sigma DMAIC to improve credit initiation process in a financial services operation	International Journal of Productivity and Performance Management	57	8	2
203	International Journal	Kumar U., Saranga H., Ramírez-Márquez J.E., Nowicki D.	2007	Six sigma project selection using data envelopment analysis	The TQM Journal	19	5	2
204	International Journal	Kumar U.D., Nowickib D., Ramírez-Márquez J.E., Vermab D.	2007	On the optimal selection of process alternatives in a Six Sigma implementation	International Journal of Production Economics	111	1	2
205	International Journal	Kumar, S., Hudson, B., & Lowry, J.	2010	Consumer purchase process improvements in e-tailing operations: A case study.	International Journal of Productivity and Performance Management	59	4	3
206	International Journal	Kumi S., Morrow J.	2006	Improving self service the six sigma way at Newcastle University Library	Program: electronic library and information systems	40	2	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
207	International Journal	Kureshi, N., Qureshi, F., & Sajid, A.	2010	Current health of quality management practices in service sector SME: A case study of Pakistan	The TQM Journal	22	3	2
208	International Journal	Kwak Y.H., Anbari F.T.	2004	Benefits, obstacles, and future of six sigma approach	Technovation	26	1	3
209	International Conference	L.M. Corbett	2010	Lean Six and its links to business excellence	_	_	_	3
210	Thesis	Lalovic M.	2002	An abet assessment model using Six Sigma methodology	_	_	_	2
211	International Journal	Laureani, A., & Antony, J.	2010	Reducing employees' turnover in transactional services: a Lean Six Sigma case study	International Journal of Productivity and Performance Management	59	7	4
212	International Journal	Lee-Mortimer A.	2006	Six sigma: effective handling of deep rooted quality problems	Assembly Automation	26	3	2
213	International Journal	Lee-Mortimer A.	2006	Six Sigma: a vital improvement approach when applied to the right problems, in the right environment	Assembly Automation	26	1	2
214	International Journal	Lendrem D., Grant I.	2002	Some recent books about six sigma	Pharmaceutical Statistics	1	1	1

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
215	Thesis	Liljeqvist H., Rehnberg K.	2004	How to improve the strength in jackscrews by use of Six Sigma	_	_	_	1
216	International Conference	Lin Ho S.	2006	Six Sigma and Educational Excellence	Management of Innovation and Technology, 2006 IEEE International Conference on	_	_	2
217	International Journal	Linderman K., Schroeder R.G., Choo A.S.	2006	Six Sigma: The role of goals in improvement teams	Journal of Operations Management	24	1	2
218	International Journal	Linderman K., Schroeder R.G., Zaheer S., Choo A.S.	2003	Six Sigma: a goal-theoretic perspective	Journal of Operations Management	21	1	2
219	International Journal	Little B.	2003	"Six sigma" techniques improve the quality of e-learning	Industrial and Commercial Training	35	3	2
220	International Journal	Liu E.W.	2006	Clinical Research The Six Sigma Way	Journal of the Association for Laboratory Automation	11	1	2
221	International Journal	Llorens-Montes F.J. And Molina L.M.	2006	Six Sigma and Management Theory: Processes, Content and Effectiveness	Total Quality Management	17	4	3
222	International Conference	Luce K., Trepanier L., Ciochetto F., Goldman L.	2005	Simulation and optimization as effective DFSS tools	Winter Simulation Conference, 2005 Proceedings of the	_	_	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
223	International Journal	M. Sokovic M., Pavletic D., Fakin S.	2005	Application of Six Sigma methodology for process design	Journal of Materials Processing Technology	162-163	1	2
224	International Conference	Mach P., Guaqueta J.	2001	Utilization of the seven Ishikawa tools (old tools) in the six sigma strategy	Electronics Technology: Concurrent Engineering in Electronic Packaging, 2001. 24th International Spring Seminar on	_	_	1
