Università degli Studi di Padova

Dipartimento di *Tecnica e Gestione dei sistemi industriali*

SCUOLA DI DOTTORATO DI RICERCA IN INGEGNERIA GESTIONALE ED ESTIMO

INDIRIZZO: INGEGNERIA GESTIONALE

CICLO: XXV

COMPLEMENTARITIES BETWEEN MASS CUSTOMIZATION CAPABILITIES AND GREEN MANAGEMENT CAPABILITIES: A LONGITUDINAL CASE STUDY

Direttore della Scuola: Ch.mo Prof. CIPRIANO FORZA

Coordinatore d'indirizzo: Ch.mo Prof. CIPRIANO FORZA

Supervisore: Ch.mo Prof. CIPRIANO FORZA

Co-Supervisore: Ch.mo Prof. ALESSIO TRENTIN

Dottoranda: ELISA PERIN

Complementarity between mass customization capabilities and green management capabilities: a longitudinal case study

Acknowledgements

Chi mi conosce sa che non sono una gran comunicatrice, soprattutto quando c'è da ringraziare. Questa volta, tuttavia, voglio davvero esprimere la mia riconoscenza verso alcune persone che hanno contribuito al mio raggiungimento di questo traguardo (anche perché non posso più giustificarmi dicendo che i ringraziamenti verranno con la prossima tesi!).

È doveroso iniziare con la mia famiglia, che ha supportato la scrittura di questa tesi in modo molto concreto. Mamma, grazie per i biscotti, tè e cioccolatini che non sono mai mancati a metà pomeriggio per staccare gli occhi dal PC. Ah, e ovviamente per la condivisione della quotidiana puntata della signora Fletcher! Papà, grazie per le avvincenti discussioni di politica e non, che a metà giornata aiutano a risvegliarsi un po' dallo stato di dipendenza mentale dalla tesi. Erica, grazie per il vestito che sicuramente in sede di discussione sto indossando! E Nicola, grazie perché senza la musica proveniente dalla tua camera la scrittura di questa tesi sarebbe stata sicuramente più monotona (anche se forse un po' più facile ;-)). A parte le battute, grazie a tutta la mia famiglia che nonostante alti e bassi è bella, vera e unita. Non è una cosa da poco, so di essere fortunata.

A Simone grazie prima di tutto per aver capito quando avevo bisogno di tranquillità e quando invece era ora di muoversi un po' dal computer. Soprattutto grazie per il supporto morale che mi hai dato in alcuni momenti, espressione un po' abusata ma in questo caso perfetta.

Alle mie migliori amiche Erika, Eleonora, Fabiana, Giulia e Marta: grazie per le distrazioni, per le parole gentili e per i momenti-pettegolezzo. Mi dispiace non essere stata un po' più vicina ad alcune di voi ultimamente.

Grandissimo è poi il mio ringraziamento ai miei coordinatori, Cipriano ed Alessio. Grazie per il supporto che mi avete dato e per la vostra forte presenza in tutte le fasi di questo dottorato. La cosa più importante che ho imparato in questi anni grazie a voi è che il gruppo vale molto più della somma dei singoli (perfettamente in tema con la tesi, neanche a farlo apposta). Per carattere e per esperienza non è una di cui ero così convinta prima di osservare il vostro lavoro.

Un ringraziamento anche al personale dell'azienda coinvolta in questo progetto di tesi che, con grande disponibilità, ha collaborato per fare in modo che la ricerca potesse svolgersi. Grazie anche a Enrico per l'aiuto in alcuni momenti critici, chissà perché quasi sempre di domenica!

I would also like to thank Professor Pär Åhlström. It was an honor to visit such a beautiful (and lean!) department. Thank you for all the helpful suggestions and advices you gave me for the improvement of my work.

Finally I thank Professor Marie Koulikoff-Souviron and Professor Juliana Hsuan that made very helpful comments on my manuscript.

Contents

ABSTRACT **1**

SOMMARIO **2**

INTRODUCTION **3**

1 LITERATURE REVIEW **7**

1.1 ORGANIZATIONAL CAPABILITIES 7

1.2 COMPLEMENTARITIES IN ORGANIZATIONS 9

1.3 MASS CUSTOMIZATION CAPABILITIES 12

1.4 GREEN MANAGEMENT CAPABILITIES 14

1.5 MASS CUSTOMIZATION AND GREEN MANAGEMENT 19

2 METHODOLOGY **21**

2.1 SETTING 22

2.2 RESEARCH PROTOCOL AND DATA COLLECTION 25

2.3 DATA ANALYSIS 27

2.4 ASSESSING RELIABILITY AND VALIDITY 30

3 RESULTS **33**

3.1 MASS CUSTOMIZATION CAPABILITIES AND FIRM PERFORMANCE IMPROVEMENT 33

3.2 GREEN MANAGEMENT CAPABILITIES AND FIRM PERFORMANCE IMPROVEMENT 37

3.3 COMPLEMENTARITIES BETWEEN CAPABILITIES 41

Symmetric complementarities *42*

Asymmetric complementarities *51*

4 DISCUSSION 59

5 CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH 63

APPENDIX: ILLUSTRATIVE DISPLAY OF INCIDENTS 65

REFERENCES 87

List of Tables

TABLE 1.1 – REVIEW OF THE MC CAPABILITIES INTRODUCED IN THE LITERATURE....14

TABLE 1.2 – REVIEW OF GM CAPABILITIES INTRODUCED IN THE LITERATURE....18

TABLE 2.1 – DIFFERENT TYPE OF CUSTOMERS....23

TABLE 3.1 – SUMMARY OF THE MCCS DEVELOPED BY THE ORGANIZATION....36

TABLE 3.2 – SUMMARY OF THE GMCS DEVELOPED BY THE ORGANIZATION....40

TABLE 3.3 – SUMMARY OF THE SYMMETRIC COMPLEMENTARITIES....51

TABLE 3.4 – SUMMARY OF THE ASYMMETRIC COMPLEMENTARITIES....58

TABLE A.1 – SOLUTION SPACE DEVELOPMENT" CAPABILITY....66

TABLE A.2 – ROBUST PROCESS DESIGN....68

TABLE A.3 – CHOICE NAVIGATION....72

TABLE A.4 – CONTINUOUS IMPROVEMENT FOR MC....74

TABLE A.5 – MC INTEGRATION INTO THE STRATEGIC PLANNING....76

TABLE A.6 – POLLUTION PREVENTION....77

TABLE A.7 – PROCESS ENVIRONMENTAL MANAGEMENT....78

TABLE A.8 – PRODUCT STEWARDSHIP....80

TABLE A.9 – GREEN SUPPLY....81

TABLE A.10 – RELATIONSHIP ENVIRONMENTAL MANAGEMENT....82

TABLE A.11 – INTEGRATING THE NATURAL ENVIRONMENT INTO STRATEGIC PLANNING....83

TABLE A.12 – GREENING THE CUSTOMER....84

TABLE A.13 – ENVIRONMENTAL SCANNING FOR GM....85

List of Illustrations

FIGURE 1.1 – A FRAMEWORK LINKING RESOURCE, ROUTINE AND CAPABILITY...9

FIGURE 1.2 - TYPES OF COMPLEMENTARITY 11

FIGURE 2.1 – THE EPD PROCESS...24

FIGURE 2.2 – CODING EXAMPLE..30

FIGURE 2.3 – THE DATA ANALYSIS STEPS 32

Abstract

Nowadays more and more companies pursuit mass customization (MC)–the provision of high product variety and customization with operational performance levels that are comparable to those of a mass producer–in combination with green management (GM)–the integration of environmental sustainability principles into the business. Both the pursuit of MC and that of GM cost companies a great deal of effort and, when MC and GM have to be combined, this represents a considerable challenge for the organization.

However, literature still lacks studies that suggest how to reduce the costs of dealing with such a combined challenge. To narrow this research gap, the present dissertation investigates whether complementarities between organizational capabilities supporting MC and organizational capabilities supporting GM exist and why. To that purpose, a longitudinal case study has been conducted in a manufacturing organization that succeeded in developing both capabilities for MC and capabilities for GM. The findings of this study indicate that complementarities between those capabilities exist and result in sub-additive costs for the organization. Some of these complementarities are symmetric, since the capabilities involved in the relationship equally complement each other. Other complementarities are asymmetric, as the development of certain capabilities for MC alleviates the cost of developing certain capabilities for GM but not vice versa. Collectively, these results improve our understanding of the interrelationships between the economic sustainability, achieved through MC, and the environmental sustainability, achieved through GM, of businesses operating in highly competitive industries whose customers ask for high product customization. Moreover, the finding of asymmetric complementarities suggests that, in such contexts, companies should first focus on developing certain capabilities for MC before embarking in the pursuit of GM.

Sommario

Sempre più aziende perseguono la *mass customization* (MC), cioè la fornitura di prodotti in elevata varietà con prestazioni operative paragonabili a quelle di un produttore di massa, in combinazione con la gestione ambientale del loro business (GM), cioè l'integrazione dei principi di sostenibilità ambientale all'interno delle attività aziendali. Il perseguimento della MC e quello della GM richiedono ciascuno un grande sforzo da parte di un'organizzazione, e le aziende che devono combinare insieme MC e GM si trovano ad affrontare una sfida considerevole. Sfortunatamente in letteratura non vi sono studi che suggeriscono come ridurre il costo di affrontare tale sfida. Per contribuire a colmare questa lacuna della letteratura, la presente tesi indaga se esistano complementarietà tra competenze organizzative di supporto alla MC e competenze organizzative di supporto alla GM e, nel caso esistano, quali ne siano le ragioni. A tal fine, è stato condotto un caso di studio longitudinale in un'azienda manifatturiera che ha sviluppato, con successo, competenze organizzative sia di MC sia di GM. I risultati di questo studio indicano che complementarietà tra tali competenze esistono e sono la fonte di costi sub-additivi per un'azienda impegnata nel perseguimento sia della MC sia della GM. Alcune di queste complementarietà sono simmetriche, poiché le competenze coinvolte nella relazione sono complementari in modo vicendevole. Altre sono asimmetriche, in quanto lo sviluppo di certe competenze di MC allevia i costi di sviluppare competenze di GM, ma non viceversa. Nel complesso questi risultati aumentano la comprensione delle interrelazioni tra la sostenibilità economica di un business, ottenuta attraverso MC, e la sua sostenibilità ambientale, ottenuta attraverso GM, in un settore caratterizzato da elevata competizione e bisogni del mercato molto eterogenei. In aggiunta, l'identificazione di complementarietà di tipo asimmetrico suggerisce che le aziende operanti in un tale contesto dovrebbero focalizzarsi sullo sviluppo di certe competenze di MC prima di imbarcarsi nel perseguimento della GM.

Introduction

Two increasingly important trends are reshaping the competitive environment in a growing number of industries. On the one hand, as competition increases and customers become more assertive, many firms are providing higher product variety and customization with operational performance levels that are comparable to those of a mass producer. The ability to provide high product variety and customization with operational performance levels that are comparable to those of a mass producer has been named in literature as mass customization (MC) (Davis, 1987; Pine, 1993; Tu et al., 2001). On the other hand, many companies, pushed, by regulatory pressure and stakeholders' environmental consciousness, are increasingly integrating environmental sustainability principles into their businesses. The integration of environmental sustainability principles into businesses has been named in literature as environmental/green management (GM) (Gupta, 1995; Angell and Klassen, 1999; Seuring, 2010). In industries where customers are assertive, competition is high and companies' environmental footprints are considerable, the two trends can both be observed and, consequently, more and more firms nowadays are pushed to adopt MC and GM in conjunction.

Academe has promptly reacted to the growing importance of MC and GM for the business community, multiplying the research initiatives on these two topics (Sarkis et al., 2011; Fogliatto et al., 2012). Previous research, however, has typically focused on either MC or GM, without addressing their possible interrelations. The only exceptions are a few, very recent and mostly analytical studies, which essentially suggest that the pursuit of MC has some intrinsic advantages (Chin and Smithwick, 2009; Nielsen et al., 2011; Pedrazzoli et al., 2011; Petersen et al., 2011), and also some disadvantages (Petersen et al., 2011) from an environmental point of view. However, none of these works address the relationships between MC and GM with a focus on the role of organizational capabilities, despite the fact that both the pursuit of MC and the pursuit of GM require that an organization possess certain fundamental capabilities (e.g. Hart, 1995; Salvador et al., 2009).

This work aims to narrow such a research gap by investigating the existence of complementarity between organizational capabilities supporting MC and organizational capabilities supporting GM, where an organizational capability is meant as the replicable capacity to bring about an intended action using organizational resources (Grant, 1996). This focus on complementarity is based on the observation that the ease of building one capability, or its effect on firm performance, increase with the level of another capability when this is its complement (Teece, 1986; Dierickx and Cool, 1989). The study of complementarities is therefore valuable because they are a way for firms to increase their efficiency and effectiveness (Walker and Ruekert, 1987; Moorman and Slotegraaf, 1999). Complementarities among capabilities have been investigated in many areas, comprising R&D (Helfat, 1997; Moorman and Slotegraaf, 1999), manufacturing (Malhotra and Mackelprang, 2012), information systems (Aral and Weill, 2007), and also GM (Christmann, 2000). However, no studies have to date investigated the complementarities between capabilities for MC and those for GM. This research takes a first step toward filling such a gap, by conducting an in-depth longitudinal case study in a company pursuing both MC and GM. The results of this work improves our understanding of the linkages between economic sustainability, achieved through MC, and environmental sustainability, achieved through GM, in businesses that offer high product variety and customization and face high levels of competition.

The remainder of this dissertation is organized as follows. Chapter 1 presents the review of the relevant literature. Then, in Chapter 2, I describe the method deployed for this work, presenting the case company, the data collection procedure and the data analysis process. Chapter 3, which reports the results of the research, is organized in three parts: namely, the description of the MC capabilities developed by the case company, the description of the GM capabilities that were also developed, and the presentation of a number of complementarities between these two sets of capabilities, with the development of corresponding propositions. Finally, Chapter 4 discusses the theoretical contributions of the study, while Chapter 5 presents the conclusions, the limitations and the associated directions for future research.

CHAPTER 1

Literature review

The literature review chapter is organized in five parts. Sections 1 and 2 give an overview of previous research on the concepts of organizational capability and of complementarity, respectively. Section 3 reviews the relatively recent and underdeveloped stream of research on the organizational capabilities supporting MC. Then, Section 4 presents the larger body of literature on the organizational capabilities supporting GM. Finally, Section 5 presents the results of the few studies addressing the linkage between MC and GM.

1.1 Organizational capabilities

An organizational capability is defined as the replicable capacity to bring about an intended action using organizational resources (Grant, 1996). Resources are stocks of available factors of production that are possessed by the organization (Amit and Schoemaker, 1993), such as financial resources, physical resources, human resources (Grant, 1991). While these resources or factor inputs can be available to most firms, the capability to use them to achieve a desired end is not uniformly distributed (Ethiraj et al., 2005). Deploying organizational resources, generally in combination, to obtain an intended result requires creating and managing complex patterns of coordination activities embedded in the firm's processes (Teece et al., 1997). The complexity and embeddedness of such underlying coordination activities make capabilities hard to observe for people outside the organization, especially when they are numerous or when they deploy intangible resources such as brand reputation (Godfrey and Hill, 1995; Zander and Kogut, 1995; Armstrong and Shimizu, 2007).

Literature has long been investigating the microfoundation of capabilities, that is, which their key underlying components are (e.g. Dutta et al., 2003; Peng et al., 2008; Felin et al., 2012). In particular, many studies consider capabilities as being made up of a number of interacting routines (Nelson and Winter, 1982; Grant, 1991; Collis, 1994; Winter, 2000; Salvato and Rerup, 2011), where routines are defined as repetitive patterns of interdependent organizational actions (Dosi et al., 2008; Parmigiani and Howard-Grenville, 2011). These recurrent patterns are what constitute the organizational knowledge of how to repeatedly organize a number of independent factors of production for the organization to obtain a desired outcome (Grant, 1991; Abell et al., 2008). For example, the capability to develop a new product is made up of several recurrent patterns of interdependent activities involving many resources (Salvato, 2009): periodic meetings bring together different employees, the creation of a prototype brings together several people, instruments and technologies, etc. Capabilities and routines are somewhat similar in that both their exercise is largely repetitious (Salvato and Rerup, 2011). However, they are two distinct concepts, as capabilities generally have larger scale: namely, they usually include more than one routine (Winter, 2000; Salvato and Rerup, 2011). Moreover, the control levers and the intended effects of the capabilities possessed by an organization are generally known by the management (Winter, 2000). Conversely, routines performed by employees can sometimes be unknown to the management, for example because employees misunderstand manager's work directions and behave in an unexpected way, or because outdated work directions are modified by employees themselves in highly empowered contexts (Pentland and Feldman, 2005). Figure 1.1 illustrates the relationship between resources, routines and capabilities.

To conclude, a point that is worth clarifying is that the definition of capabilities as replicable capacity to bring about an intended action using organizational resources, is typical of the strategic management literature. Differently, the operations strategy literature mainly sees capabilities as "business unit's intended or realized competitive performance or operational strengths" (Peng et al., 2008: 730). Coherently, works taking this point of view, measure capabilities through indicators such as delivery time, conformance quality or costs (e.g. Ferdows and De Meyer, 1990; Flynn and Flynn, 2004). These two conceptualizations of capabilities are very different, as the strategic-management one focuses on the “means” or pathways to achieve an outcome, while the operations-strategy one focuses on the outcome itself (Swink and Hegarty, 1998; Peng et al., 2008).

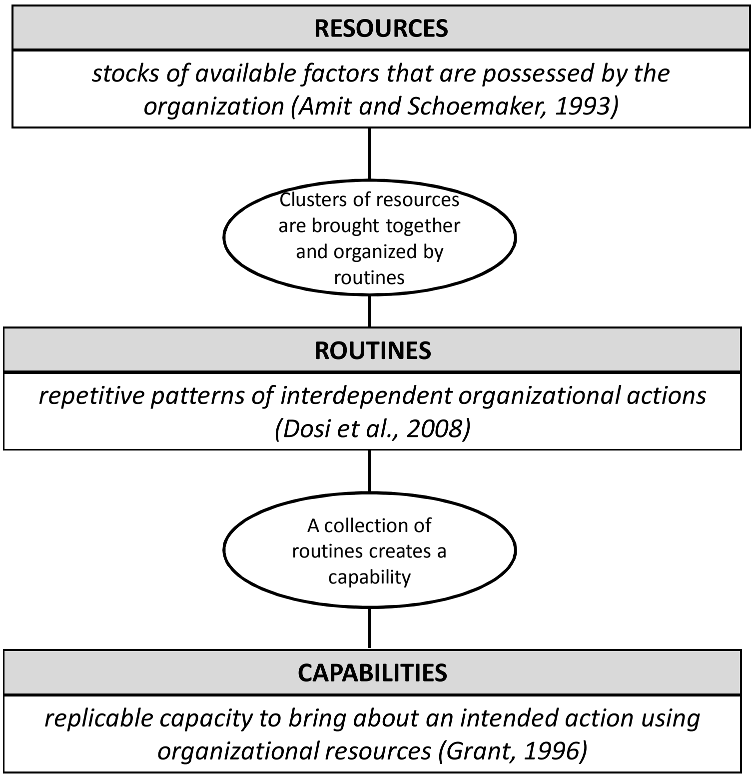

Figure 1.1 – A framework linking resource, routine and capability adapted from Peng et al., (2008)

1.2 Complementarities in organizations

The concept of “complementarities” was originally introduced by Edgeworth (1881), who defines a number of activities as complementary if doing more of one of them increases the returns to doing more of the others. Milgrom and Roberts (1994) have subsequently modeled complementarities in formal terms as the existence of positive mixed-partial derivatives in a payoff function. In other words, complementarities occur when the marginal returns to one variable increase in the levels of other variables and, because of such synergistic effects, bundling these variables together in a production system results in an economic outcome that is greater than the sum of the individual contributions of the same variables taken individually.