225	International Journal	Mahanti R., Antony J.	2005	Confluence of six sigma, simulation and software development	Managerial Auditing Journal	20	7	2
226	International Journal	Mahanti R., Antony J.	2009	Six Sigma in the Indian software industry: some observations and results from a pilot survey	The TQM Journal	21	6	2
227	International Journal	Maleyeff J., Kaminsky F.C.	2002	Six sigma and introductory statistics education	Education + Training	44	2	2
228	International Journal	Man J.	2002	Six Sigma and lifelong learning	Work Study	51	4	2
229	International Journal	Manual D.	2006	Six Sigma methodology: reducing defects in business processes	Filtration & Separation	43	1	2
230	International Journal	Markarian J.	2004	What is Six Sigma?	Reinforced plastics	48	7	2
231	International Journal	McAdam R. et. al.	2009	Customer-orientated Six Sigma in call centre performance measurement	International Journal of Quality & Reliability Management	26	9	3

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
232	International Journal	McAdam R., Lafferty B.	2004	A multilevel case study critique of six sigma: statistical control or strategic change?	International Journal of Operations & Production Management	24	5	4
233	International Journal	McAdam, R., & Hazlett, S.	2010	An absorptive capacity interpretation of Six Sigma	Journal of Manufacturing Technology Management	21	5	2
234	International Conference	McCarthy B.M., Stauffer R.	2001	Enhancing Six Sigma through simulation with iGrafx Process for Six Sigma	Simulation Conference, 2001. Proceedings of the Winter	–	–	1
235	International Journal	McCarty T.D., Fisher S.A.	2007	Six sigma: it is not what you think	Journal of Corporate Real Estate	9	3	2
236	International Journal	Mitchell B.	1992	The Six Sigma appeal [SPC]	Engineering Management Journal	2	1	3
237	International Journal	Mitra A.	2004	Six sigma education: a critical role for academia	The TQM Journal	16	4	2
238	International Journal	Montgomery D.C.	2010	A modern framework for achieving enterprise excellence	International Journal of Lean Six Sigma	1	1	5
239	International Journal	Montgomery D.C., Woodall W.H.	2008	An overview of six sigma	International Statistical Review	76	3	4
240	International Journal	Moorman D.W.	2005	On the quest for six sigma	The American Journal of Surgery	189	3	1

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
241	International Journal	Motwani J., Kumar A., Antony J.	2004	A business process change framework for examining the implementation of six sigma: a case study of Dow Chemicals	The TQM Journal	16	4	2
242	International Conference	Mulligan S.P., Jereb R.A.., Luhning, B.E.,	1991	IBM Austin Electronic Card Assembly and Test six sigma process modeling strategy	Electronics Manufacturing Technology Symposium, 1991., Eleventh IEEE/CHMT International	_	_	2
243	International Conference	Murugappan M., Keeni G.	2000	Quality improvement-the Six Sigma way	Quality Software, 2000. Proceedings. First Asia-Pacific Conference on	_	_	2
244	International Journal	Murugappan M., Keeni G.	2003	Blending CMM and Six Sigma to meet business goals	Software, IEEE	20	2	2
245	International Journal	Myers Glower M.	2006	Six Sigma: Bringing it to your team	Nurse Leader	4	2	2
246	International Journal	Nabhani F. and Shokri A.	2009	Reducing the delivery lead time in a food distribution SME through the implementation of six sigma methodology	Journal of Manufacturing Technology Management	20	7	2
247	International Journal	Nakhai B. and Neves J.S.	2009	The challenges of six sigma in improving service quality	International Journal of Quality & Reliability Management	26	7	5
248	International Conference	Narahari Y., Viswanadham N., Bhattacharya R.	2000	Design of synchronized supply chains: a six sigma tolerancing approach	Robotics and Automation, 2000. Proceedings. ICRA '00	_	_	2
249	International Journal	Näslund D.	2008	Lean, six sigma and lean sigma: fads or real process improvement methods?	Business Process Management Journal	14	3	4

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
250	International Book	Naumann E., Hoisington S.H.	2001	Customer Centered Six Sigma	_	_	_	2
251	International Journal	Nellis T., Harrington H.J.	2003	Remember, the (Internet) applet doesn't fall far from the tree	The TQM Journal	15	5	2
252	International Conference	Nirmala B., Azmi M.	2006	Capacity Improvement Through Cycle Time Reduction	Electronic Materials and Packaging, 2006. EMAP 2006. International Conference on	_	_	1
253	Thesis	Nonthaleerak P., Hendry L.	2005	Exploring the Six Sigma phenomenon using multiple case study evidence	_	_	_	1
254	International Journal	Noone, B. M., Namasivayam, K., & Tomlinson, H. S.	2010	Examining the application of six sigma in the service exchange	Managing Service Quality	20	3	4
255	International Conference	Normand J.F., Draper R.E.	1997	Resolution of insulation related manufacturing problems using the Six Sigma methodology and tools	Electrical Insulation Conference, 1997, and Electrical Manufacturing & Coil Winding Conference. Proceedings	_	_	1
256	Thesis	Nyrén G.	2007	A Six Sigma project at Ericsson Network Technologies	_	_	_	1
257	International Journal	O'Neill M., Duvall C.	2005	A Six Sigma quality approach to workplace evaluation	Jorunal of Facilities Management	3	3	2
258	International Book	Pande P.S., Neuman R.P., Cavanagh R.R.	2002	The Six Sigma Way	_	_	_	4

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
259	International Journal	Pandey A.	2007	Strategically focused training in Six Sigma way: a case study	Journal of European Industrial Training	31	2	2
260	International Conference	Park Y., Park H., Choi H., Baik J.	2006	A Study on the Application of Six Sigma Tools to PSP/TSP for Process Improvement	Computer and Information Science, 2006 and 2006 1st IEEE/ACIS International Workshop on Component-Based Software Engineering, Software Architecture and Reuse	–	–	1
261	International Conference	Patil V.H., Kamlapur S.M., Dhore M.L.	2006	Six Sigma in Education: To Achieve Overall Excellence in the Field of Education	Information Technology: New Generations	–	–	2
262	International Journal	Peltokorpi A. and Kujala J.	2006	Time-based analysis of total cost of patient episodes. A case study of hip replacement	International Journal of Health Care Quality Assurance	19	2	2
263	International Journal	Pepper M.P.J. and Spedding T.A.	2010	The evolution of lean Six Sigma	International Journal of Quality & Reliability Management	27	2	4
264	International Journal	Pfeifer T., Reissiger W., Canales C.	2004	Integrating six sigma with quality management systems	The TQM Journal	16	4	3
265	International Journal	Pollit, D.	2006	Toshiba sparks a wave of innovation: New structures and incentives stimulate employee creativity	Human Resource Management International Digest	14	6	2
266	International Journal	Preeprem Nonthaleerak P., Hendry L.	2008	Exploring the six sigma phenomenon using multiple case study evidence	International Journal of Operations & Production Management	28	3	2

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267	International Journal	Proudlove N., Moxham C., Boaden R.	2008	Lessons for Lean in Healthcare from Using Six Sigma in the NHS	Public Money & Management	28	1	3
268	International Book	Pyzdek T.	2000	The Complete Guide to Six Sigma	_	_	_	3
269	International Journal	Radhakrishnan R., Mark K., Powell B.	2008	IT service management for high availability	IBM Systems Journal	47	4	3
270	International Journal	Raisinghani M.S., Ette H., Pierce R., Cannon G., Daripaly P.	2005	Six Sigma: concepts, tools, and applications	Industrial Management & Data Systems	105	4	4
271	International Conference	Ramakrishnan S., Tsai P.F., Drayer C.M., Srihari K.	2008	Using simulation with Design For Six Sigma in a server manufacturing environment	Simulation Conference, 2008. WSC 2008. Winter	_	_	2