In the field of strategy and organization, the notion of complementarity gained particular prominence after Teece's (1986) discussion of the role of complementary assets in innovation, and Dierickx and Cool's (1989) definition of assets interconnectedness. Specifically, Teece argued that, in order to increase the profits generated by an innovation, a firm needs to access a number of complementary assets. For example, distribution channels and brand name are assets that enable the successful commercialization of the innovation (Teece, 1986). Subsequently, Dierickx and Cool observed that the ease of building one asset may increase with the levels of another asset, and when this happens the two assets are defined as interconnected (this term is used as a synonym of complementary, as observed by Moorman and Slotegraaf, 1999). For example, when a firm possesses an extensive service-network, it may be facilitated in the new product development process, as it has a granted access to consumer experiences and wishes (Dierickx and Cool, 1989).

Based on these seminal studies, a number of subsequent works have addressed complementarities by identifying organizational elements (resources, capabilities, strategies…) that increase the returns an organization can obtain from an asset, or that facilitate the development of such an asset. For instance, a culture that encourages change is shown to increase the profitability of implementing information technology (Powell and Dent-Micallef, 1997), and quality management capabilities are found to decrease the cost for developing an environmental management system (Darnall and Edwards, 2006).

These studies on complementarities can be classified based on the types of elements investigated, which can be resources and capabilities, organizational practices and structures, strategies, or phenomena outside the organization (Ennen and Richter, 2010). In particular, the majority of the research to date has focused on resources and capabilities (Ennen and Richter, 2010), such as human resources (Powell and Dent-Micallef, 1997) or R&D capabilities (Helfat, 1997). Studies on complementarities can also be classified depending on how the complementary elements interact, namely in an asymmetric or in a symmetric way (Choi et al., 2008). In the former case (depicted in Figure 1.2-A), one element (X_1) impacts the performance variable (Y) independently of, that is regardless of the presence of its complementary element (X_2). The role of X_2 is to further enhance the impact of X_1 on Y. This is equivalent to saying that X_1 has a direct impact on Y and X_2 is a moderator that enhances this impact. This notion of asymmetric complementarity is coherent with Milgrom and Roberts's (1995) observation that complementarities can sometimes be a matter of "order" between the elements in the relationship, in that one element specifically increases the returns of the other but not vice versa. Conversely, in the case of symmetric complementarities (Figure 1.2-B), "both input variables behave in a similar manner in effecting the performance outcome" (Choi et al., 2008: 241). This condition implies that not only X_2 moderates the impact of X_1 on Y, but also X_1 moderates the impact of X_2 on Y. Several examples of these two types of complementarities can be found in literature. For instance, Powell and Dent-Micallef (1997) illustrate the case of an asymmetric complementarity: the positive effect of the use of information technology (X_1) on the firm's financial performance (Y) is higher when the organization develops a certain type of culture (X_2), which encourages change and experimentation. On the other hand, Moorman and Slotegraaf (1999) provide an example of symmetric complementarity: marketing capabilities (a firm's ability to develop and maintain relationships with customers - X_1) increase the positive effect of the technology capabilities (ability to formulate and develop new products and related processes - X_2) on product quality (Y) and technology capabilities, in turn, increase the effect of the marketing capabilities on the same performance dimension.

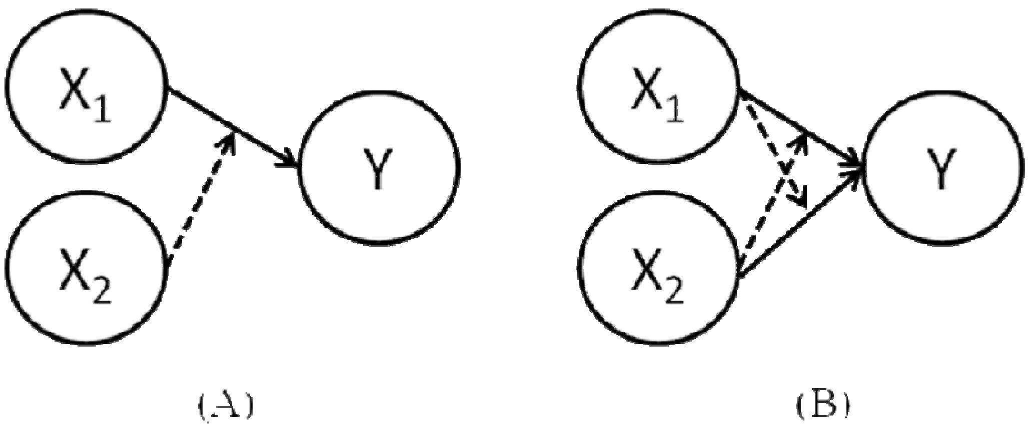

Figure 1.2 - Types of complementarity

(A) asymmetric (B) symmetric (adapted from Choi et al., 2008: 241)

1.3 Mass customization capabilities

In many business environments, characterized by heterogeneous customer requirements and fierce competition, manufacturers are forced to offer customized products and services at prices, quality and speed that are comparable to those of a mass producer. Pine (1993: 48) defines such a “mass production of individually customized goods and services” as mass customization (MC). The analysis and implementation of MC has received growing consideration by researchers since the late 1980s. In particular practices and technologies that support MC have been largely studied (for a comprehensive review of the literature on MC see: Da Silveira et al., 2001; Fogliatto et al., 2012).

The first authors to use the term “capability” in conjunction with the tem “mass customization” were Tu et al., (2001). They introduce the notion of mass customization capability (MCC), defined as an organization’s ability to produce differentiated products without sacrificing manufacturing costs and production volume and while also being able to quickly deliver those products to individual customers (Tu et al., 2001). Similar to the manufacturing capabilities studied in the operations management literature, this MCC is conceptualized as a competitive performance rather than as a combination of resources or routines that contribute to determine such performance (Peng et al., 2008).

Conversely, Zipkin (2001) identifies three MCCs that are more in line with the ‘‘capabilities as routine-bundles’’ view, which is typical of the strategic management literature (Peng et al., 2008). These capabilities, that is “elicitation”, “process flexibility” and “logistics”, are related to the one proposed by Tu et al. (2001) in that they can be thought as the means that a company needs to employ for achieving Tu et al.’s (2001) MCC. “Elicitation” capability is the capacity to identify exactly what the customer wants, which can be hard since customers themselves “often have trouble deciding what they want and then communicating or acting on their decisions” (Zipkin, 2001: 82). A way to obtain such a capability is through the use of customer relationship management systems that collect information about customers to predict their individual wants and behaviors (Zipkin, 2001). “Process flexibility” capability is the capacity to innovate production technology to increase its flexibility. This can be achieved for example through the adoption of numerically-controlled manufacturing technology (Zipkin, 2001). Finally, “logistics” capability is the capacity to deliver the right customized product to the right customer. This is quite different from mass-market distribution, and switching from the latter to the former has proved difficult for many companies. This capability can for example be obtained by attaching bar-codes to the products on order to associate each variant with the relevant information needed to produce it and deliver it (Zipkin, 2001).

Subsequently, Salvador et al. (2008; 2009), elaborating on Zipkin’s (2001) capabilities, propose three capabilities that support the organizational movement towards MC. The first capability is “choice navigation”, that is the capacity to support the customer in choosing the product, among those offered by the company, that best satisfies his/her needs while minimizing the complexity and the burden s/he perceives during the choice. One possible approach for obtaining this capability is the implementation of an “assortment matching” software, automatically matching models of the customers’ needs with characteristics of the existing solution space (Salvador et al., 2009). Another capability, called “solution space development”, is the capacity to identify the product attributes along which customers’ needs diverge. This capability can be developed, for example, by providing the customers with an “innovation toolkit” where they can themselves design a solution that perfectly fits their needs, including those needs that are unsatisfied by existing products (von Hippel and Katz, 2002; Salvador et al., 2009). Finally, the third capability, termed “robust process design”, is the capacity to reuse or recombine existing organizational and value-chain resources to fulfill a stream of differentiated customer’s needs. One way to develop this capability is to use flexible automation, such as reprogrammable, multi-functional robots (Salvador et al., 2009). As already mentioned, these three capabilities build on, and expand, Zipkin’s (2001) ones. Specifically, “choice navigation” includes Zipkin’s “elicitation” capability, as the identification of the product that is the most suitable for a customer first requires understanding the needs and wants of that customer. “Solution space development” is also related to Zipkin’s “elicitation” capability, in that identifying the product attributes along which customer’s needs are heterogeneous requires the analysis of customer’s needs data, which the company must be able to collect. Finally “robust process design” is an expansion of Zipkin’s “process flexibility” and “logistic” capabilities, as the resources that should be re-combinable and reusable to fulfill heterogeneous customers' needs encompasses all the value chain, including the company's production technology as well as the resources used for the delivery of customized products.

A summary of the MCCs introduced in this section is made in Table 1.1.

Table 1.1 – Review of the MC capabilities introduced in the literature

Author	MC capability	Author's definition
Tu et al. (2001)	Mass customization capability	"ability of a firm to quickly produce customized products on a large scale at a cost comparable to non-customized products"
Zipkin (2001)	Elicitation	"interacting with the customer and obtaining specific information"
	Process flexibility	"production technology that fabricates the product according to the information"
	Logistics	"processing stages and distribution that are able to maintain the identity of each item and to deliver the right one to the right customer"
Salvador et al. (2008; 2009)	Choice navigation	"supporting the customer in identifying their own solution while minimizing complexity and the burden of choice"
	Solution space development	"identifying the product attributes along which customer needs diverge"
	Robust process design	"reusing or recombining existing organizational and value-chain resources to fulfill a stream of differentiated customer needs"

1.4 Green management capabilities

Companies nowadays are not only expected to be responsible to their shareholders but to society in general, matching their economic and financial results with the minimization of ecological footprints and increased attention to social aspects (McWilliams and Siegel, 2001). This attention to the well-being of society is reflected in the concept of social responsibility, defined as "discretionary corporate activity intended to further social welfare" (Barnett, 2007: 795). Corporate social responsibility is a theme that has gained large prominence in academic research in recent times; in particular, large attention has been paid to the preservation of the environment (Russo and Fouts, 1997). The integration of environmental sustainability principles into a company's business has been termed Green Management (GM) and it is a concept that emerged in 1990s (Lee, 2009). It was during that decade that the term "eco-efficiency" was coined and that organizations started to look for innovative ways to improve materials use and production systems (Pane Haden et al., 2009). "Green organizations" are those that have achieved a full integration of environmental initiatives into their goals and strategies, achieving in turn advantages such as lower costs, increased innovation, or higher reputation (Porter and van der Linde, 1995).

In recent years, management scholars have become particularly interested in the organizational capabilities that underlie GM. Hart (1995), in his seminal article, first introduced the idea the firm's pursuit of GM is rooted in a set of valuable organizational capabilities, which I term green/environmental management capabilities (GMCs) in line with previous literature (Lee and Klassen, 2008; Wong et al., 2012). Specifically, the GMCs he identified are "product stewardship", "pollution prevention" and "sustainable development". "Product stewardship" aims at minimizing the product environmental impact through the inclusion of life-cycle-analysis during the new product development (NPD) process. "Pollution prevention" aims at incrementally reducing emissions, effluents and waste caused by the organization by proactively eliminating the sources of such pollution rather than by controlling it with end-of-pipe technologies. Finally, "sustainable development" pursues long-term organizational commitment towards social-environmental sustainability.

Many subsequent studies in the strategic management literature have built on these capabilities to understand their possible antecedents and/or consequences on the firm's economic performance. For example, Russo and Fouts (1997) analyze the positive effect of "pollution prevention" on the company's profitability, and find that the rate of industry growth positively moderates this relationship. Marcus and Geffen (1998) find that government and markets are two main forces that drive and enable the acquisition of "pollution prevention" capability. Judge and Douglas (1998) suggest that, in order to develop Hart's capabilities, a firms should also have the capability of "integrating environmental issues into the strategic planning process". De Bakker and Nijhof (2002) also analyze how an organization can shape Hart's organizational capabilities, and they propose repeated cycles of conceptualization and implementation activities that transform external stakeholders' expectations into internal capacities. Finally, Aragón-Correa and Sharma (2003) see Hart's three capabilities as the basis for a higher-level capability, termed "proactive environmental strategy". The impact of this capability on the firm's competitive advantage is found to depend on a number of contextual factors: for example, the complexity of the general business strengthens this positive relationship, while decision response uncertainty (meant as the inability or risk in predicting the consequences of individual decisions) weakens it.

The concept of organizational capability supporting GM has also been adopted in the operations and supply chain management field, with an obvious focus on operational and supply chain processes. Bowen et al. (2001), for example, propose the "green supply" capability, defined as the capacity to manage the supply chain to improve the environmental performance of purchased inputs or of the suppliers that provide them. Miemczyk (2008), conversely, focus on downstream supply chain operations, and identify the organizational capabilities needed to support the product recovery at the end of its life. Similarly, Wong et al. (2012) introduce the capacity of "process stewardship", focusing on the efficient use of materials and resources along the downstream supply chain. Instead, Bremmers et al. (2009) take a holistic view of the supply chain, and propose the capability of "environmental information and communication". This includes the communication of the firm's environmental performance to a variety of external stakeholders, and the exchange of information in the entire supply network to reduce the product life-cycle impact. An even more comprehensive approach to GM is finally taken by the work of Lee and Klassen (2008), proposing five GMCs that span not only operations but every area of the company where environmental practices can be implemented: the NPD process ("product environmental management" capability–cf. Table 1.2), the production and manufacturing process ("process environmental management" capability–cf. Table 1.2), other daily business routines ("organization environmental management" capability–cf. Table 1.2), supply chain management ("supply chain environmental management" capability–cf. Table 1.2) and the communication with external stakeholders ("relationship environmental management" capability–cf. Table 1.2).

All the aforementioned capabilities have a clear environmental purpose, stated in their definition. In addition to such GMCs, the relevant literature discusses other capabilities that are of support to GM but do not have such a deliberate environmental purpose. Accordingly, those capabilities can be seen as complementary assets for GMCs, rather than actual GMCs, and are not included in Table 1.2. For example, Sharma and Vredenburg (1998) identify the capabilities of "stakeholder integration" (capacity to develop trust-based collaborative relationships with stakeholders), "continuous innovation" (capacity to continuously generate a stream of innovations) and "higher order learning" (capacity to develop new understandings of surrounding events in order to interpret new and existing information in a different way). These three organizational capabilities are found by the authors to give important competitive benefits to companies pursuing "green" strategies, for example by allowing firms to improve green reputations. However, these capabilities do not have an explicit and primary "green" purpose. Other examples are the organizational capabilities proposed by Hofman et al. (2012) (namely, advanced technological expertise, past experiences with inter-firm relations and capacity for product innovation) or the capabilities proposed by Beske (2012) (including supply chain partner development and supply chain control). Unfortunately, none of these works presenting complementary capabilities to GMCs, shades light on the possible complementary role of MCCs.

Table 1.2 – Review of GM capabilities introduced in the literature

Author	GM capability	Author's definition
Hart (1995)	Product stewardship	"integrating the "voice of environment"… into product design and development processes"
	Pollution prevention	"emissions and effluents are reduced, changed, or prevented through better house-keeping, material substitution, recycling, or process innovation"
	Sustainable development	"effort… to sever the negative links between environment and economic activity in the developing countries of the South"
Judge and Douglas (1998)	Integrating the natural environment into strategic planning	"capability to incorporate issues related to the environment into the strategic planning process"
Bowen et al. (2001)	Green supply	"supply management activities that are attempts to improve the environmental performance of purchased inputs, or of the suppliers that provide them"
Aragón-Correa and Sharma (2003)	Proactive environmental capability	dynamic capability to "manage the interface between a business and its natural environment"
Lee and Klassen (2008)	Product environmental management	"providing green products to the customer through environmental practices in a New Product Development process"
	Process environmental management	"sustaining cleaner production and manufacturing processes that meet or exceed expectations"
	Organization environmental management	"integrating environmental issues into daily business routines by building an environmental management system"
	Supply chain environmental management	"motivating suppliers to be environmentally responsible and to reduce the environmental burdens caused by logistics"
	Relationship environmental management	"sustaining environmentally sound relationships with external stakeholders through various communication methods"

Table 1.2 Continued

Author	GM capability	Author’s definition
Miemczyk, (2008)	Product recovery capabilities	the capabilities that support product recovery “the aim of which is to reduce the impact of products on the natural environment at the end of their life”
Bremmers et al. (2009)	Process-oriented environmental information and communication	“respond to external environmental demands by providing and transferring information on the use of inputs, the firm’s environmental organization and the level of emissions”
	Product-oriented environmental information and communication	“exchanging information in a network to achieve cleaner production goals and fundamentally change the impact of (organizational) products along the product life-cycle”
Wong et al. (2012)	Product stewardship	“reducing environmental burden with less use of hazardous and nonrenewable materials in products development, considering the environmental impact in product design, packaging, and material used”
	Process stewardship	“reducing adverse environmental impact in the processes ranging from production, distribution, to end-of-life product management”

1.5 Mass customization and green management

The studies investigating the linkage between MC and GM are few, very recent and most of them are conference papers reporting preliminary results of ongoing researches. These works typically consider a few, widely acknowledged MC enablers, such as product modularity or postponement, to conceptually examine their effects, if any, on the firm’s environmental performance. Nielsen et al. (2011), for example, suggest that product modularity reduces the life-cycle environmental impact of customized goods because the increased similarity in the production technology used to fulfill heterogeneous customer’s needs has a positive impact on energy and resource consumption owing to higher potential for optimizing processes. Badurdeen and Liyanage (2011), in turn, point to the environmental benefits of postponing product differentiation until customer order receipt, which eliminates the risk of having inventories of obsolete products and, therefore, reduces waste. In another conceptual paper, Petersen et al. (2011) argue that MC enablers may have both positive and negative effects on the firm's environmental performance, depending on the specific type of product. In this vein, the works by Pedrazzoli et al. (2011) and Chin and Smithwick (2009) examine the specific cases of, respectively, footwear and men's dress shirt. They investigate (partly with hypothetical data) whether producing and distributing these products accordingly to the MC paradigm is less or more sustainable than doing that under the paradigm of mass production. What they find is that, in both cases, mass customization enablers, such as direct delivery, lead to lower overall consumption of energy and resources.