272	International Journal	Ramamoorti S., Watson M.W., Zabel M.	2008	Engineering Value Into Enterprise Risk Management	Internal Auditor	65	5	2
273	International Journal	Ravichandran J.	2007	Cost-based process weights for DPMO and the overall performance of an organization	The TQM Journal	19	5	2
274	International Conference	Redling T.J.	2005	Application of Six Sigma tools to product line business plan development	Digital Avionics Systems Conference, 2005. DASC 2005. The 24th	_	_	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
275	International Conference	Redzic C., Baik J.	2006	Six Sigma Approach in Software Quality Improvement	Software Engineering Research, Management and Applications, 2006. Fourth International Conference on	_	_	2
276	International Conference	Ren X., Zhang G.	2008	Research on Decision Support for Six Sigma Project Selection Based on Fuzzy Evaluation	Wireless Communications, Networking and Mobile Computing, 2008. WiCOM '08. 4th International Conference on	_	_	2
277	International Journal	Revere L., Black K., Huq A.	2004	Integrating Six Sigma and CQI for improving patient care	The TQM Journal	16	2	4
278	International Journal	Rieley J.B., Puaar S.	2002	Recession proofing Six Sigma	Manufacturing Engineer	81	1	2
279	International Journal	Roy S., Choudhary P.	2007	Six Sigma speeds the “settling in” process at Bharati Computers Limited: New employees become productive more quickly after streamlining process	Management	15	2	2
280	International Conference	Safwat T., Ezzat A.	2008	Applying Six sigma techniques in plastic injection molding industry	Industrial Engineering and Engineering Management, 2008. IEEM 2008. IEEE International Conference	_	_	2
281	International Journal	Sahooa A.K., Tiwarib M.K., Milehamc A.R.	2008	Six Sigma based approach to optimize radial forging operation variables	Journal of Materials Processing Technology	202	1	2
282	International Journal	Savolainen T., Haikonen A.	2007	Dynamics of organizational learning and continuous improvement in six sigma implementation	The TQM Journal	19	1	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
283	International Journal	Schroeder R.G., Linderman K., Liedtke C., Choo A.S.	2008	Six Sigma: Definition and underlying theory	Journal of Operations Management	26	4	4
284	International Journal	Scott B.S., Wilcock A.E., Kanetkar V.	2009	A survey of structured continuous improvement programs in the Canadian food sector	Food Control	20	3	2
285	International Journal	Sehwail L., DeYong C.	2003	Six Sigma in health care	Leadership in Health Services	16	4	4
286	International Conference	Seifert M.J.	2005	The use of discrete event simulation in a design for Six Sigma project	Winter Simulation Conference, 2005	–	–	2
287	International Journal	Sekhar H., Mahanti R.	2006	Confluence of Six Sigma, simulation and environmental quality: An application in foundry industries	Management of Environmental Quality: An International Journal	17	2	2
288	International Journal	Senapati N.R.	2004	Six Sigma: myths and realities	International Journal of Quality & Reliability Management	21	6	2
289	International Conference	Seow C., Hall D.	2004	Six sigma as a process enabler and strategic facilitator for knowledge in sustainable development: a SME case study	Engineering Management Conference, 2004. Proceedings. 2004 IEEE International	–	–	2
290	International Journal	Setijono D.	2008	DisPMO and DePMO as six sigma-based forward-looking quality performance measures	The TQM Journal	20	6	2
291	International Journal	Setijono D.	2010	Normal approximation through data replication when estimating DisPMO, DePMO, left-side and right-side Sigma levels from non-normal data	International Journal of Quality & Reliability Management	27	3	2
292	International Journal	Setijono D., Dahlgaard J.J.	2007	Customer value as a key performance indicator (KPI) and a key improvement indicator (KII)	Measuring Business Excellence	11	2	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
293	International Journal	Shah R., Chandrasekaran A., Linderman K.	2008	In pursuit of implementation patterns: the context of Lean and Six Sigma	International Journal of Production Research	46	23	2
294	International Conference	Shimoyama K., Oyama A., Fujii K.	2005	A new efficient and useful robust optimization approach - design for multi-objective six sigma	Evolutionary Computation, 2005. The 2005 IEEE Congress on	–	–	1
295	International Conference	Smith M.K., Van der Meer R., MacBride J.	2010	Implementing lean six sigma in a front office customer service centre – identification of managerial challenges	–	–	–	4
296	International Journal	Snee, R.D.	2010	Lean Six Sigma getting better all the time	International Journal of Lean Six Sigma	1	1	4
297	International Journal	Snee, R.D. and Rodebaugh	2002	The project selection process	Quality Progress	35	9	4
298	International Conference	Song-Kyoo K.	2008	Enhanced evaluation method of sigma level in Six-sigma activities	Management of Innovation and Technology, 2008. ICMIT 2008. 4th IEEE International Conference on	–	–	1
299	International Journal	Stevenson, W., Mergen A.E.	2006	Teaching six sigma concepts in a business school curriculum	Total Quality Management & Business Excellence	17	6	2
300	International Journal	Strang D., Jung D.I.	2009	Participatory Improvement at a Global Bank: The Diffusion of Quality Teams and the Demise of a Six Sigma Initiative	Organization Studies	30	1	2
301	National Journal	Studt T.	2002	Implementing six sigma in R&D.	R&D Magazine	44	8	1

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
302	International Journal	Su C.T. and Chao C.J.	2008	A systematic methodology for the creation of Six Sigma projects: A case study of semiconductor foundry	Expert Systems with Applications	34	4	2
303	International Journal	Sulek J.M. et. al.	2005	Measuring performance in multi-stage service operations: An application of cause selecting control charts	Journal of Operations Management	24	–	3
304	International Journal	Sung H. et. al.	2009	The relationship between quality management and the speed of new product development	The TQM Journal	21	6	2
305	International Conference	Sutherland P.E.	2001	Assessment of industrial distribution system reliability using Six Sigma techniques	Industrial and Commercial Power Systems Technical Conference, 2001. Conference Record. Papers Presented at the 2001 Annual Meeting. 2001 IEEE	–	–	1
306	International Conference	Sutherland P.E.	2001	Assessment of industrial distribution system reliability using Six Sigma methodology	Electricity Distribution, 2001. Part 1: Contributions. CIRED. 16th International Conference and Exhibition	–	–	1
307	International Journal	Taho Y., Chiung-Hsi H.	2009	Six-Sigma project selection using national quality award criteria and Delphi fuzzy multiple criteria decision-making method	Expert Systems with Applications	36	1	1
308	International Journal	Taner M. T., Sezen B., Antony J.	2007	An overview of six sigma applications in healthcare industry	International Journal of Health Care Quality Assurance	20	4	3
309	International Journal	Taner M.T. and Sezen B.	2009	An application of Six Sigma methodology to turnover intentions in health care	International Journal of Health Care Quality Assurance	22	3	3

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
310	International Journal	Tannock J.D.T., Balogun O., Hawisa H.	2007	A variation management system supporting six sigma	Journal of Manufacturing Technology Management	18	5	2
311	International Journal	Tarantino A.	2009	Risk management for the next generation	Industrial Management	51	1	2
312	International Book	Thevnin C.	2004	Effective management commitment enhances six sigma success	–	–	–	2
313	International Journal	Thirunavukkarasu V., Devadasan S.R., Prabhushankar G.V., Murugesh R., Senthilkumar K.M.	2008	Conceptualisation of Total Six Sigma Function Deployment through literature snapshots	International Journal of Applied Management Science	1	1	2