None of the abovementioned works, however, address the relationships between MC and GM with a focus on organizational capabilities even if the latter ones are recognized as being fundamental to the successful pursuit of MC and of GM. Moreover, a study of the complementarities between MC and GM is still lacking, even if this could provide indications to companies on how to reduce the efforts required to pursuit both MC and GM. To address this gap, this study joins the stream of literature that investigates complementarities between capabilities (Ennen and Richter, 2010), by specifically addressing the following research question: which are the complementarities (if any) between MCCs and GMCs, and why do such complementarities exist?

CHAPTER 2

Methodology

An exploratory case study was conducted to answer the research question motivated in the previous chapter. Case study was considered a fruitful strategy for this work, given the early stage of the research on the topic (Edmondson and McManus, 2007). Case studies are also particularly suited for understanding the "how" and the "why" behind relationships (Yin, 2009), aspects which are of interest in this research. Finally, case study research, when also relying on direct observation, is particularly useful for studying organizational routines (Cohen et al., 1996), which I consider as a constituent part of capabilities, in line with the literature presented in Section 1.1.

In particular, I conducted a longitudinal case study, which has the potential for increasing the internal validity of results by facilitating the identification of cause-effect relationships (Leonard-Barton, 1990). It additionally relieves the risk that participants do not recall relevant events or that their recollection is subject to bias (Voss et al., 2002). However, while offering these important advantages, longitudinal case studies are also very time and resources consuming (Åhlström and Karlsson, 2009), and due to resource constraints this work is based on a single case study.

Consistent with previous studies on organizational capabilities (Lockett et al., 2009), the chosen level of analysis is the business unit, as different business units may have different capabilities. The theoretical propositions derived in this work will coherently concern the existence of complementarities between capabilities at that level of analysis.

The case was selected following the "extreme situation" decision rule (Pettigrew, 1990: 275): to limit the shortcomings of having only one case, it is important to choose a situation where the phenomena of interest are more likely to be clearly observable. The chosen case provided such an opportunity because it was far from having high

MCCs and GMCs but was strongly committed to developing both MCCs and GMCs. Such commitment was expected to make it more likely to observe complementarities, if any, between MCCs and GMCs.

2.1 Setting

The study was conducted over a period of 36 months, from the middle of 2008 until the middle of 2011, in a large manufacturing firm operating in the vehicle wash equipment sector. This industry dates back to the year of car invention, and it gradually gained prominence as worldwide legislation started to limit the possibility to wash vehicles in uncontrolled environments, where hydrocarbons and oils can contaminate the environment. Competition in this industry is high, as at least six multinational companies (in addition to a number of regional producers) compete in the market with similar products. The world's leading producer is a large German company, whose products are characterized by high technological levels and highly competitive prices. The company selected for this study is another large multinational player in this sector. It has been producing, for over 50 years, washing equipment for every type of vehicle: cars, buses, tankers, trains, streetcars, underground trains and military vehicles. The company has approximately a total of 300 employees for an average production of 1100 washing systems per year. It is present with a strong distribution network in over 60 countries, with agents in Europe, North and South America, the Middle East, North Africa, Australia, and Indochina. The company is renowned for the high degree of product customization it can provide to its customers, offering a complete service from the design of the product up until its final installation and start-up.

The business unit that was selected for this study is the car-wash unit (150 employees, 35 million euro of sales), producing rollover units, conveyors and self-service units for different type of customers, who are described in Table 2.1.

Table 2.1 – Different type of customers

Type of customer	Description
Car Dealers	These customers are dealers of various car manufacturers. Aesthetics is an important factor when choosing a car, so it is important that vehicles for sale are clean and well maintained. For this purpose car dealers do not need a product with numerous functionalities or with a particularly appealing design.
Car service-stations	Many oil companies include car washing equipment in their service-stations in addition to the fuel pumps. These customers ask for a large variety of product functionalities, and normally ask for personalized looking of the product (logo and colors of the oil company). Other customers in this category are independent car service stations that switch from a manual washing service to an automated system.
Privates	It includes private customers that own a car fleet and car park operators, who are interested in purchasing a personal car wash system. These customers normally ask for basic products with high quality/price ratio.

At the beginning of the observation, the high degree of product customization was provided to the customers at the expense of operational performance. Since customers often asked for products that were not included in the company's pre-engineered solution space, the organization had to satisfy those requests according to an engineer-to-order approach, with subsequent negative implications on delivery lead-times, costs and also quality. Moreover, given the low prices offered by some of the competitors, customers were generally unwilling to pay high price premium for such customization and higher costs resulted in decreased margins for the company. In 2008 new owners took over the company, changed part of its top management and initiated a number of activities to address the worsening operational performance and the decreasing profitability of the business. The new owners and management were well conscious that it was necessary to develop organizational capabilities of support to the pursuit of MC. For this purpose, between the middle of 2008 and the beginning of 2009, they formalized an ambitious project including the adoption of a product configurator, the reorganization of the inventory management and production planning and control systems, the redefinition of the production cycles and layout and the adjustment of the NPD process to make it more coherent with a MC strategy.

At the beginning of the study the organization was also scarcely considering environmental issues, even though the business was characterized by high resource consumption (water, energy, chemicals) and potentially severe water and land pollution during product use. Competitors were similarly neglecting environmental issues, except for some cases of ISO 14000 certification or of solar panels use in production plants. Starting from 2008, the new ownership and top management decided to try to revitalize the brand and to differentiate it from competitors through the development of capabilities of support to GM. Accordingly, in early 2009, the company’s mission and vision were formally aligned with this objective and the top management of the car wash unit chose to apply for an Environmental Product Declaration (EPD – the certification process is summarized in Figure 2.1) for the envisioned new products as a concrete way to implement the new strategy in their business unit. I considered this choice as a sign of true dedication to environmental issues, since EPD offers more transparency, quantification, and verification as compared to the other standards, labels or certifications concerning GM (Skaar and Fet, 2012).

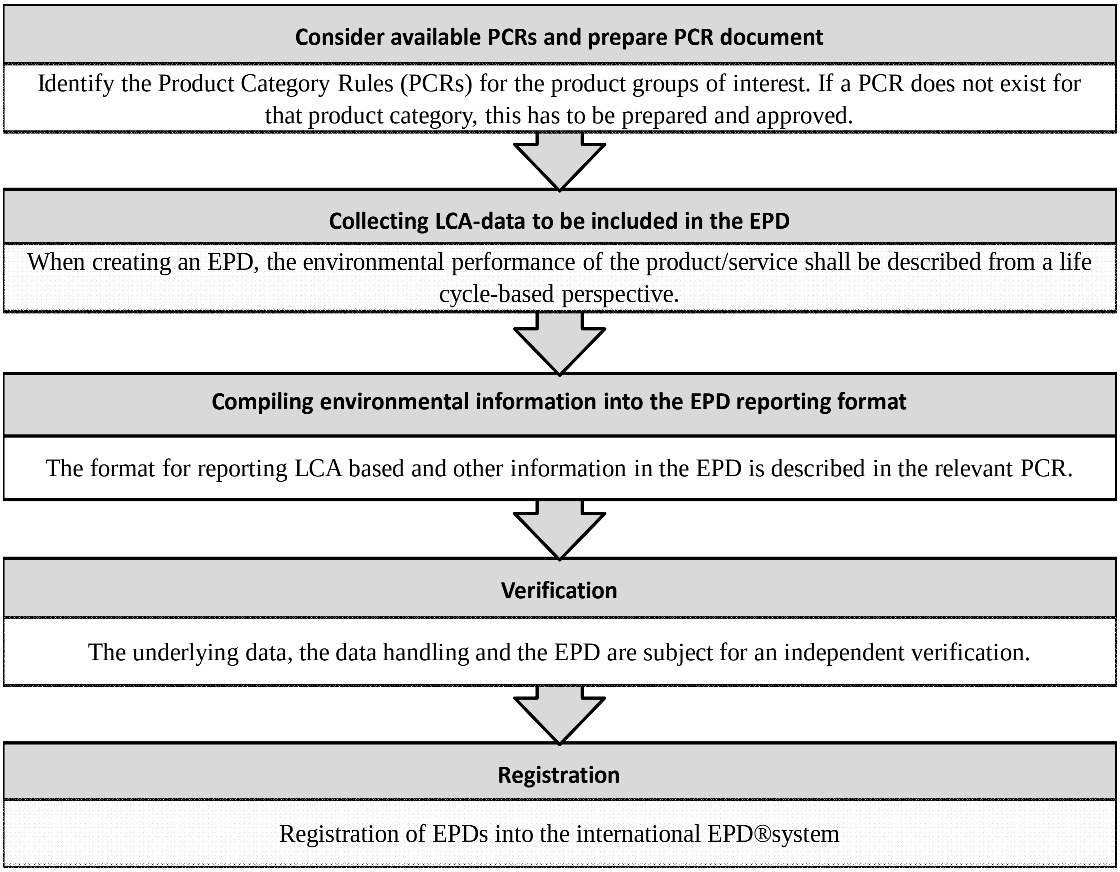

Figure 2.1 – The EPD process (Source of the information: http://www.environdec.com/)

2.2 Research protocol and data collection

To discover linkages among organizational constructs when significant organizational change is occurring, it is necessary to collect data about variations in the level of those constructs (Åhlström and Karlsson, 2009). Accordingly, to study the complementarities among the MCCs and the GMCs being developed by the case company, it was fundamental to collect data about the variations in the level of those capabilities. However, since capabilities (defined as the replicable capacity to bring about an intended action using organizational resources (Grant, 1996)) are difficult to observe (see Chapter 1.1), I chose to join the stream of literature that considers routines as the operationalizations (Peng et al., 2008) or “building blocks” (Dosi et al., 2008) of organizational capabilities. Therefore, in this study the variations in the level of the capabilities of interest were measured by the variations in their underlying routines. Coherent with the terminology used in longitudinal studies, I termed the variations in the levels of capabilities as events, and variations in their underlying routines as incidents (Van de Ven and Poole, 1990). Events are conceptual constructs that are not directly observable, as is the case of organizational capabilities, while incidents are the empirical indicators that can be observed in lieu of events (Van de Ven and Poole, 1990), as is the case of routines. In other words, incidents are the empirical indicators that an event has happened and, on the other side, events are conceptual constructs explaining the pattern of incidents that are empirically observed.

Data on incidents were collected through multiple methods, in order to triangulate the information obtained by accessing different informants and sources (Huber and Power, 1985). A free access to relevant data was facilitated by the established relationship between one of my supervisors and the company, which helped me to overcome one of the major obstacles in case studies, that is, the fact that organizations tend to hide their inner functioning to the external observers (Sofer, 1961).

First of all, I conducted qualitative interviews with the managers (Van Maanen, 1979) who were knowledgeable of fundamental processes and functional areas for MC and GM: namely, the operations manager, the R&D manager, the information systems manager, the managing director and the sales manager. Since the company had a functional structure, different parts of the same processes were owned by different managers. This allowed me to compare multiple points of view about the same incident, when this affected several parts of the organization. For example, the data about the newly established inter-functional meetings for NPD were gathered from the managing director, the R&D manager and the operations manager, thus allowing the comparison on multiple points of view of the same fact. Second, I relied on the field notes that I collected over the period of observation during regular visits to the company (at least once in a month), recording as accurately as possible the actions as they occurred (Van Maanen, 1979). For example, some data about the EPD certification process were recorded based on the direct observation of the process.

Many useful data also emerged from interaction with lower-level employees such as IT personnel, assembly line operators and purchasing personnel. Informal conversations with personnel at lower levels of the firm’s hierarchy improved my understanding of organizational capabilities. This is because the resources used by the routines making up a capability can belong not only to several functions, but also to several organizational levels (Day, 1994). As lower-level resources and routines underlying capabilities can sometimes be less visible to managers than to lower-level employees (Winter, 2000), it was important to complement managers’ point of view with data gathered from lower-level employees. However, the latter were not a primary source of data as they are often unconscious of the goals they contribute to achieve (i.e., which organizational capability they contribute to deploy) when using resources or when executing routines.

Finally, the organization made a very large amount of documents available, so that it was possible for me to triangulate and complete the data obtained from the periodic interviews (Scandura and Williams, 2000). For example, meeting reports were looked through in order to obtain evidence of managerial decisions regarding MC and GM, and process maps or plant layouts were examined in order to gain evidence about the main routines underlying NPD, order acquisition etc. The company website was also analyzed to collect additional information about the company’s history and communications to stakeholders.

The interview protocol consisted of two different kinds of qualitative interviews that were carried out for this case study. These interviews required approximately 50 hours of meetings with the key informants, which were taped and subsequently transcribed, during periodical visits between middle 2008 and middle 2011. The first kind of interviews consisted in the unstructured narration, by the respondents, of what was enabling the organization to improve its ability to provide high product variety to the market in a quasi-mass production way, and of what was allowing the organization to manage its business more environmentally. In this way, informants were used as surrogate observers (Scott, 1965). This approach is in line with previous attempts to measure organizational capabilities: by relying on in-depth field interviews, one can hope to capture some of the richness and complexity that is fundamental to a concept intrinsically difficult to measure, such as that of organizational capability (Henderson and Cockburn, 1994).

The second kind of interviews, which were carried out in alternation with the first ones, consisted in semi-structured interviews. Their aim was to periodically collect incidents in a more systematic and comprehensive way, helping me to control and complete the understanding gained from the unstructured interviews, whose respondents could overlook important themes, and from the other data sources. During semi-structured interviews, I asked the respondents for detailed information about a predefined list of capabilities (both MCCs and GMCs). This list was initially obtained based on the literature review, and was expanded during the case study: before each semi-structured interview, I preliminary analyzed the data collected until that moment (see the Data Analysis section), and I dynamically adjusted the interview protocol if a new, relevant capability had emerged from the analysis. This iterative and constant comparison between data and constructs helped me to convergence on well-measured constructs (Eisenhardt, 1989).

2.3 Data analysis

The data collection phase produced a very large amount of data (270 pages of interviews transcriptions, over 1100 pages of notes and documents), which is "paradoxically both the strength and the weakness of the in-depth longitudinal study" (Leonard-Barton, 1990:255). For this reason, it is particularly important to follow a data analysis process that allows reducing large amount of data without obscuring the relationships the researchers wish to discern.

First of all, during the data collection phase, I periodically reviewed the collected material and typed it up as a case narrative, as suggested by literature on longitudinal case studies (Pettigrew, 1990; Åhlström and Karlsson, 2009). The narrative was basically a compilation of all the relevant data regarding the organizational pursuit of MC and GM, reported in chronological order in two documents, which were extended as more information was progressively collected.

Then, I followed the procedure proposed by Van de Ven and Poole (1990) for incident coding. First of all, the two narrative documents were decomposed into basic elements of information: the incidents. I identified as incidents all the changes in the way things (pertaining to MC and GM) were routinely done in the organization. Conversely, ad-hoc problem solving or one-time activities were discarded, in line with Winter (2003) discussion of what constitutes a routine. Consider for example the following two pieces of narrative:

> *"In early 2009, the new operations manager completed the creation of an assembly manual, describing all the possible activities that assembly line operators may have to perform, including which instruments they have to use for each activity. The assembly line supervisor, after the adoption of the manual, started to monitor the operators and correct the behavior of l the employees not respecting the standard procedures…"*

> *"The idea of the top management was to obtain an ISO 14000 certification. In May 2010, the operations manager and the health and safety manager, supported by an external audit team, assessed the organizational processes to identify noncompliance with the prescriptions of an ISO 14000 certification (the idea of getting the certification was however discarded after some months, to focus on the EPD). The identified non-compliances were used to guide a few improvements to the processes, for example in the waste management system…"*

The happening reported in the first extract was considered as an incident, since it changed the pattern of actions of the assembly line operators, who were previously used to assemble products based on their own "way of working", possibly changing sequences of activities or instruments and, thus, creating products that could slightly differ from each other even when two customers' order were identical. Conversely, the happening described in the second extract was not selected as an incident pertaining to any GMC, even though it led to a number of small incremental improvements of the business processes from an environmental perspective; such improvements were the consequence of a one-time collaboration with an external organization, not the result of a change in any organizational routine.

Subsequently, I analyzed the incidents obtained following the aforementioned procedure (all listed in a data sheet). I began by generating an open coding (Strauss and Corbin, 1990), developing categories through clustering incidents (i.e. changes to routines or new routines) around particular themes. For example, incidents regarding the redesign of products with higher component commonalities (e.g. the training of engineers in NPD techniques for increasing carry over), or the redesign of processes to increase the standardization of production activities (e.g. the creation of a mixed model assembly line), were clustered around the theme of “NPD that increases the reuse of available resources”. Subsequently, most categories were further tied together in a hierarchical grouping, as more abstract categories were attributed to the coded incidents. Figure 2.2 illustrates an example of such grouping.

The result of this coding step was an initial set of MCCs and GMCs with their sub-dimensions. Categories and sub-categories were subsequently revised several times during the study; for example, some themes were broken down as too many incidents got the same code, creating the problem of “bulk” (Miles and Huberman, 1994), and some emerged over time. When a new category emerged from the coding, I tentatively defined a new MCC or GMC to be included in the subsequent semi-structured interviews for further investigation and refinement (as described in Section 2.2).

Once these steps were concluded, I looked for relationships among constructs. A simple illustrative format was used to display the coded incidents in a clear sequence (Miles and Huberman, 1994): I created one time-ordered matrix for each identified capability, and sorted every incident based on the capability sub-dimension and the time-period it referred to. These matrices (with a distilled summary phrase for each incident) are reported in the Appendix. Then, I looked for similarities among tables (common incidents or overlaps) and other meaningful relations (cause-effect relationships among incidents, output of an incident that influences another incident…) that could be associated with complementarities between capabilities, and looked through all the data to find other supporting or disconfirming evidence. Moreover, once certain patterns had emerged, I also began to delve into them further during the following interviews either to confirm the pattern, search for limits, or to abandon disconfirmed relationships.