314	International Journal	Thomas A., Barton R.	2006	Developing an SME based six sigma strategy	Journal of Manufacturing Technology Management	17	4	2
315	International Journal	Thomas A., Barton R., Byard P.	2008	Developing a Six Sigma maintenance model	Journal of Quality in Maintenance Engineering	14	3	2
316	International Journal	Thomas A., Barton R., Chuke-Okafor C.	2009	Applying lean six sigma in a small engineering company – a model for change	Journal of Manufacturing Technology Management	20	1	3
317	International Journal	Thomas A., Barton R., Chuke-Okafor C.	2009	Applying lean six sigma in a small engineering company – a model for change	Journal of Manufacturing Technology Management	20	1	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
318	International Journal	Tiwari M.K., Antony J.; Montgomery D.C.	2008	Effective decision support to implement lean and six sigma methodologies in the manufacturing and service sectors	International Journal of Production Research	46	23	1
319	International Conference	Tobias P.A.	1991	A Six Sigma program implementation	Custom Integrated Circuits Conference, 1991., Proceedings of the IEEE 1991	–	–	1
320	International Conference	Tonini A.C., De Mesquita Spinola M., Barbin Laurindo F.J.	2006	Six Sigma and Software Development Process: DMAIC Improvements	Technology Management for the Global Future, 2006. PICMET 2006	–	–	2
321	International Conference	Tonini A.C., Laurindo F.J.B., De Spinola M.	2007	An Application of Six Sigma with Lean Production Practices for Identifying Common Causes of Software Process Variability	Management of Engineering and Technology, Portland International Center for	–	–	1
322	International Journal	Torres E.J., Guo K.L.	2004	Quality improvement techniques to improve patient satisfaction	International Journal of Health Care Quality Assurance	17	6	2
323	International Journal	Utley S. and May J.G.	2009	Monitoring service quality with residuals control charts	Managing Service Quality	19	2	2
324	International Journal	Van Iwaarden J., Van der Wiele T., Dale B., Williams R., Bertsch B.	2008	The Six Sigma improvement approach: a transnational comparison	International Journal of Production Research	46	23	3
325	International Journal	Waterman B.	2006	Does total quality apply to knowledge work? Absolutely!	Journal for Quality & Participation	19	6	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
326	International Journal	Wei C., Sheen G., Tai C., Lee K.	2010	Using Six Sigma to improve replenishment process in a direct selling company	Supply Chain Management: An International Journal	15	1	2
327	International Journal	Wessel G., Burcher P.	2004	Six sigma for small and medium-sized enterprises	The TQM Journal	16	4	2
328	International Conference	White R.V.	1992	An introduction to Six Sigma with a design example	Applied Power Electronics Conference and Exposition, 1992. APEC '92. Conference Proceedings 1992., Seventh Annual	–	–	2
329	International Journal	Wiele, T. V. D., Iwaarden, J. V., & Power, D	2010	Six Sigma implementation in Ireland: the role of multinational firms	International Journal of Quality & Reliability Management	27	9	3
330	Thesis	Workman-Germann J., Woodward-Hagg H.	2007	Implementing Lean Six Sigma Methodologies in the Radiology Department of a Hospital Healthcare System	–	–	–	2
331	International Journal	Wu C. and Lin C.	2009	Case study of knowledge creation facilitated by Six Sigma	International Journal of Quality & Reliability Management	26	9	2
332	International Journal	Xingxing Z., Fredendall L.D., Douglas T.J.	2008	The evolving theory of quality management: The role of Six Sigma	Journal of Operations Management	26	1	4
333	International Conference	Xinjun Z.	2005	Integrated TRIZ and Six Sigma theories for service/process innovation	Services Systems and Services Management, 2005. Proceedings of ICSSSM '05. 2005 International Conference on	–	–	1