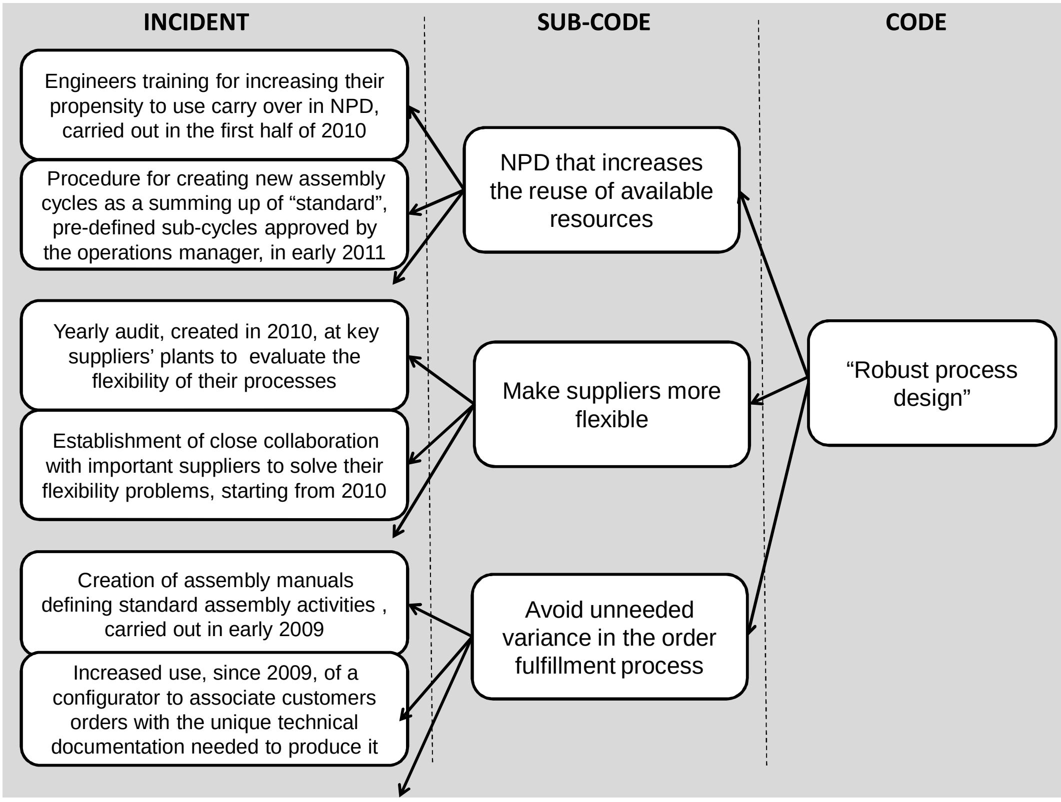

Figure 2.2 – Coding example

2.4 Assessing reliability and validity

Judging qualitative research requires the reader to know the steps that the author made to achieve the results of the study (Corbin and Strauss, 1990). In this way it is possible to assess whether the findings are reasonable, drawn from materials that have been processed with care and discipline.

A dimension for assessing case research quality is reliability, which means that if another researcher replicates the study the same result would be obtained (Yin, 2009). Techniques for ensuring reliability in case studies are establishing a case study protocol for data collection and executing an interview protocol (Eisenhardt, 1989; Voss et al., 2002). Moreover, formation of a case study data base allows for other researchers to access the files (Yin, 2009). As described in this chapter, I adopted all these technique in my research.

Another dimension to assess is construct validity, that is whether the study establishes a correct operationalization of constructs (Voss et al., 2002). The use of multiple data sources provides increased construct validity and stronger substantiation of constructs and propositions (Eisenhardt, 1989; Leonard-Barton, 1990; Voss et al., 2002). As described in Section 2.2, data was collected from a number of different sources and respondents, allowing for data triangulation. In order to further ensure construct validity, during data analysis I followed the procedure proposed by Van de Ven and Poole (1990). During some of the semi-structured interviews, I mentioned to the respondents the incidents identified until then, and asked them to indicate whether any incident was missing or incorrectly described. Based on this feedback, incidents were in some cases revised. Moreover, to evaluate the quality of the data coding scheme used in the analysis, my coding was reviewed by other people in the research group, as suggested by (Dubé and Paré, 2003), and during that phase some incidents were re-coded based on group discussion. This activity allowed for alleviating the influence of subjectivity, personal and positional biases in the reduction of rich qualitative data to few dimensions of meaning (Van de Ven and Poole, 1990).

Another dimension to assess is generalizability, which is a crucial issue for case studies, in particular for single case studies. It is important to bear in mind that generalization from case studies takes place towards theory, not towards universe (Yin, 2009). Instead of inferential statistics, this generalization relies on analytical or theoretical arguments, to judge whether particular findings would be valid in other circumstances (Glaser and Strauss, 1967; Yin, 2009). For each complementarity identified through the data analysis, I made a logical argument for its generalizability, linking parts of these arguments with extant literature. Moreover, those arguments were then examined in light of the literature on complementarities, to look for possible similarities and contradictions (Eisenhardt, 1989). Based on the comparison with the works by Milgrom and Roberts (1994, 1995) and Choi et al. (2008), I observed that the complementarities I had identified could be classified in two categories proposed in literature, and which are further illustrated in Section 3.3.

The whole data analysis process, including quality assessment, is illustrated in Figure 2.3.

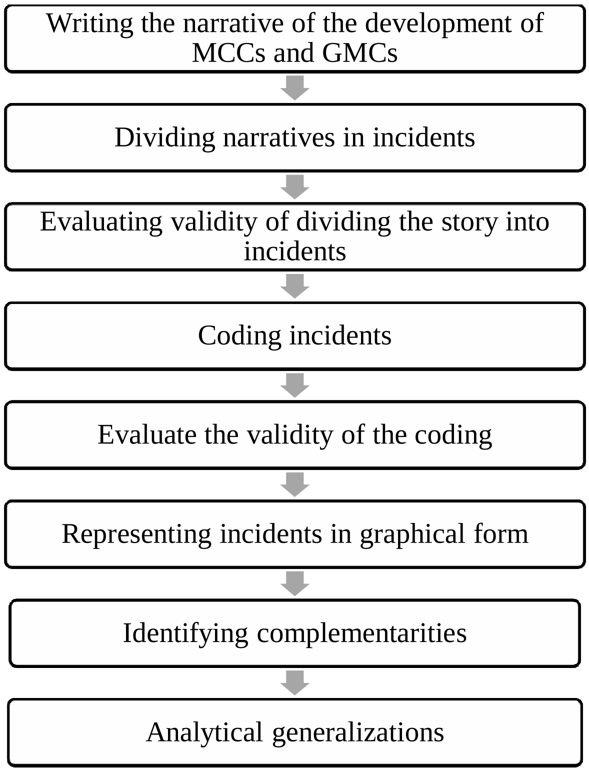

Figure 2.3 – The data analysis steps

CHAPTER 3

Results

3.1 Mass customization capabilities and firm performance improvement

From June 2008 to June 2011, the organization took many steps on the way to MC, and was successful in improving its operational performance without reducing the level of product variety offered to its customers. First of all, costs were reduced, including logistics costs (the stocks of structural components of the product–i.e. bearers and legs–decreased by more than 20%, those of other components by 40%) and processing costs (the number of direct-labor hours per product unit fell by 10%). Second, time performance was improved: order-to-delivery lead-times decreased by 60%, throughput times by 40%, and time-to-market also fell (the three new product families launched in 2011 were developed in 18 months, the same time span previously required to develop one single product family). Finally, improvements concerned also quality performance: product quality improved (as witnessed by reflected 30% decrease in warranty costs) and process quality also rose (-5% product specification errors, -50% errors in the technical documentation for final assembly line operators).

All these performance improvements were the result of the development of a number of MCCs (summarized in Table 3.1). The organization developed the capacity to identify the product attributes along which customer needs diverge, termed as “solution space development” capability (Salvador et al., 2009). This capability, since the middle of 2009, had benefited from the systematic collection of market information by technical office, sales office and post-sales service personnel during visits to the customers’ working sites. In November 2010, this capability further improved due to the creation of a dedicated marketing office led by an experienced marketing manager.

Since then, the office has been in charge of monitoring competitors' offerings, identifying new customers' needs and estimating the market potential for new products or product features. For example, in April-May 2011 a market research, including many visits to customers' sites, was carried out to understand how customers normally used the product, which problems they had and which options were the most or least preferred by different types of customers.

The business unit also enhanced its capacity to reuse or recombine existing organizational and value-chain resources to fulfill a stream of differentiated customer's needs, termed as "robust process design" capability (Salvador et al., 2009). In summer 2009, the organization started to use a novel procedure for developing new products. According to this procedure, the R&D manager, the sales or (after November 2010) marketing manager and the operations manager were required to evaluate, together, the multiple technical solutions that could be used to provide the product functionalities asked by the market. This procedure helped the company to develop new product families that could actually be produced with the available resources. The "robust process design" capability further improved starting from February 2011, when the assembly cycles of new products started to be created only by combining pre-defined assembly sub-cycles that had been approved by the operations manager.

Another MCC that was developed during the period of observation was the capability to support customers in identifying their own solution while minimizing the complexity and the burden of choice, termed "choice navigation" capability (Salvador et al., 2009). This capability highly increased in the second half of 2009, when the organization started to segment customers into homogeneous groups asking for similar product solutions. Salespeople took advantage of this market segmentation to ease the customer's decision process by restricting the products alternatives initially presented to the customer to those typically asked by customers belonging to the same market segment. In mid 2010, a product configurator also started to be used to direct the customer towards the most suitable product in the solution space. In particular, the configurator supported the salesperson during order acquisition, by guiding the configuration dialogue with the customers and by providing images and descriptions that communicate both the benefits (performance and functionalities provided) and the costs (impact on the product price) of the available product choices.

The analysis of the data collected during the case study highlighted two additional capabilities that have helped the organization move towards MC during the period of observation, but had not been previously introduced in literature. On the one hand, the organization developed the capacity to continuously generate a stream of incremental innovations to reduce the negative operational implications of product customization, which I term “continuous improvement for MC” capability. Given the high variety of products to be developed by the R&D department, the time that used to be dedicated to the creation of the technical documents of each product was limited, and these documents used to have many errors, such as missing components or wrong component descriptions. These mistakes, in turn, increased the time and effort required to fulfill a customer’s order, as wrong instructions were given to the assembly line operators. To reduce this problem, in middle 2010 the organization introduced a new procedure: workers in the assembly line have to fill in a form every time they find a problem in the technical documents of the products, and the R&D office has to monthly review these indications to solve the signaled problems. Moreover, in 2011 the organization started to collaborate with an international management consulting company to develop some instruments supporting this continuous improvement effort, such as the kaizen journal or blackboards for tracking the progression of improvement activities. Collectively, all these new routines improved the company’s ability to continuously alleviate the negative implications of product customization on operational performance.

In addition, the organization also enhanced its capacity to incorporate MC into the strategic planning process, which I term “MC integration into the strategic planning” capability. Since November 2009, the product planning meetings started to be based on market segmentation documents, including detailed information about the main differences between market segments, both in terms of desired product functionalities and in terms of target price. These pieces of information were useful to guide the planning of new product families launched since the beginning of 2011. For example those new families, were dedicated to different market segments, each with its needs and a different target price. At the same time every manager (operations, service, R&D…) attended these meetings in order to highlight problems that each decision could create to his/her functional area. In this way the product plans finally included only solutions that did not excessively impair internal processes.

Table 3.1 – Summary of the MCCs developed by the organization

Capability	Definition	Some approaches adopted by the case company to develop the capability
"Solution space development"	Capacity to identify the product attributes along which customer needs diverge	• Post-sales, technical and sales/marketing personnel visit to the customers' working site to observe the customers • Creation of a dedicated marketing office to monitor customers' needs
"Robust process design"	Capacity to reuse or recombine existing organizational and value-chain resources to fulfill a stream of differentiated customer's needs	• R&D manager, sales/marketing manager and operations managers integration for NPD • Assembly cycles created by combining only pre-defined and standard assembly sub-cycles
"Choice navigation"	Capability to support customers in identifying their own solution while minimizing the complexity and the burden they perceive during the choice	• Customers segmentation into homogeneous groups, asking for similar product solutions • Adoption of a sales product configurator
"Continuous improvement for MC"	Capacity to continuously generate a stream of incremental innovations to reduce the negative operational implications of product customization	• Procedure for collecting employees suggestions in the assembly line • Adoption of instruments supporting continuous improvement such as kaizen journal
"MC integration into the strategic planning"	Capacity to incorporate MC into the strategic planning process	• Product planning decisions based on market segmentation documents • Every manager attends product planning meeting to highlight problems that each decision poses to his/her functional area

3.2 Green management capabilities and firm performance improvement

During the period of observation, the organization greatly reduced the environmental impact of its products and processes. In 2009, water consumption in the production process was reduced by 30% with respect to 2008. In 2010 and 2011, the energy consumption of the assembly line fell by 10% yearly. In January 2010, the creation of special wastes in the assembly line was completely eliminated. In addition, the amount of liquid paint used in the manufacturing process was halved. By November 2010, the pollution associated with product disposal was reduced, as the product external panels started to be made up of fully recyclable materials. Additionally, the new products launched in 2011 had 90% less decoration plastics and less powerful engines while preserving the same performance levels. Following all these achievements and a life-cycle environmental impact assessment, in February 2011 three new product families were awarded the EPD, and this event was reported by local and national journals, drawing the attention of some big multinational customers interested in "going green".

These improvements in the firm's environmental performance are the result of the development, during the observation period, of a number of GMCs (summarized in

Table 3.2). First, the company enhanced its capacity to sustain manufacturing processes that meet or exceed environmental targets, which is termed "process environmental management" capability (Lee and Klassen, 2008). This capacity was improved starting from 2010, when the organization appointed an employee to regularly monitor the compliance of production processes with target environmental performance. The company decided that the data collected through this monitoring would be analyzed every six months to look for trends and to inform managers about these trends. Moreover, input-control practices started to be embedded in the assembly line operations, such as the switch off of the painting sprayer when not used on the product (beginning of 2010).

Another GMC developed by the company during the period of observation was the capacity to continuously generate a stream of incremental innovations to proactively reduce waste and source consumption of internal operations, which is termed "pollution prevention" capability (Hart, 1995). For example, since the beginning of 2010, the R&D department has systematically analyzed the reports created by the product testing department to identify possible areas of improvements of the products environmental impact (for example, a few reports regarding problematic pumps revealed that the existing gaskets increased the water consumption of the product during its use, thus prompting the change of those gaskets). Moreover, in early 2010 the operations manager and the health & safety manager started to analyze data on the energy consumption of the assembly process in order to find ways to reduce it (based on the results of this analysis, for example, work shifts were reorganized to decrease energy consumption).

Another GMC that was developed is the capacity to incorporate environmental concerns into the NPD process so as to reduce products life-cycle impact, which is termed “product stewardship” capability (Hart, 1995). This capacity was developed through regular collaborations with external stakeholders who were competent at managing environmental issues. Specifically, in 2009, the organization started to collaborate with some research institutions and with its suppliers to jointly develop greener products. For example, one of these collaborations allowed launching a new product, in January 2009, whose external panels were 100% recyclable. Another important element was the development of an organization-wide commitment towards the achievement of a life-cycle product certification: the sharing of this goal across all the departments created a “green attitude” in all the different areas of the organization, thus supporting an inter-departmental dialogue during the NPD process with the aim of reducing the product impact according to a life-cycle approach.

The supply chain was another area where GM was pursued. In particular, a GMC that was developed is the organizational capacity, termed “green supply” capability (Bowen et al., 2001), to manage the relationship with suppliers to improve the environmental performance of purchased inputs or of the suppliers themselves. For example, since the beginning of 2010 a means for developing such capability has been to systematically encourage suppliers to obtain an environmental certification, so as to qualify as potential suppliers of the company. Moreover the organization started to collaborate with some suppliers to help them develop new “greener” components, as happened with a new low-emissions engine and a new car wash shampoo.

Another GMC that was developed is the capability to sustain environmentally sound relationships with external stakeholders through various communication method, such as disclosure of environmental information, which is termed “relationship environmental management” capability (Lee and Klassen, 2008). This capability was improved mainly through the acquisition of the EPD certification and the creation of all the routines needed for yearly renovating and updating this certification. Specifically, the procedures for collecting those data were clearly identified, and the marketing department was appointed for promoting the certification among external stakeholders.

Another GMC that improved during the period of observation was the capacity to incorporate issues related to the environment into the strategic planning process, which is termed “integrating the natural environment into strategic planning” capability (Judge and Douglas, 1998). This capacity was mainly driven by the definition of a “green” company vision and mission in February 2009. The company logo was also redesigned to inspire an idea of eco-friendliness. These changes to the company identity strongly influenced all the organization members, and coherently directed all the managerial choices during the strategic planning process. Moreover, since the end of 2009, the health & safety manager (responsible for overseeing some environmental aspects) has participated in the product planning meetings, so that environmental issues can always be taken into consideration during those meetings.

The analysis of the data collected during the case study pointed out two additional organizational capabilities that have helped the organization move towards GM, but had not been previously introduced in literature. First, the organization enhanced its capacity to advise, and where relevant, to educate and support customers in the environmental-friendly use, transportation, storage, and disposal of products, which I term “greening the customer” capability. This capacity increased when, at the end of 2009, the organization started to promote among all its customers the use of particular detergents that were less harmful for the environment. Additionally, the organization started, in April 2010, to advise the customers on how to measure out detergents, both in summer and winter, in order to minimize their consumption. Finally, at the middle of 2011 the R&D department concluded the developed of manuals with the instructions for a “green” use of the company’s products, that is, the rules for minimizing the pollution created by the products during their use.

Another GMC that improved during the period of observation was the capacity to relate to external stakeholders (customers, suppliers, general public, governments etc.)

to understand their priorities and needs with regard to environmental issues, which I term "environmental scanning for GM" capability. In 2009, the company began improving this capacity through the participation in industry fairs and supplier fairs, or contacts with NGOs and environmental agencies. Moreover, visits to customers' sites by engineers, post-sales personnel or sales personnel were the other channel used to gain understanding of the customers' problems and desires from an environmental point of view. In November 2010, this capability was strongly improved through the creation of a marketing department in charge of monitoring, in a more systematic way, competitor's green products as well as market requirements and technological developments in the environmental domain.

Table 3.2 – Summary of the GMCs developed by the organization

Capability	Definition	Some approaches adopted by the case company to develop the capability
"Process environmental management"	Capacity to sustain manufacturing processes that meet or exceed environmental targets	• Regular monitoring of the processes compliance with target environmental performance • Input-control practices in the assembly line operations
"Pollution prevention"	Capacity to continuously generate a stream of incremental innovations to reduce waste and source consumption of internal operations	• Analysis of the reports created by the product testing department to identify possible areas of environmental improvements for the product • Monitor of electric consumption in the production process to understand how to reduce it
"Product stewardship"	Capacity to incorporate environmental concerns into the NPD process so as to reduce products life-cycle impact	• Use of LCA techniques to design new products • Inter-organizational relations aimed at reducing the product impact with a life-cycle approach

Table 3.2 Continued

Capability	Definition	Some approaches adopted by the case company to develop the capability
“Green supply”	Capacity to manage the relationship with suppliers to improve the environmental performance of purchased inputs, or of the suppliers themselves	• Encourage suppliers to obtain an environmental certification • Support suppliers in the development of new “greener” components
“Relationship environmental management”	Capability to sustain environmentally sound relationships with external stakeholders through various communication method, such as disclosure of environmental information	• Acquisition and yearly renewal of an environmental certification • Promotion of the certification among external stakeholders
“Integrating the natural environment into strategic planning”	Capacity to incorporate issues related to the environment into the strategic planning process	• Definition of a green company vision and mission • Health & safety manager participating to product planning meetings
“Greening the customer”	Capacity to advise, and where relevant, to educate and support customers in the environmental-friendly use, transportation, storage, and disposal of products	• Advise the customer on how to measure out detergents • Develop manuals with the instructions for a “green” use of the products
“Environmental scanning for GM”	Capacity to relate to external stakeholders (customers, suppliers, general public, governments etc.) to understand their priorities and needs with regard to environmental issues	• Participation to industry fairs and suppliers’ fairs • Creation of a marketing function monitoring customers’ environmental needs and suppliers’ green initiatives

3.3 Complementarities between capabilities

The evidence collected during the case study suggests that some MCCs and some GMCs are positively related. Complementarity effects were observed in multiple areas of the organization, spanning from the operational processes to the NPD process and the marketing process. In the following sections, first I present evidence of each complementarity effect observed at the case company and, then, I propose a logical argument for the generalization of the same relationship towards other firms pursuing MC and GM. In presenting these results, I distinguish between two groups of complementarities: namely, symmetric complementarities and asymmetric complementarities.

Symmetric complementarities

Drawing upon Choi et al. (2008), I classify a complementarity relationship as symmetric when the capabilities involved in the relationship equally complement each other. Specifically, in the case of the following propositions (summarized in Table 3.3), the cost of building one capability decreases with the levels of its complementary capability and vice versa. This is because both capabilities rely on a common routine, whose cost is shared when the two capabilities are both developed by an organization. For each symmetric complementarity, I present the shared routines, explaining why they underlie the capabilities involved in the relationship.

A first symmetric complementarity is between “environmental scanning for GM” capability and “solution space development” capability, which share marketing routines for recording customers’ behavioral patterns in order to understand their needs and wants. The case study shows that the observation of customers’ behavior during regular customer visits conducted by marketing/sales personnel and R&D personnel allowed the organization to uncover, for example, that some of its customers unexpectedly needed to modify the product settings to enable the drying of hand washed cars. Observation of customers’ behavioral patterns, in this case, enabled the case company to spot an unfulfilled and valuable difference among its target customers’ needs: namely, the fact that some customers need a “drying-only” option, which is not required by the rest of the target market. More generally, observation-based marketing research routines are of assistance in building the organizational capacity to identify differences among customer needs, especially the unfulfilled and most valuables differences. This is a complex and costly capability to build (Salvador et al., 2009), as it requires collecting and analyzing a great deal of information about individuals (Pine, 1993). The possibility to gather data about a wide variety of aspects without having to ask any questions to the respondents is a distinctive advantage of observation-based marketing research routines, especially of those based on personal observation (Malhotra, 2002). Unsurprisingly, Salvador et al. (2009) point to such marketing research methods, which allow for recording customers' behavioral patterns in either real or simulated experiences of product purchase/use, as useful approaches to develop "solution space development" capability.

The same observation-based marketing research routines proved to be helpful for building "environmental scanning for GM" capability at the case company. The observation of customer behavior during regular customer visits conducted by marketing/sales personnel and R&D personnel allowed the organization to uncover, for example, that customers typically overlooked the periodical maintenance activities required by the water purification system (such as the regeneration of exhausted chemicals), even though they claimed water purification to be one of their main concerns. Observation of customers' behavioral patterns, in this case, enabled the case company to understand that target customers needed a very simple water treatment technology, since they were unwilling to put much effort into the maintenance of a more complex system. More generally, observation-based marketing research routines are of assistance in building the organizational capacity to understand external stakeholders' priorities and needs with regard to environmental issues. Gathering self-report information about external stakeholders' attitudes, preferences and actual behaviors in the environmental domain is difficult, as people asked about ethical topics, such as the aforementioned ones, are unlikely to report any unsustainable behaviors (Roxas and Lindsay, 2012). The possibility to gather data about areas that the respondent is unwilling to discuss honestly is a recognized advantage of observation-based marketing research methods (Malhotra, 2002).

Based on the above arguments, I propose that:

P1. The cost of jointly developing "environmental scanning for GM" and "solution space development" capability is lower than the sum of the costs of developing them separately.

A second symmetric complementarity is between "product stewardship" capability and "robust process design" capability, which share lateral relations-based coordination routines in the NPD process, where lateral relations are defined as ‘‘joint decision processes which cut across lines of authority’’ (Galbraith, 1974: 32). In my case study, I observed that cross-functional meetings were instituted at various stages of the NPD process for the design review activities, with at least the presence of R&D manager, operations manager, sales or marketing manager. In addition, to increase the effectiveness of these joint decision processes, the organization invested in the breaking of interpretive barriers between departments, that is barriers to linkages and collaboration mainly due to different styles in which people organize their thinking and action (Dougherty, 1992). In particular, in early 2009, the company organized outdoor team-building activities for all its managers (about thirty people) in order to share a common vision of the company identity and innovation goals. Moreover, in middle 2009, the design review meetings started to be supported by a document guiding the formalization of the participants’ opinions in a structured way, thus helping the managers of different departments to communicate in a standardized language and format. These initiatives contributed to the effectiveness of the cross-functional meetings that, since 2009, have been systematically deployed to design products with reduced life-cycle impact. For example, during one of the NPD meetings for the development of a new product family in May 2010, the operations manager pointed out that a highly polluting painting process would have been necessary to produce the new careening design solution that the R&D department was contemplating to make the product look like greenery (and thus reduce the aesthetic impact of the product in the urban landscape). Further team discussions led to the adoption of an alternative design solution, not requiring the same polluting process while still allowing the achievement of the desired product aesthetic. More generally, the use of lateral relations is of assistance in building the capacity to incorporate environmental concerns into the NPD process to design products with a reduced life-cycle environmental impact. This capability is difficult to obtain since every step of the value-chain (from the supply of raw materials up until the disposition of used products) contributes to build up the product environmental impact, and this must be taken into consideration while designing the product (Hart, 1995). The great diversity of knowledge needed for the development of “greener” products increases the necessity to coordinate diverse organizational members through networks that allow for sharing a large amount of information (Lenox and Ehrenfeld, 1997). The possibility to increase the organizational information-processing capacity during the execution of a task is a distinctive advantage of the use of lateral relations (Galbraith, 1974; Joyce et al., 1997). Unsurprisingly, the GM literature suggests that cross-functional teams (Lenox and Ehrenfeld, 1997; Johansson and Magnusson, 2006; van Kleef and Roome, 2007) or liaison personnel between different departments (Simon et al., 2000) facilitate the development of eco-friendly products.

The same NPD routines proved to be helpful for building “robust process design” capability at the case company. The use of effective lateral relations in the NPD process facilitated the design of products that could be produced by using the available resources in the assembly process. As explained above, the organization established regular, cross-functional meetings during the NPD process, and also invested in the breaking of interpretive barriers between different departments, for example through team-building initiatives. During one of these cross-functional meetings, for example, the operations manager, the R&D manager and the marketing manager jointly assessed a couple of alternative design solutions for the angled vertical movement of the product brushes. Such a joint evaluation, from a technical and operational and commercial perspective, allowed for identifying the design solution that, given the estimated production volume, could be produced by using the available human and technological resources in the assembly process. Conversely, the discarded solution would have required additional resources. More generally, the use of lateral relations is of assistance in building the capacity to satisfy each customer’s order by reusing and recombining existing organizational and value-chain resources (Tseng and Jiao, 1998; Salvador et al., 2009). Designing a solution space that enables such a reuse and recombination of resources requires a high capacity to process information during the NPD process. Considerable information exchange is necessary, for example, between marketing and operations to determine optimal product assortment (Åhlström and Westbrook, 1999; Morgan et al., 2001; Trentin et al., 2012a). Considerable information exchange is also necessary between design and manufacturing to assess whether each of the high number of product options being developed can be produced by using the available production resources. A recognized way to augment the information processing capacity of an organization and thus enable fast information exchange among different areas of the company is to use lateral relations (Galbraith, 1974; Joyce et al., 1997).

Based on the above arguments, I propose that:

P2. The cost of jointly developing "robust process design" capability and "product stewardship" capability is lower than the sum of the costs of developing them separately

A third symmetric complementarity is between "continuous improvement for MC" capability and "pollution prevention" capability, which share routines for employees' involvement in improvement actions. The organization observed in my study developed, in middle 2010, a procedure for collecting the suggestions of line employees, analyzing them, signaling the state of implementation of those that were consistent with the company goals, and giving feedbacks about all the accomplished results. The rapid implementation of many improvement suggestions and the availability of constant feedbacks (possibly to explain why certain suggestions had not been accepted) made employees feel the importance of their contribution for the ongoing change of organizational processes. Conversely, in the past, workers had partially given up signaling problems because their suggestions had rarely been taken into consideration and implemented, so that problems had kept on repeating over time. After the introduction of the new procedure, for example, some assembly line operators highlighted that, during the zinc-coating process performed by a supplier, the holes and the threading of some components were covered and, consequently, they needed to be reworked during the assembly process at the company site. Such finishing activities caused the scattered production of small quantities of zinc powder dispersed along the assembly process, which were hard to collect for dismissal. The suggestion made by employees initiated the project for shifting such finishing activities down to the supplier's zinc-coating plant, which is equipped with specific processes for the proper dismissal of zinc powder. More generally, employee involvement in problem solving favors the capability to continuously generate a stream of incremental innovations to reduce waste and source consumption (Hanna et al., 2000). Identifying and working on the organizational areas where waste and source reduction is viable is a complex task because even ancillary operations, such as storage or materials handling, can be sizable sources of waste that must all be considered to identify areas for improvement (Higgins, 1995). Given the diverse information that has to be collected, employee involvement -“a participative process to use the entire capacity of workers, designed to encourage employee commitment to organizational success” (Cotton, 1993: 3)- is particularly valuable in waste reduction initiatives (e.g. Denton, 1999; Hanna et al., 2000; Govindarajulu and Daily, 2004). To enable an effective employee involvement in the continuous reduction of waste and source consumption, the company must create an environment where workers are encouraged to suggest their ideas for innovation, for instance through reward systems (May and Flannery, 1995) or through some form of review and feedback of the workers’ ideas (Govindarajulu and Daily, 2004).

The same routines for employees’ involvement proved to be helpful for building “pollution prevention” capability at the case company. The organizational procedure for effectively collecting and analyzing the suggestions made by assembly line operators, helped the R&D personnel to uncover and resolve a number of little problems in the product architecture. For instance, some structural components, which must be assembled together in certain low-volume product variants, needed to be reworked to fit each other (with the subsequent loss of efficiency in the process) due to their incompatible shapes. Employees’ signaling of these problems helped the organization to quickly resolve them. More generally, employee involvement in problem solving assists the capability to continuously generate a stream of incremental innovations to reduce the negative operational implications of product customization (Kristal et al., 2010). This capability implies not only the continuous enhancement of individual product components and of individual transformational activities, which task is shared by both mass producers and mass customizers; it also entails the continuous improvement of both the product architecture and the process architecture, which link those individual parts and activities, respectively (Pine et al., 1993). Many authors argue that a modular architecture is a key to pursuing MC, because it provides a means for producing a large variety of products while preserving repetitiveness in production (e.g. Duray et al., 2000; Tu et al., 2004). However, in many practical cases, products and processes are not perfectly modular (Schilling, 2000) because companies try to balance between the gains and the costs of decomposing a system into re-combinable modules (Mikkola, 2007). In the presence of non-perfectly modular product/process architectures, there is a higher risk that problems in some interfaces between parts or activities are detected only after the launch of a product family. This is because, as the degree of modularity decreases, the variety of parts and processes tends to increase (Ulrich, 1995), and a company may choose to focus its NPD resources only on higher-volume parts and processes because of budget and time constraints. Consequently, problems in some interfaces may not be detected and overcome before the product family is launched, just because they are specific to low-volume product variants. The identification of these problems is facilitated if the employees involved in the operational processes are encouraged to voluntarily make suggestions and signal interface problems where they actually occur.

Based on the above, I posit that:

P3. The cost of jointly developing "continuous improvement for MC" capability and "pollution prevention" capability is lower than the sum of the costs of developing them separately.

A fourth symmetric complementarity involves "robust process design" capability, "product stewardship" capability and "green supply" capability, which all share routines for external integration with suppliers. Since 2010, the case company has organized yearly meetings of an inter-organizational team, composed of both company's personnel (purchasing manager, quality manager, the dedicated buyer and sometimes the operations manager) and supplier's personnel (functional managers and, in some cases, the owner/s), to analyze the supplier's processes at its plant. During these meetings, the team members discuss about the available production processes in order to understand their levels of performance and, in particular, to identify constraints to manufacturing flexibility. During one of these visits, for instance, it emerged that the plastic injection molding process of one supplier was a main constraint to that supplier's flexibility. This was because components of different sizes were obtained by developing an ad-hoc mold for each of them, with negative consequences on mix flexibility, because of large minimum lot size constraints. To alleviate this constraint, the company and the supplier personnel worked together to develop a system that obstructs different parts of the mold cavity depending on the size of the plastic component to be produced. This action enabled the supplier to produce a large variety of components for the case company by re-using the same molds. More generally, external integration with suppliers supports the capacity to reuse and recombine existing value chain resources to fulfill heterogeneous customers' needs (Mikkola and Skjøtt-Larsen, 2004; Squire et al., 2006b; Zhang et al., 2010). This capability requires understanding possible constraints to suppliers' flexibility, either to set them as limits during the NPD process (Tseng and Jiao, 1998; Zhang et al., 2008) or to try to reduce them (Rungtusanatham and Salvador, 2008; Brabazon et al., 2010). However, both understanding these constraints, as well as reducing them, is not that straightforward, since manufacturing flexibility is a complex, multidimensional, and hard-to-capture concept (Sethi and Sethi, 1990; Upton, 1994; Koste and Malhotra, 1999; Fogliatto et al., 2003). On the one hand understanding constraints to manufacturing flexibility requires assessing a large variety of aspects, ranging from technological or "hardware" features, such as the setup costs of the machines used in the process, to "software" features, such as organizational structure and coordination mechanisms, which affect the realization of the full potential of manufacturing technology (Sethi and Sethi, 1990; De Toni and Tonchia, 1998). Given the large amount of information needed to evaluate the manufacturing flexibility of its suppliers, a company is more likely to seek, with them, a relationship form that contributes to reduce ambiguity and risk (Cannon and Perreault, 1999). Supplier integration -the process of interaction and collaboration in which buyer and supplier work together in a cooperative manner to arrive at mutually acceptable outcomes for their organizations (Pagell, 2004)- is recognized as being an appropriate type of relationship in that respect (Cannon and Perreault, 1999; Premkumar et al., 2005). On the other hand, reducing the identified constraints to supplier's flexibility is also facilitated by supplier integration as the two collaborating organizations generate significantly more knowledge than one company alone (Koufteros et al., 2007). Moreover, collaboration with supplier's personnel plays a direct and critical role in achieving significant supplier improvement, more than other supplier development activities such as providing incentives for improved performance or instigating competition among suppliers (Krause et al., 2000). Therefore, external integration with suppliers facilitates "robust process design" capability by easing both the identification of suppliers' flexibility constraints and their removal.

Similarly, the case study showed that strong collaboration with suppliers during the NPD process helped the organization to redesign, for example, its painting process so as to make it "greener". The supplier that collaborated in this redesign was the one responsible for supplying and managing (i.e., titration, removal of exhausted materials…) some chemicals used in the production process. The deep knowledge of this supplier in the field of low-pollution chemicals enabled the substitution of the phosphate-based materials previously used in the process with new nanotechnological materials, thus eliminating the creation of special waste in the assembly line. More generally, external integration with the suppliers possessing specialized environmental expertise supported the organization in the development of a "product stewardship" capability(Geffen and Rothenberg, 2000). Designing a product with a reduced life-cycle environmental impact requires understanding and minimizing the negative effects of different design choices at every step of the value chain, from raw material procurement up to disposition (Hart, 1995). However, this is not a simple process, since companies are not directly involved in all of these stages of the product life-cycle (Albino et al., 2012), and for this reason they need to complement their experience and competencies by drawing on outside expertise (Geffen and Rothenberg, 2000). Supplier integration is of support in this situation, as suppliers can help the company to understand the environmental impacts of the product components they produce and to identify ways of reducing these impacts (Lamming and Hampson, 1996).

Finally, collaboration with suppliers helped the organization to improve the environmental performance of some of its suppliers. For example, the organization started a partnership with a supplier of detergents for the development of a new, eco-friendly car wash shampoo, which the company would subsequently have suggested to all of its end customers. This prospect of reward motivated the supplier to develop one of the "greenest" detergents in the market (which was actually promoted among all the company's customers). More generally, upstream integration is of assistance to the development of a "green supply" capability. The capacity to manage the relationships with suppliers to reduce their environmental impact requires a company to trigger not only small incremental improvements, but also more innovative changes to the suppliers' products and processes (Geffen and Rothenberg, 2000; Vachon, 2007). However, the push towards innovative changes increases the risk borne by the supplier, as it becomes more difficult to predict how well innovations will eventually address the identified environmental problem (Sharfman et al., 2009). To motivate suppliers to work toward environmental innovation of products and processes, it is important for the company to interact with them in cooperative efforts to share risks and rewards of the innovation initiatives (Geffen and Rothenberg, 2000; Bowen et al., 2001; Sharfman et al., 2009). For example a possible reward is the higher opportunity, for the supplier, to embed its product in the customer's value chain (Lamming and Hampson, 1996).

Therefore, I posit that:

P4. The cost of jointly developing "robust process design" capability, "product stewardship" capability and "green supply" capability is lower than the sum of the costs of developing them separately.

Table 3.3 – Summary of the symmetric complementarities

Proposition	Routines shared by the complementary capabilities
P1. The cost of jointly developing "environmental scanning for GM" and "solution space development" capability is lower than the sum of the costs of developing them separately.	Recording customers' behavioral patterns so as to understand their needs and wants
P2. The cost of jointly developing "robust process design" capability and "product stewardship" capability is lower than the sum of the costs of developing them separately	Lateral relations-based coordination in the NPD process
P3. The cost of jointly developing "continuous improvement for MC" capability and "pollution prevention" capability is lower than the sum of the costs of developing them separately.	Employees' involvement in improvement actions
P4. The cost of jointly developing "robust process design" capability, "product stewardship" capability and "green supply" capability is lower than the sum of the costs of developing them separately.	External integration with suppliers

Asymmetric complementarities

Drawing upon Choi et al. (2008), I classify a complementarity relationship as asymmetric when the cost of developing one capability decreases with the level of another capability, but not vice versa. Stated otherwise, in each complementarity it is possible to univocally distinguish between a “complemented” and a “complementing” variable, whose roles are not symmetrical. In the following paragraphs, I present five asymmetric complementarities (summarized in Table 3.4), providing empirical evidence of each complementarity at the case company and then making a logical argument for the generalizability of the same complementarity.