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
334	International Journal	Xinying L., Shuhong W., Jie Q., Jian Guo Z., Youguang G., Zhi Wei L.	2008	Robust Optimization in HTS Cable Based on Design for Six Sigma	Magnetics, IEEE Transactions on	44	6	1
335	International Journal	Ya-Chen H., Pearn W.L., Pei-Ching W.	2008	Capability adjustment for gamma processes with mean shift consideration in implementing Six Sigma program	European Journal of Operational Research	191	1	2
336	International Journal	Yang C.C., Lin W.T., Chen H.M., Shi Y.H.	2009	Improving scheduling of emergency physicians using data mining analysis	Expert Systems with Applications	36	2	1
337	International Journal	Ying-Chin H., Ou-Chuan C., Wen-Bo W.	2008	An empirical study of key success factors for Six Sigma Green Belt projects at an Asian MRO company	Journal of Air Transport Management	14	1	3
338	International Conference	Zhang W., Hill A., Gilbreath G.H	2009	Six Sigma: A restrospective and prospective study	POMS 20th Annual Conference, Orlando, Florida, USA	_	_	5
339	Thesis	Zhang L., Khan A.	2008	Applying Six Sigma in Software Companies for Process Improvement	_	_	_	1
340	International Conference	Zhang Q., Gao J.	2004	Machine learning - the Six Sigma way	Intelligent Control and Automation, 2004. WCICA 2004. Fifth World Congress on	_	_	2
341	International Conference	Zhang Y., Xu Y., Wan Z.	2007	Research on the Application of Six Sigma Method in Logistic Corporation	Automation and Logistics, 2007 IEEE International Conference on	_	_	2

#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
342	International Conference	Zhangzhihong, Hezhen, Guowei	2007	Improvement Study on Six Sigma Mechanical Design Tolerancing with Design of Experiment	Wireless Communications, Networking and Mobile Computing, 2007. WiCom 2007. International Conference on	–	–	2
343	International Conference	Zhao X., He Z., Gui F., Zhang S.	2008	Research on the Application of Six Sigma in Software Process Improvement	Intelligent Information Hiding and Multimedia Signal Processing, 2008. IIHMSP '08 International Conference on	–	–	2
344	International Journal	Zhedan P., Hyuncheol P., Jongmoon B., Hojin C.,	2007	A Six Sigma Framework for Software Process Improvements and its Implementation	Software Engineering Conference	4	7	2
345	International Journal	Zou, X. T., and Lee, W	2010	A study of knowledge flow in Six Sigma teams in a Chinese manufacturing enterprise	VINE: The journal of information and knowledge management systems	40	3/4	3
346	International Conference	Zu X., Fredendall L., Robbins T.	2006	Organizational culture and quality practices in six sigma	–	–	–	4
347	International Journal	Zu X., Robbins T.L., Fredendall L.D.	2010	Mapping thecritical links between organizational culture and TQM/Six Sigma practices	Int. J.ProductionEconomics	123	–	2
348	International Journal	–	2002	Black belts save Motorola a billion	Strategic Direction	18	1	2
349	International Journal	–	2003	A revealing study of Six Sigma	Strategic Direction	19	8	2

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#	SOURCE	AUTHORS	YEAR	TITLE	JOURNAL	VOLUME	ISSUE	EVALUATION
350	International Journal	–	2004	Six Sigma:quality processing through statistical analysis	Plastics Additives & Compounding	–	–	2
351	International Journal	–	2004	Successful cost reduction methodologies: World leading manufactures highlight tools and techniques for achieving major cost reduction	Strategic Direction	20	4	2
352	International Journal	–	2005	Six Sigma contionues to thrive and evolve	Manufacturing Engineer	84	1	1
353	International Journal	–	2005	Best practices at Dow Chemicals	Strategic Direction	21	1	2
354	International Journal	–	2007	Probing the potential of Six Sigma	Strategic Direction	23	3	2
355	International Journal	–	2007	Samsung does six sigma	Strategic Direction	23	9	2

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