A first asymmetric complementarity is between “robust process design” capability and “relationship environmental management”. The case study shows that the reuse of existing parts and processes to fulfill heterogeneous customer’s needs facilitated, at the case company, the development of the capacity to inform external stakeholder about the life-cycle impacts of the new product families marketed since 2011. For example, estimation of the energy and raw materials necessary to produce the drying module of one product family necessitated developing appropriate instruments, measurement procedures, employees’ skills, etc. These estimates were used by the organization to compute and communicate the life-cycle impact of not only the abovementioned product family, but of another two families sharing the same drying unit. The same happened with most of the other product components (such as the wheel washer module, the measuring pumps,…) because the degree of component commonality among the new product families had risen up to 80% (it was 40% in middle 2008) as a result of the improved organizational capacity to reuse value chain resources to fulfill heterogeneous customer’s needs.

To generalize, the communication of the firm’s environmental performance to external stakeholders, with the aim to develop environmentally sound relationships with them, goes beyond the obligatory reporting to the government and encompasses the voluntary disclosure of more comprehensive environmental information relevant to the general public (Lee and Klassen, 2008). Such a disclosure requires collecting, analyzing and reporting a large amount of information about the use of inputs (energy, iron, lead,...) and the levels of pollution (CO_2, waste water,...) caused by the firm’s internal processes and products (Bremmers et al., 2009). The higher the number of diverse parts and processes used by the company, the more resources (instruments, dedicated employees, …) are needed to assess the company environmental impact, because the use of inputs and the levels of pollution have to be estimated for a great number of different elements. Conversely, the reuse of existing parts and processes to fulfill heterogeneous customer's needs reduces the number and heterogeneity of elements to be assessed in terms of input use and pollution creation, thus reducing the costs of developing the capacity to estimate and communicate the firm's environmental performance in high-product-variety contexts.

Based on these considerations, I propose that:

P5. As "robust process design" capability increases, the cost of developing "relationship environmental management" capability decreases.

A second asymmetric complementarity is between "robust process design" and "greening the customer" capability. The evidence collected in the case study shows that the reuse of existing parts and processes to fulfill heterogeneous customer's needs facilitated, at the case company, the development of the capacity to educate the customer to a more sustainable use of the product families launched after 2011. To educate the customers to a "green" use of the new products, the company decided to provide customers with a user manual. These manuals include the description of all the possible environmental impacts of the product use (e.g., energy consumption per cycle, water consumption per cycle, percentage of chemicals in the waste water, noise…) and a threshold value for each impact. In case of overrun of these thresholds, the manual also includes specific guidelines for the customers on how to improve their way of using the product so as to bring back the pollution to acceptable levels. The creation of these manuals required that the organization determined threshold values for a number of environmental impacts for each product family, along with the "best practices" to follow in case of overrun (further differences between variants were left aside, since they are considerably less relevant than difference between families). Due to the high commonality of parts among the new product families - as a result of the improved organizational capacity of "robust process design" –the manuals were largely the same for all the three new product families (e.g., the practices for reducing chemical consumption). Additionally, most of the family-specific information (e.g., the water consumption thresholds) could be determined for all the three product families at a relatively low cost, since the needed procedures (measurement steps, computation algorithms…) and resources (employees, instruments…) were the same for all the families.

More generally, the reuse of existing parts and processes to fulfill heterogeneous customer's needs reduces the cost of developing "greening the customer" capability in high-product-variety contexts. The latter capacity requires that the organization identify which aspects of the product can have a significant environmental impact during the product life-time and how to minimize that impact. Should the products of a company not share any parts or processes, the analysis would have to be conducted from scratch for each product, thus requiring the processing of large amounts of information. Conversely, commonalities between products reduce this information-processing load, because when a part is found to be responsible for the environmental impact of one product, and a best-practice is identified to reduce that impact, the same information can be exploited for all the products sharing the same part.

Therefore, I propose that:

P6. As "robust process design" capability increases, the cost of developing "greening the customer" capability decreases.

A third asymmetric complementarity is between "robust process design" and "pollution prevention" capability. The case study shows that, as the reuse of available resources to satisfy heterogeneous customers' needs increased at the case company, it became less costly for the organization to identify and introduce incremental process improvements to reduce waste in its assembly line. At the beginning of the study, assembly activities used to be organized in separate work cells, with some modules or subassemblies being processed by more than one cell and each cell processing more than one module. In 2010, the lay-out was redesigned to create a mixed-model assembly line, and the variability of assembly tasks performed at each station of the assembly line was minimized, while still allowing the system to produce all the required variants. The increased standardization of the assembly process facilitated the execution of statistical analyses to identify areas of possible improvement of the process environmental performance. Thanks to the lower variability of tasks carried out at each station, the analysis allowed identification of some factors that negatively affected the environmental performance of the assembly process. For example, the working schedule was identified as one of the drivers influencing the energy consumption of the painting line, so the shifts allocation criteria were changed to paint products during the most favorable part of the day.

More generally, the reuse of existing parts and processes reduces the cost of developing “pollution prevention” capability in high-product-variety contexts. The capacity to continuously generate a stream of incremental innovations to reduce waste and source consumption requires identifying and eliminating the causes of waste, rather than just reducing its effects with end-of-pipe pollution-control technology (Hart, 1995, 1997). Such proactive attitude towards pollution and source reduction is generally based on instruments, grounded in total quality management, to gather and analyze relevant information (Hart, 1995; Kitazawa and Sarkis, 2000; Tarì and José, 2010). However, when the variety of parts and processes used by an organization is high, systematic analysis activities, such as cause-effect analysis or statistical process control, become harder and more costly to perform because inputs are multi-type and batches are small (Mikkola, 2007; Jiang et al., 2012). The reuse of existing parts and processes to fulfill a large variety of customer’s needs, conversely, allows increasing volumes of individual parts and processes, thus simplifying those analysis activities.

Based on these considerations, I propose that:

P7. As “robust process design” capability increases, the cost of developing “pollution prevention” capability decreases.

A fourth asymmetric complementarity is between “robust process design” capability and “product stewardship” capability. The evidence collected at the case company shows that the former capability facilitated the design of new products with a reduced life-cycle environmental impact. For example, to decrease the energy consumed by one product family during the use, its air-drying module (composed of a number of nozzles and their interfaces with the rest of the product) was entirely redesigned. Such a redesign required a complex fluid dynamic optimization, executed in collaboration with external consultants. Given that the air-drying module was common to all the three new product families (finally awarded the EPD) - due to the company’s enhanced “robust process design” capability – the same “green” innovation was applied to all of the three product families, without the need to perform any further design activity.

More generally, “robust process design” facilitates the development of “product stewardship” capability in high-product-variety contexts. The latter capability results in components and processes with reduced impact on the environment, for example processes using less toxic materials or components with more recyclable materials (Maxwell and van der Vorst, 2003). When product variants have high component and process commonality, by virtue of “robust process design” capability, the eco-friendly redesign of such variants is less resource-intensive than a similar redesign of product variants with totally different components and processes. This is because the number of parts and processes to be redesigned decreases.

Therefore, I posit that:

P8. As “robust process design” capability increases, the cost of developing “product stewardship” capability decreases.

A final asymmetric complementarity is between the capabilities of “choice navigation” and “product stewardship”. The case study shows that the capacity to support customers in the identification of their best solution among those offered by the company facilitated the design of products with reduced life-cycle environmental impacts. In May 2009, the company launched the first eco-friendly product family, designed for low water and energy consumption. At that time, however, the organization still had low “choice navigation” capability, and sometimes customers ended up with ordering a product solution requiring ad-hoc engineering even when an available product variant could perfectly satisfy their needs. This happened because the solution space was very wide and complex, and was continuously changed by the R&D department with limited communication to the salespersons. For example, an ad-hoc product variant was once developed to satisfy the customer’s request for a product that could wash under the car body shell. Such ad-hoc engineering was unnecessary, because there was a pre-engineered variant of the new eco-friendly product that fully met that request. Yet, it was a product variant that was rarely asked by customers, and salespersons did not know it existed. The ad-hoc engineering of the required variant led to a product that was not as energy and water efficient as the pre-engineered one, since the price and delivery time expected by the customer did not allow for including environmental considerations in the engineering of the new product. In 2010, the organization adopted a sales configurator, which automatically executes the search for the product variant best fitting the set of requirements specified by the customer. The search is based on algorithms, implemented in the configurator software, which map possible customer's requests into the available product options in the company solution space. The introduction of the configurator contributed to decrease the number of "special" orders (orders requiring ad-hoc engineering activities) by 90% from 2009 to 2011: almost every product sold by the company nowadays belongs to its pre-engineered solution space, which includes products that have been designed with a focus on their environmental optimization.

More generally, "choice navigation" capability eases the development of a "product stewardship" capability in the case of companies offering complex capital goods, typically sold through salespersons or agents. Companies offering such products are typically willing to perform ad-hoc engineering to fulfill the idiosyncratic needs of their customers. In this context, there is a risk that, in the order acquisition process, the salesperson and the customer agree on a solution that requires ad-hoc engineering even when a fully pre-engineered product, belonging to the company's solution space, could equally satisfy the same customer's needs (Forza and Salvador, 2002; Trentin et al., 2011, 2012b). This risk tends to materialize when it is too complex for the salesperson to identify that product within the solution space offered to the market. Ad-hoc engineering activities introduced in the order fulfillment process tend to augment costs and lengthen lead-times (Squire et al., 2006a), thus making it more difficult to meet the price and delivery date expected by the customer. In a context of tight resource and time constraints, optimization of product environmental impacts may be penalized, since reducing environmental impact is usually not the first priority issue during design (Lofthouse, 2006). "Choice navigation" capability, conversely, reduces the risk that salespersons sell a solution requiring ad-hoc engineering even when it is not necessary. By doing that, this capability decreases the need for ad-hoc engineering activities during the order fulfillment process, so that most NPD activities are performed on a to-forecast basis, in larger scale, and with larger availability of resources for the reduction of the product life-cycle impact.

Based on the above considerations, I propose that:

P9. As "choice navigation" capability increases, the cost of developing "product stewardship" capability decreases

Table 3.4 – Summary of the asymmetric complementarities

Proposition	Summary of the complementarity mechanism
P5. As “robust process design” capability increases, the costs of developing “relationship environmental management” capability decrease	The reuse of existing parts and processes to fulfill heterogeneous customer’s needs reduces the number of elements to be assessed in terms of input use and pollution creation
P6. As “robust process design” capability increases, the costs of developing “greening the customer” capability decrease	The reuse of existing parts and processes to fulfill heterogeneous customer’s needs reduces the information-processing load of identifying which product aspects have a significant environmental impact during the product life-time, and which the way is to minimize that impact
P7. As “robust process design” capability increases, the costs of developing “pollution prevention” capability decrease	The reuse of existing parts and processes to fulfill a large variety of customer’s needs allows increasing volumes of individual parts and processes, thus simplifying the identification and elimination of the causes of waste
P8. As “robust process design” capability increases, the costs of developing “product stewardship” capability decrease	When existing parts and processes are reused to fulfill a large variety of customer’s needs, the number and variety of parts to be redesigned in an eco-friendly way decrease
P9. As “choice navigation” capability increases, the cost of developing “product stewardship” capability decreases	Choice navigation” capability decreases the reliance on ad-hoc solutions to fulfill customer’s orders: in this way NPD activities are less pressured by time and cost constraints and they can include more environmental considerations

CHAPTER 4

Discussion

This dissertation has empirically investigated the existence of complementarities between MCCs and GMCs. The results support the idea that developing specific pairs or triples of MCCs and GMCs results in sub-additive costs.

In particular, two types of complementarity relationships emerged from the study. In the first type–the symmetric ones–an MCC and a GMC share a routine that form a strong foundation for both of them. For this reason, the cost for jointly developing the two capabilities is lower than the sum of the costs for developing each of them. Specifically, what is shared by specific MCCs and specific GMCs are marketing routines for recording customers' behavioral patterns in order to understand their needs and wants, lateral relations-based coordination routines in the NPD process, employees' involvement routines and routines for external integration with suppliers.

The second type of complementarities–the asymmetric ones–involves an order between the capabilities under consideration, as one capability facilitates the development of the other, but not vice versa. Specifically, the MCCs that increase the reuse of available resources and processes (namely "robust process design" and "choice navigation") facilitate the development of the GMCs of communicating the firm's performance to external stakeholders, of educating customers to a "greener" use of the product, of incrementally improving the firm's environmental performance, and of redesigning products and processes to reduce their life-cycle impacts.

Noteworthy, in these two types of complementarities the role of time is different. In the symmetric case, the complementarity exists regardless of the time sequence in which the complementary capabilities are developed. They can be developed concurrently, in a certain sequence or in the opposite one: complementarity will exist all the same. Conversely, in the case of asymmetric complementarities, the improvement in one capability must precede the development of the other capability; if they are developed in the opposite sequence, complementarity will not hold. Such a distinction could be made due to the observation of the organization over time, as longitudinal studies facilitate the understanding of mechanisms behind causal relationships (Leonard-Barton, 1990). Conversely, with a retrospective study the different role of time in the relationships would have more likely been hidden from the researcher.

The present dissertation contributes to the literature in at least two ways. First, it answers the call for more studies on the relationship between the socio-environmental pillars and the economic pillar of sustainability (Surroca et al., 2010; Seuring, 2012). Specifically, this is the first work to study that relationship in the case of an organization operating in a highly competitive industry whose customers ask for high product customization. In such a context, common to many companies nowadays, the organization I have studied was able to ensure both the economic sustainability of its car wash equipment business, by developing a number of MCCs, and the environmental sustainability of the same business, by developing a number of GMCs. More important, these two pillars of sustainability were not only compatible, but also complementary to some extent, as the development of certain pairs of MCCs and GMCs resulted in sub-additive costs for the organization.

Secondly, the results of this study contribute to both the literature on MC and that on GM by highlighting complementary assets for these two strategies, where a complementary asset for a strategy is defined as any organizational element that increases the value of that strategy (Teece, 1986; Ennen and Richter, 2010). On the one hand, with regard to MC, the dissertation indicates that, when a company possesses complementary GMCs, the costs associated with the development of a number of MCCs decrease. This study is one of the first to identify complementary assets for MC, the only exceptions being two works investigating the role of organizational web-expertise in the commercialization of mass-customized goods (Lee et al., 2000; Dellaert and Dabholkar, 2009). Lee et al. (2000) find that the use of the Internet is complementary to the commercialization of mass-customized products, since it allows consumers to better understand product characteristics and how they relate to users' needs. This, in turn, decreases the cost of collecting consumer individual preferences to tailor the product/service accordingly and thus increases the company profits. Dellaert and Dabholkar (2009) suggest that, when a mass customizer is able to develop specific on-line services supporting its e-commerce channel (such as immediate visual product feedback at each stage of the product configuration process), this enhances the customer's perception of the value of the product s/he is configuring, his/her enjoyment in configuring the product and his/her perception of control over the outcome of the configuration process. This, in turn, increases the likelihood of customers purchasing mass-customized products. Previous research looking for complementary assets to MC has therefore focused only on assets that support the sale of mass-customized goods. In this work, I enlarge the scope of the debate to include a higher number of organizational areas, ranging from production, to NPD and marketing.

On the other hand, with regard to GM, the dissertation indicates that, when a company possesses complementary MCCs, the costs associated with the development of a number of GMCs decrease. The inquiry of complementary assets for GM is a longer history in literature. Previous works have identified several complementary assets for GM, such as process innovation and implementation capacity (Christmann, 2000), quality and data management practices (Simpson and Samson, 2010) or acceptance of change by the organization members (López-Gamero et al., 2008). However, this is the first research that examines complementary assets for GM in a business context where offering product variety is critical to win customer orders. In such a context, the MCCs of "solution space development", "robust process design", "continuous improvement for MC" and "choice navigation", which had never been identified by previous studies as complementary assets for GM, are found to lower the costs associated with the implementation of GM.

Another contribution to the GM literature arises from the asymmetric nature of some of the complementarities identified in this dissertation. These asymmetric complementarities support the existence of a path dependency (or sequence) in the pursuit of GM, as suggested by several studies on complementary assets for GM (Hart, 1995; Christmann, 2000; Darnall and Edwards, 2006). Hart (1995) first observed that, when a firm lacks well-developed basic competences such as those for quality management, the implementation of "pollution prevention" capability can be hindered. For this reason, a company first has to focus on the improvement of these basic competences and then on the development of “pollution prevention” capability. Other studies have added on that work by identifying other complementary assets, such as a quality-based management systems (Darnall and Edwards, 2006), that should be developed before trying to achieve GM. My findings support the perspective of these studies and contribute to this literature by documenting the existence of a specific path dependency in a competitive environment where customers ask for high product customization. In such an environment, a company can hardly pursue GM at acceptable costs before the company develops high “robust process design” and “choice navigation” capabilities.

A final contribution to both the MC literature and the GM literature is the fact that, while most of the capabilities discussed in this work were introduced in literature by previous studies (for example, “robust process design” capability or “product stewardship” capability), other relevant capabilities are proposed here for the first time. The relevance of these MCCs or GMCs is supported by the fact that, in one case, they can be mapped onto particular sub-dimensions of capabilities already introduced in literature. This is the case of “greening the customer base” capability, which can be seen as a part of “product-oriented information and communication” capability (Bremmers et al., 2009), which concerns communication with customers (while communication with suppliers is included in “green supply” capability). In the case of the other capabilities, which do not find correspondence in previously defined organizational capabilities, nonetheless there is an implicit support by the existing literature. “Environmental scanning for GM” capability reflects the importance of scanning behaviors for staying abreast of competitive trends and future legislation in the environmental domain (Anderson and Bateman, 2000). “MC integration within the strategic planning process” capability is supported by those works that highlight the importance of developing a manufacturing/operations strategy to support the pursuit of MC (Brown and Bessant, 2003; Duray, 2006). “Continuous improvement for MC” capability, finally, finds support in those works discussing the importance of continuous improvement for the pursuit of MC (Selladurai, 2004; Liu et al., 2006; Huang et al., 2008).

CHAPTER 5

Conclusions, limitations and future research

The results of this study support the existence of complementary relationships between individual MCCs and individual GMCs, leading to sub-additive costs for a company pursuing both MC and GM. These results contribute to the literature on the relationship between economic and environmental sustainability of the business, by showing that the two pillars are, to some extent, complementary when a company operates in a highly competitive industry whose customers ask for product customization.

This work additionally contributes to the literature on MC and to the literature on GM by indicating complementary assets that, for each of these two strategies, had not been identified by previous research. On the one hand, this study shows that some GMCs are complementary assets for MC. On the other hand, it shows that some MCCs are complementary assets for GM when the company's target market requires high product variety.

As regards the implications of this study for practice, the theoretical results of this research can be of interest especially for companies supplying complex customized products in highly-competitive business-to-business contexts. These firms can achieve significant cost savings when pursuing both MC and GM, by exploiting the complementarities identified in this study. In particular the theoretical results of this research suggest that part of these cost savings can only be achieved if it the company first improves or develops certain MCCs, namely "robust process design" and "choice navigation" capabilities, and then starts working on GM.

While contributing both to the academic literature and to managerial practice, this study is not without limitations: results are based on a single case study, which is subject to limits in generalizability and several potential biases (Voss et al., 2002). Even though reasoning about contextual factors has helped me identify some boundaries of validity, more complete boundaries of validity are likely to emerge from the testing of the propositions in various settings (Whetten, 1989). Moreover, additional work is needed to include the social pillar of sustainability in the debate, since this study only focused on the economical and environmental pillars. Finally, future studies should complement the research on the relationships between MCCs and GMCs by investigating the existence of tradeoffs between these two set of capabilities and how to alleviate such trade-offs, if any.

APPENDIX: illustrative display of incidents

Table A.1 – Solution space development" capability

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Identify heterogeneity in customer's need through the analysis of customer's expressed preferences	Customer's needs analysis and sales estimates are made by the sales office only based on their personal experience and past sales trends. These analyses are not performed routinely, but on the need based, when the R&D office needs indications for some NDP choices. Sales personnel are not evaluated based on the correctness of such information and are not incentivized to improve. As a consequence the organizational understanding of the customers' characteristics is low, and this results in a solutions space that does not match the customers' needs.		The technical department starts to collaborate with the post sales personnel (who follow the installations of the products in the customers' working site) to have more precise information about customers' habits in terms of product use	The sales office starts to formalize their market knowledge by creating a market segmentation document - periodically presented to the entire organization. The documents include the product functionalities preferred by each segment and the characteristics of the segment. This increases the reliability of the sales forecasts.	The organization starts to make in-depth interviews with a representative set of customers (both their own customers and competitors' ones) to better understand their profiling characteristics and their priorities in terms of the available product features	Development of a marketing office, directed by an experienced marketing manager, including some technical persons (more expert of the product technical characteristics) and an area manager (more expert of the market). The office starts to survey large pools of customers to improve the organizational understanding of their characteristics and complains New incentives-based initiatives aimed at increasing the correctness of the agents' sales forecasts	Lean sales purchasing project: creation of an information system for determining more reliable sales forecasts per product family. Agents are trained for the use of such system. The marketing office is charged to conduct the pre-competitive analysis of new product features (agents are also involved in the analysis) Creation of an autonomous service office that has to monitor (and report) systematically all the problems experienced by the customers

Anticipate customer’s need by looking for customer’s unexpressed preferences	New products concepts are limitedly tested, with maximum two customer evaluating them		Salespersons together with some technical personnel start to visit customers (company’s and competitors’ ones) to support the market segmentation activity with observational data	Visiting clients to test pre-series products (10 tests, for 3-4 months) becomes a formal procedure, involving operations, R&D, salespersons, post-sales. After the pre-series, a higher number of pre-production products (10-15) are similarly tested by customers for several months.		Planning of a regular data collection procedure, for gathering data about customer's behavior through automatic instruments

Table A.2 – Robust process design

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
NPD that increases the reuse of available resources	There are five different technological products platforms, with a low degree of component commonality (on average 14% of common components, 36% for portals). Many product sub-assemblies are (unneeded) duplication of other available sub-assemblies (for example numerous variants of dosing pumps perform exactly the same functionality). This proliferation of component variants happens because there is no product planning (the sales office gives indications for NPD, based on their experience of the market, or the designer themselves invent some new module normally without a pre-competitive analysis). Moreover designers use single-level BOMs (hampering the analysis of part commonalities among products), they have low familiarity with the assembly process (so they design product that are difficult to be produced), there is no culture supporting carry over in the NPD (designers sometimes redesign available component based on their own creative vein) and there are no	New operations and R&D manager, with experience in and attitude for innovation	Development of a new procedure for design review during the NPD process (including a series of multifunctional meetings to ensure that the product can be produced reusing available processes) Adoption of the “generic BOM” in the R&D department (the abstract representation of a set of product variants as the result of the combination of different types of components) New procedure for product coding: the code uniquely represents (in	Training of the designers, to strongly emphasized the need to increase the carry-over of components in the NPD process Restructuring of existing BOMs and assembly cycles, so that one product functionality is associated with only one product sub-assembly and exclusively with one assembly cell. The management control office helps designers in this activity illustrating the implication of different ways of structuring the	Redesign of the assembly process layout to create a multi-product assembly line (with fixed takt time), with parallel workstations for performing particular customization activities Procedure for including suppliers in the NPD process, to modify design elements that cannot be produced efficiently by suppliers given their available processes	Technical personnel visit the manufacturing facilities. This makes them understand the problems experienced by operations because of the high variety of components and activities to manage. This in turn creates higher attention during NPD to avoid problematic design solutions. Substitution of a designer that resisted against the standardization of product modules and parts. The R&D department increases its	Definition of a new process for creating the assembly cycles of new products: new cycles can only be created by summing up “standard”, pre-defined sub-cycles approved by the operations manager. When this is not possible, the operations manager herself has to create new sub-cycles that are compatible with the available assembly line characteristics.

	strict rules for product coding (two identical components can result in two different codes because they are named in different ways by different designers).	addition to other information) the sequence of assembly steps needed to produce the variant (speaking code). This forces designers to keep into account the production cycle during the NPD	BOM on cost computation. Institutionalization of yearly product plan meeting, whose decisions are used by the R&D office to direct the NPD activities	openness to the change. New procedure for the design of engineered-to-order products: they can be developed only after ensuring their alignment with the organizational product plans, their operational feasibility given the available process and their economic return given a target price The marketing office includes technical personnel to facilitate the communication between the two offices, and thus the correct transfer of commercial information for the NPD process

Continued on the next page

Continued from previous page

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Avoid unneeded variance in the order fulfillment process	Even identical customers' needs can result in different products design. The technical documentation of past products is sometimes absent or too difficult to retrieve when needed to produce a variant again after some time. In these cases the product technical documentation (drawings, bills of materials…) are recreated from scratch, often resulting in a product that is different from the previous one. Moreover during order acquisition, salespersons often agree on the provision of engineered-to-order products, regardless of whether these orders can be fulfilled with the available organizational resources or not. For this reason new assembly cycles are continuously created, increasing the variability in the activities performed by employees. Another problem is the low degree of standardization of the assembly activities. Experienced operators assemble the product by memory, in their own personal, historical way. This affects the repetitiveness of the product testing activities, as identical products can be assembled differently, thus requiring changes to the quality checks procedure.		Creation of assembly manuals to standardize the behavior of operators in the assembly processes	Creation of a new rule for product coding and description. The responsibility of the coding process is given to a single person, to further ensure the homogeneity of the coding. Increased use of a technical configurator to automatically generate the technical documentation required for the production of all the solution modeled in the software. The system eliminates the creation of redundant design solution when an existing one can be reused		Starting the implementation of the new technical configurator, integrated with the sales configurator. This integration avoids errors in the transfer of the commercial order to the technical office Weekly interfunctional meeting for the planning of the order fulfillment activities	The product configurator automatically determines the product shipping-related information

Make suppliers more flexibile	The supply chain is particularly dispersed and fragmented, mainly for historical reasons. Lot sizes required by many suppliers are large and this increases inventory cost for the organization (for example, a supplier of structural components requires minimum purchase lot that produced inventory for up to four months). In addition, due to the company's inability in making accurate sales forecasts, suppliers are often required to deliver components with tight time constrains, which most of them are not able to satisfy. Such a low reliability in the supply process causes high workloads on the purchasing department – for day-to-day troubleshooting – leaving no resources for strategic and longer-term relationship development with suppliers		Establishment of an annual meeting with the most important suppliers (fifty) to communicate the company's strategy –included MC-related goals- and discuss the implication for the suppliers (to allow them proactively react to expected changes to the company's supply strategy)	Creation of annual audit at key suppliers' plants, to conduct a risk assessment of their supply capability (based on company size, type of ownership, number of machines available ...) and of the robustness of their business Establishment of close collaboration with important suppliers to solve problems identified during the audits and in some case develop a kanban-based supply	Adoption of a procedure for dismissing non-crucial or low-performing suppliers (based on the periodic assessment and benchmark of suppliers' characteristics) to free resources for the development of close relations with the most important ones

Table A.3 – Choice navigation

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Minimize complexity and the burden perceived by the customer when making a choice	The communication of the pros and con of the available product choices is up to the agent - for highly experienced agents this is not a problem, while in other cases the salesperson supports the customer only in the choices he is more knowledgeable about (generally no new products or top-class products)			When the customer has to make a difficult choice, the agents are instructed to use market segmentation information (which start to be provided by the sales office) to suggest to the customers the option typically chosen by the same segment.	The newly adopted sales configurator provides detailed explanations of each product option, helping the agent to explain to the customers the advantages and disadvantages of each choice, through illustrative images, texts and 3D rendering of the product	Illustrative images, texts and 3D rendering of the product available also for foreign markets	
Present to the customer only the choices that lead him/her towards the best product in the solution space	Agents/salespersons are given an overview of the new products during some meetings, often insufficient to make them understand the value and the functionality of the most complex products. These meetings are, moreover, very few so agents/salespersons are often not aware of the ultimate solution launched by the company. Given the lack of support some salespersons offer to the customer only the few		Increases in the agents' propensity to direct customers towards pre-engineered products, thanks to the new process for order validation: before launching an order in the	Agents are instructed to use market segmentation information to initially present to the customer only the part of the solution space which is typically chosen by the same	Between May 2009 and June 2010, a cross-functional team creates the sales dialogue of the new sales product configurator (and the manual for using it). The system suggests an ordered sequence of questions that the salesperson has to	Availability of the sales configurator to the foreigner markets, by virtue of the translation of the configuration dialogues in a number of languages Training of agents on the use of the	In-depth training of the agents and salespersons on the new products (they start to sell the top-level products because they finally have the required

	products they are more expert on, even when a more suitable product is available for the customer in the solution space (this is especially true in the case of conveyors – which are more complex and salesperson expertise is even more limited). In other cases the agents accept every customer's request (being unable to propose other solutions), even when these requests lead to a product that is not included in the solution space. This happens for more or less 10% of orders – up to 50% in the case of conveyors. In some of these cases the customer has to be re-contacted by customer service personnel to change his/her order, because it is found to be unfeasible (given incompatible functionalities). In other cases the R&D office develops a new product that tries to reconcile the incompatible functionalities.	production system the company staff (customer service) has to insert it into the ERP system, correcting errors in the configuration, price and delivery times promised to the customer. Then the agent is required to validate the revised version of the order before it is formally accepted.	segment	ask to the customer. The dialogue changed based on previous answers of the customer, therefore adapting to his/her needs	configurator	knowledge)

Table A.4 – Continuous improvement for MC

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Continuous enhancement of individual product components and individual transformational activities	The organization suffers from large product quality problems (high warranty and non-compliance costs). The information collected during post-sales interventions, however, is not used to try to systematically solve problems: this information is revised about every three months by the technical department but the approach is unstructured (no analysis of the occurrences or of the economic impacts of the problems, nor a structured approach in solving them - e.g. PDCA). Moreover employees' suggestions for improvement are often not analyzed for lack of time and lack of a structured procedure for suggestion implementation. The testing of new products is often not executed because of time constrains in the development of engineered-to -order products. Solutions of quality problems signaled by the customers are not extended to other products that have similar problems	New director of the technical department: he starts to promote a culture of continuous improvement among all designers (especially in terms of defining clear improvement objectives and documenting results)	Post-sales service gives regular statistical information on the product quality problems that are observed (ex. mean time between failures) and on the cost needed to fix them. These data start to be analyzed by R&D office every 3 months to identify improvement priorities	From the end of 2009 visiting clients to test pre-series products becomes a formal procedure. It helps to eliminate "batches" of problems (that were previously eliminated one by one only as the customers identified them when using the products). After the pre-series, a number of pre-production products are similarly tested to look for problems	The product testing phase is systematized - no product can be delivered to the customer before testing	Training of employees on kaizen principles helps to further structure the product testing phase, increasing the attention on objectives definition, analysis of the results, and formal reporting of results. Adoption of visual management principles to signal things that the employees have to improve in their way of working	

Continuous improvement of the product architecture and the process architecture	At the beginning of the observation, the continuous design and introduction of new product variants creates a high number of production problems: the lack of time that is devoted to the design of each product does not allow the R&D department to make a thorough inspection of the technical documents produced, and it is impossible to validate each new projects together with the production department to check its practical feasibility. This leads to numerous errors in the bills of materials or in the technical drawings (in 10% of the portals): bills can have missing component (e.g. solenoid valve), or blueprints can have wrong information. When assembly line operators notice the error, they normally have to rework some pieces or pause production to gather missing components. These errors detected by production personnel are reported in a "defects file" (since 2007). However, there is no well-defined process for the routine analysis and systematic resolution of these problems (in mid-2008, the percentage of problems solved is about 60%)	The "defects file" starts to be reviewed every month to correct compatibility problems among product components	The creation of the assembly line allows employees to better observe incompatibilities /problem in the transition from one working station to the other	A blackboard is introduced alongside of the assembly line, with forms for suggesting improvements or report problems (both about product and process). The operations manager and a production person analyze weekly those forms to implement suggestions that are considered valid. Suggestions/problems regarding the product architecture are discussed every two weeks with the technical department to create an implementation plan. Once the plan is created detailed and actions are taken, and feedbacks are provided to the employees.

Table A.5 – MC integration into the strategic planning

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Include customer's needs in the strategic planning process	The strategic planning process includes the sales manager but decisions are based on his own perception of the customers' needs, not on formal market analysis. This often leads to the misinterpretation of what the market wants, and to product plans that are unprofitable		Formalization, in the company vision and mission, of the fact that the customer is at the center of business strategy			The product planning meetings are supported by market segmentation documents and pre competitive analysis made by the marketing office, to keep into consideration what the customers really want	
Minimize the negative operational impact of the strategic planning decisions	No contribution of the top management to the product plan decisions	New managing director, aiming at improving the company's profitability chooses a new top management that can support his vision (innovation-oriented persons) Formalization of the strategic plan for the pursuit of MC	The "strategic plan for MC" (including the adoption of product configurator, redesign of the NPD process..) is set as the most important improvement plan of the year	Institutionalization of yearly product plan meeting, attended by the all the top management (i.e. operations, R&D, sales, marketing, service, finance and control, information systems and human resources, quality and health & safety). All participants evaluate the proposed product plan, highlighting the problems it could create in their department: this helps to reconsider product choices in order to ensure their economic viability			

Table A.6 – Pollution prevention

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Continuously reduce the environmental impact of the process	No actions to reduce the environmental impact of the process				The Health and Safety manager presents the results of his environmental analyses to the managers that stand over polluting processes. These managers have to present an improvement plan to reduce impacts that are found to be excessive. The Health and Safety manager has to assess and eventually modify the plan before large scale implementation The company starts to monitor electricity consumption of the production process to understand which variables influence such consumption. Data is then used to make improvements to the process to reduce its energy consumption	A blackboard is introduced alongside of the assembly line, with forms for suggesting improvements or report problems (both about product and process). Once an improvement plan is created based on an employee's suggestion, feedbacks are provided. New procedures for environmental improvements: improvements have to be carefully planned, implemented and assessed	
Continuously reduce the environmental impact of the product	No actions to reduce the environmental impact of the products				The R&D department starts to collaborate with the product testing department to carry out experimentation to identify possible environmental improvements of the product	The maintenance technicians are trained (through their participation in the process assessment for the EPD) to identify product malfunctioning that hamper environmental performance	Planning of a large-scale customer data collection to identify problems - in the product use - that affect environmental performance

Table A.7 – Process environmental management

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Monitoring of process environmental performance	The company respects the environment regulation about process monitoring (special waste, wastewater, oils). The employee charged of this activity is the Health and Safety manager. Feedbacks are given to the manager supervising non-conformant processes with irregular periodicity		Outsourcing of the management control activities regarding the organizational EM system		The new environmental manual includes instructions (and appoints a responsible) for periodical measuring and assessing: wastewater in the painting process (monthly), special waste (every six months) energy and water consumption (every three months). In addition, every six months reports are to be created based on these data The monitoring of the chemical processes starts to be made by a (more expert) supplier	Consumption of paint powders starts to be monitored Titration of chemicals is done twice a day (vs. once every week)	
Managing current processes to minimize their environmental impact	Work instructions include the prescription of separate collection of waste materials, (paper and plastic). Maintenance of the production technology is regularly performed				Switch-off of the painting sprayer when no products are in the painting process Waste powder paints is recovered and used	Warehouse reorganization: stocks of products that are rarely handled are located in more distant zones, while high-turnover ones are placed near the picking point to minimize the emission of the internal logistics	

Managing current processes to minimize risk of environmental incidents	Chemicals are sometimes stored in unprotected areas; some are expired and not disposed for a long time. Employees training on management of environmental risks is performed every two years		Following two breaks in a washing plant that had resulted in the waste of large volumes of water, the company introduces a monitoring system that issue an alarm in the event of abnormal water consumption New procedure for the closure of the water plant when there is the risk of further breakage of pipes Formal procedures for tracking the expiry date of chemicals	Yearly training for employees about environmental risks management. Specific training for employees in the warehouse that handle chemicals	Revision of the safety manual to include environmental issues (thus becoming the "environment and safety" manual). It includes all the relevant environmental regulations, it identifies personnel responsible for environmental emergencies and procedures to be followed in case of environmental incidents	Warehouse reorganization: harmful products are located in lower shelves to minimize their handling

Table A.8 – Product stewardship

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Reduce the environmental impact caused by external stakeholders through product redesign	The impact of the product outside the company's boundaries is unknown and there are no attempts to reduce it	Beginning of a regular collaboration with research institutions to develop technical innovations that can reduce energy consumption of the product in use and end-of-life product impact	Partnership with an external design studio to identify more recyclable materials that can replace the ones used in the current products Formalization of the redesign objectives to be accomplished with the research institutions: optimization of fluid jets, use of renewable energy, reduction of noise levels		Procedure for including suppliers in the NPD process to receive suggestion on how to design the product in order to include supplier's "greener" products Long-term collaboration with a consultancy company to identify the product life-cycle steps that are the most polluting – to guide the design of the future products.		The design of the product takes into consideration the product shipment operations (decomposition of the product into sub assemblies that fit a standard container – to allow the 3PL to optimize its routings – and redesign of the packaging to make it reusable)
Reduce the organizational environmental impact through product/process redesign	There are no organizational attempts to design the product in a way that it can be produced with low environmental impact – only personal initiatives of few designers	The new R&D and operations manager share an interest for environmental preservation and informally discuss about possible improvements to the company's products and processes			Interfunctional meetings for the design review during the NPD process start to include environmental aspects of the product	Visits of the technical personnel to manufacturing facilities to make them understand the problems experienced by operations – included environmental issues	

Table A.9 – Green supply

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Reduce the environmental performance of the supplied components	No collaboration with existing suppliers to reduce their environmental impacts				The purchasing department is highly involved the EPD project (participation to suppliers' presentation of new green products, collaboration with the R&D to find greener components on the market – with training on what "greener" means -…). When assigning a new supply contract (and multiple suppliers are available), the office starts to look for current suppliers that can provide a greener product. If no one does, the personnel try to find a supplier that is available to redesign its component, in collaboration with the company R&D, to make it more environmental friendly		
Monitoring of suppliers' environmental performance improvement	The company looked for reliable suppliers who complied with the laws including environmental ones.			Establishment of an annual meeting with most critical suppliers to communicate the company's strategy, including green objectives. During these meeting the company communicates that suppliers' "going green" will be preferred over other suppliers	If none of the current supplier is available for green procurement, the purchasing office looks for a new supplier that can provide evidence of higher environmental performance (e.g. LCA or other certificates) Yearly supplier evaluation procedure includes supplier's possession of environmental certifications		

Table A.10 – Relationship environmental management

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Relationship environmental management	The company creates the compulsory documents required by the legislator (about waste and chemical management, water pollutions…)				Development of the procedures and instruments for computing the life-cycle impact of the product. Nomination of a responsible for the EPD certification Beginning of participation to industry fairs to present products in a way to visually communicate their green performance (reproduction of a natural environment in the stand, green colors...)		The company is the first in the world in its sector to obtain the environmental product declaration EPD® for its products. This declaration certifies the environmental impact of the products calculated in all phases of its life cycle. The marketing office starts to promote the achievement of the environmental certification

Table A.11 – Integrating the natural environment into strategic planning

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Integrating the natural environment into strategic planning	No resources dedicated to green management	New top management, interested in environmental values and ethics. The management and ownership agreed immediately about the increasing importance of environmental issues in their business. They initiate the review of the corporate vision and mission	Redefinition of company's mission and vision and redesign of the corporate logo to reflect environmental sustainability. This operatively results in the definition of important green projects, including high investments for collaborations with universities and research institutions Meeting with the middle level managers to encourage the sharing of the new "green" organizational values. Managers are then charged to be spokesman of the green mission among the rest of the employees	Institutionalization of yearly product plan meetings, also attended by the Health & Safety manager (responsible for overseeing some environmental aspects), who gives an opinion about the environmental implication of different strategic choices available to top management. This helps to identify the choices that are more in line with the green strategy These meetings are additionally supported by information about competitors' initiatives in the environmental domain	The strategic decision to pursuit the EPD certification guides the company's decisions of resource allocation among new product/service projects		

Table A.12 – Greening the customer

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Determine the information that can help the customer to be "greener")	No initiatives to identify new information that can be used by the customer to reduce the environmental impact of the product during use				Beginning of product testing aimed at understand the best dosing of shampoo under different climate conditions	Systematic testing of the new products to estimate their environmental performance under different use conditions and to find which customers' behaviors may influence such performance	
Instruct the customer on how to be "greener" when using the product	The user manual given to the customer includes instructions that must be followed to avoid incompliance with environmental regulations (mainly in the water treatment). Salespersons are not trained on the environmental implication of the products therefore they cannot give further support to the customer			The organization starts giving samples of low-pollution shampoo to the customers, to promote the use of such chemical	Personnel advice customers, during post sales visits or new product installation, on how to dose chemicals	Start of the creation of a "green manual" with instructions for the proper use of the product to minimize its environmental performance. The manual includes threshold value of recommended environmental impact of the product in use and suggestions on how to reduce such impact.	In-depth training of the agents and salespersons on the new products characteristics – so that they are able to give indications to the customer about the environmental advantages of the new products Planning of a communication campaign with an NGO, to discourage the use of unsustainable practices in car washing

Table A.13 – Environmental scanning for GM

Capability sub-dimension	BEGINNING	2008 - II sem.	2009- I sem.	2009 - II sem.	2010 - I sem.	2010 - II sem.	2011- I sem.
Environmental scanning for GM	The company was not conscious of the customer's need for more environmental friendly products. It was losing market share because it was disregarding the importance of water treatment systems (a complementary product sold to the customer with the washing equipment).	An external office is used for monitoring environmental legislation	The participation to industry fairs and suppliers' fairs allows monitoring competitor's initiatives in the environmental domain and discussing with customers about their interest for "green products". Some contacts are additionally made with NGOs present at fairs, to understand what they would like the company to do in the environmental domain. The R&D manager scans specialized magazines to identify technical development that can be used for green product redesign	The sales office, supported by the R&D office, starts to analyze and benchmark competitors' products from a green point of view. Salespersons together with some technical personnel start to visit customers (company's and competitors' ones) to support the market scanning with observational data	The purchasing department starts to monitor new green supply opportunities Visits to the customers' site, conducted by R&D, salespersons and post sales personnel during the testing of product pre-series are used to identify customer's priorities in terms of environmental improvement of the product	Creation of a Marketing department responsible for monitoring customer's environmental needs and competitors' green initiatives - through in depth interviews, surveys and customer visits	Planning of a large-scale visit to customer's site to gather reliable data on how customers normally use the product and which environmental problems they have

References

Abell, P., Felin, T., Foss, N., 2008. Building micro-foundations for the routines, capabilities, and performance links. Managerial and Decision Economics 29(6), 489-502.

Åhlström, P., Karlsson, C., 2009. Longitudinal field studies, in: Karlsson, C. (Ed.), Researching Operations Management. Routledge, New York, USA, pp. 196-235.

Åhlström, P., Westbrook, R., 1999. Implications of mass customization for operations management: An exploratory survey. International Journal of Operations & Production Management 19(3), 262-275.

Albino, V., Dangelico, R.M., Pontrandolfo, P., 2012. Do inter-organizational collaborations enhance a firm's environmental performance? A study of the largest U.S. companies. Journal of Cleaner Production 37, 304-315.

Amit, R., Schoemaker, P.J.H., 1993. Strategic assets and organizational rent. Strategic Management Journal 14(1), 33-46.

Anderson, L.M., Bateman, T.S., 2000. Individual environmental initiative: championing natural environmental issues in U.S. business organizations. Academy of Management Journal 43(4), 548-570.

Angell, L.C., Klassen, R.D., 1999. Integrating environmental issues into the mainstream: an agenda for research in operations management. Journal of Operations Management 17(5), 575-598.

Aragón-Correa, J.A., Sharma, S., 2003. A Contingent Resource-Based View Of Proactive Corporate Environmental Strategy. The Academy of Management Review 28(1), 71-88.

Aral, A.S., Weill, A.P., 2007. IT Assets, Organizational Capabilities, and Firm Performance: How Resource Allocations and Organizational Differences Explain Performance Variation. J Organization Science 18(5), 763-780.

Armstrong, C.E., Shimizu, K., 2007. A Review of Approaches to Empirical Research on the Resource-Based View of the Firm? Journal of Management 33(6), 959-986.

Badurdeen, F., Liyanage, J.P., 2011. Sustainable value co-creation through mass customisation: a framework. International Journal of Sustainable Manufacturing 2(2/3), 180-203.

Barnett, M.L., 2007. Stakeholder influence capacity and the variability of financial returns to corporate social responsibility. Academy of Management Review 32(3), 794-816.

Beske, P., 2012. Dynamic capabilities and sustainable supply chain management. International Journal of Physical Distribution and Logistics Management 42(4), 372-387.

Bowen, F.E., Cousins, P.D., Lamming, R.C., Farukt, A.C., 2001. The role of supply management capabilities in green supply. Production and Operations Management 10(2), 174-189.

Brabazon, P.G., MacCarthy, B., Woodcock, A., Hawkins, R.W., 2010. Mass Customization in the Automotive Industry: Comparing Interdealer Trading and Reconfiguration Flexibilities in Order Fulfillment. Production and Operations Management 19(5), 489-502.

Bremmers, H., Haverkamp, D.J., Omta, O., 2009. Dynamic behavioral fingerprinting': what drives the deployment of environmental information and communication capabilities? Journal of Cleaner Production 17(8), 751-761.

Brown, S., Bessant, J., 2003. The manufacturing strategy-capabilities links in mass customisation and agile manufacturing - an exploratory study. International Journal of Operations & Production Management 23(7), 707-730.

Cannon, J., Perreault, W., 1999. Buyer-Seller Relationships in Business Markets. Journal of Marketing Research 36(4), 439-460.

Chin, R., Smithwick, D., 2009. Environmental Impacts of Utilizing Mass Customization: Energy and Material Use of Mass Customization vs. Mass Production, 5th World Conference on Mass Customization & Personalization MCPC2009, Helsinki.

Choi, B., Poon, S.K., Davis, J.G., 2008. Effects of knowledge management strategy on organizational performance: A complementarity theory-based approach. Omega 36(2), 235-251.

Christmann, P., 2000. Effects of "Best Practices" of Environmental Management on Cost Advantage: The Role of Complementary Assets Academy of Management Journal 43(4), 663-680.

Cohen, M.D., Burkhart, R., Dosi, G., Egidi, M., Marengo, L., Warglien, M., Winter, S., 1996. Routines and Other Recurring Action Patterns of Organizations: Contemporary Research Issues. Industrial and Corporate Change 5(3), 653-698.

Collis, D.J., 1994. Research Note: How Valuable Are Organizational Capabilities? Strategic Management Journal 15(S1), 143-152.

Corbin, J., Strauss, A., 1990. Grounded theory research: Procedures, canons, and evaluative criteria. Qualitative Sociology 13(1), 3-21.

Cotton, J.L., 1993. Employee involvement: Methods for improving performance and work attitudes. Sage Publications, Inc., Thousand Oaks, CA.

Da Silveira, G., Borenstein, D., Fogliatto, F.S., 2001. Mass customization: Literature review and research directions. International Journal of Production Economics 72(1), 1-13.

Darnall, N., Edwards, D.Jr, 2006. Predicting the cost of environmental management system adoption: the role of capabilities, resources and ownership structure. Strategic Management Journal 27(4), 301-320.

Davis, S.M., 1987. Future perfect. Addison-Wesley, Reading, MA.

Day, G.S., 1994. The capabilities of market-driven organizations. Journal of Marketing 58(4), 37.

de Bakker, F., Nijhof, A., 2002. Responsible chain management: a capability assessment framework. Business Strategy and the Environment 11(1), 63-75.

De Toni, A., Tonchia, S., 1998. Manufacturing flexibility: A literature review. International Journal of Production Research 36(6), 1587-1617.

Dellaert, B.G.C., Dabholkar, P.A., 2009. Increasing the Attractiveness of Mass Customization: The Role of Complementary On-line Services and Range of Options. International Journal of Electronic Commerce 13(3), 43-70.

Denton, D.K., 1999. Employee involvement, pollution control and pieces to the puzzle. Environmental Management and Health 10(2), 105-111.

Dierickx, I., Cool, K., 1989. Asset Stock Accumulation and Sustainability of Competitive Advantage. Management Science 35(12), 1504-1511.

Dosi, G., Faillo, M., Marengo, L., 2008. Organizational Capabilities, Patterns of Knowledge Accumulation and Governance Structures in Business Firms: An Introduction. Organization Studies 29(8/9), 1165-1185.

Dougherty, D., 1992. Interpretive Barriers to Successful Product Innovation in Large Firms. Organization Science 3(2), 179-202.

Dubé, L., Paré, G., 2003. Rigor in Information Systems Positivist Case Research: Current Practices, Trends, and Recommendations. MIS Quarterly 27(4), 597-636.

Duray, R., 2006. Pursuing capabilities of flexibility and quality: financial performance implications for mass customisers. International Journal of Mass Customisation 1(2/3), 260-271.

Duray, R., Ward, P.T., Milligan, G.W., Berry, W.L., 2000. Approaches to mass customization: configurations and empirical validation. Journal of Operations Management 18(6), 605-625.

Dutta, S., Zbaracki, M.J., Bergen, M., 2003. Pricing process as a capability: a resource-based perspective. Strategic Management Journal 24(7), 615-630.

Edgeworth, F.Y., 1881. Mathematical physics: An essay on the application of mathematics to the moral sciences. Kegan Paul, London.

Edmondson, A.C., McManus, S.E., 2007. Methodological fit in management field research. Academy of Management Review 32(4), 1155–1179.

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. The Academy of Management Review 14(4), 532-550.

Ennen, E., Richter, A., 2010. The Whole Is More Than the Sum of Its Parts - Or Is It? A Review of the Empirical Literature on Complementarities in Organizations. Journal of Management 36(1), 207-233.

Ethiraj, S.K., Kale, P., Krishnan, M.S., Singh, J.V., 2005. Where do capabilities come from and how do they matter? A study in the software services industry. Strategic Management Journal 26(1), 25-45.

Felin, T., Foss, N.J., Heimeriks, K.H., Madsen, T.L., 2012. Microfoundations of Routines and Capabilities: Individuals, Processes, and Structure. Journal of Management Studies 49(8), 1351-1374.

Ferdows, K., De Meyer, A., 1990. Lasting improvements in manufacturing performance: In search of a new theory. Journal of Operations Management 9(2), 168-184.

Flynn, B.B., Flynn, E.J., 2004. An exploratory study of the nature of cumulative capabilities. Journal of Operations Management 22(5), 439-457.

Fogliatto, F.S., da Silveira, G.J.C., Borenstein, D., 2012. The mass customization decade: An updated review of the literature. International Journal of Production Economics 138(1), 14-25.

Fogliatto, F.S., Da Silveira, G.J.C., Royer, R., 2003. Flexibility-driven index for measuring mass customization feasibility on industrialized products. International Journal of Production Research 41(8), 1811-1829.

Forza, C., Salvador, F., 2002. Managing for variety in the order acquisition and fulfilment process: The contribution of product configuration systems. International Journal of Production Economics 76(1), 87-98.

Galbraith, J.R., 1974. Organization Design: An Information Processing View. Interfaces 4(3), 28-36.

Geffen, C.A., Rothenberg, S., 2000. Suppliers and environmental innovation: The automotive paint process. International Journal of Operations & Production Management 20(2), 166 - 186.

Glaser, B.G., Strauss, A.L., 1967. The Discovery of Grounded Theory. Strategies for Qualitative Research. . Aldine Publishing Company, Chicago.

Godfrey, P.C., Hill, C.W.L., 1995. The problem of unobservables in strategic management research. Strategic Management Journal 16(7), 519-533.

Govindarajulu, N., Daily, B.F., 2004. Motivating employees for environmental improvement. Industrial Management & Data Systems 104(4), 364-372.

Grant, R.M., 1991. The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation. California Management Review 33(3), 114-135.

Grant, R.M., 1996. Prospering in Dynamically-Competitive Environments: Organizational Capability as Knowledge Integration. Organization Science 7(4), 375-387.

Gupta, M.C., 1995. Environmental management and its impact on the operations function. International Journal of Operations & Production Management 15(8), 34-51.

Hanna, M.D., Newman, W.R., Johnson, P., 2000. Linking operational and environmental improvement through employee involvement. International Journal of Operations & Production Management 20(2), 148-165.

Hart, S.L., 1995. A Natural-Resource-Based View Of The Firm. The Academy of Management Review 20(4), 986-1014.

Hart, S.L., 1997. Beyond Greening: Strategies for a Sustainable World. Harvard Business Review 75(1), 66-76.

Helfat, C.E., 1997. Know-how and asset complementarity and dynamic capability accumulation: the case of R&D. Strategic Management Journal 18(5), 339-360.

Henderson, R., Cockburn, I., 1994. Measuring Competence? Exploring Firm Effects in Pharmaceutical Research. Strategic Management Journal 15(S1), 63-84.

Higgins, T.E., 1995. Pollution Prevention Handbook. Lewis Publishers, Boca Raton, FL.

Hofmann, K.H., Theyel, G., Wood, C.H., 2012. Identifying Firm Capabilities as Drivers of Environmental Management and Sustainability Practices - Evidence from Small and Medium-Sized Manufacturers. Business Strategy and the Environment 21(8), 530-545.

Huang, X., Kristal, M.M., Schroeder, R.G., 2008. Linking learning and effective process implementation to mass customization capability. Journal of Operations Management 26(6), 714-729.

Huber, G.P., Power, D.J., 1985. Retrospective Reports of Strategic Level Managers: Guidelines for Increasing their Accuracy. Strategic Management Journal 6(2), 171-180.

Jiang, X., Sun, X., Wang, S., Wang, R., 2012. Intelligent Process Quality Control System for Mass Customization.

Johansson, G., Magnusson, T., 2006. Organising for environmental considerations in complex product development projects: implications from introducing a "Green" sub-project. Journal of Cleaner Production 14(15/16), 1368-1376.

Joyce, W.F., McGee, V.E., Slocum, J.W., 1997. Designing Lateral Organizations: An Analysis of the Benefits, Costs, and Enablers of Nonhierarchical Organizational Forms*. Decision Sciences 28(1), 1-25.

Judge, W.Q., Douglas, T.J., 1998. Performance Implications of Incorporating Natural Environmental Issues into the Strategic Planning Process: An Empirical Assessment. Journal of Management Studies 35(2), 241-262.

Kitazawa, S., Sarkis, J., 2000. The relationship between ISO 14001 and continuous source reduction programs. International Journal of Operations & Production Management 20(2), 225-248.

Koste, L.L., Malhotra, M.K., 1999. A theoretical framework for analyzing the dimensions of manufacturing flexibility. Journal of Operations Management 18(1), 75-93.

Koufteros, X.A., Edwin Cheng, T.C., Lai, K.-H., 2007. "Black-box" and "gray-box" supplier integration in product development: Antecedents, consequences and the moderating role of firm size. Journal of Operations Management 25(4), 847-870.

Krause, D.R., Scannell, T.V., Calantone, R.J., 2000. A Structural Analysis of the Effectiveness of Buying Firms' Strategies to Improve Supplier Performance. Decision Sciences 31(1), 33-55.

Kristal, M.M., Huang, X., Schroeder, R.G., 2010. The effect of quality management on mass customization capability. International Journal of Operations & Production Management 30(9), 900-922.

Lamming, R., Hampson, J., 1996. The Environment as a Supply Chain Management Issue. British Journal of Management 7(S1), S45-S62.

Lee, C.H.S., Barua, A., Whinston, A.B., 2000. The Complementarity Of Mass Customization And Electronic Commerce. Economics of Innovation and New Technology 9(2), 81-110.

Lee, K.-H., 2009. Why and how to adopt green management into business organizations?: The case study of Korean SMEs in manufacturing industry. Management Decision 47(7), 1101 - 1121.

Lee, S.-Y., Klassen, R.D., 2008. Drivers and Enablers That Foster Environmental Management Capabilities in Small- and Medium-Sized Suppliers in Supply Chains. Production and Operations Management 17(6), 573-586.

Lenox, M., Ehrenfeld, J., 1997. Organizing for effective environmental design. Business Strategy and the Environment 6(4), 187-196.

Leonard-Barton, D., 1990. A dual methodology for case studies: synergistic use of a longitudinal single site with replicated multiple sites. Organization Science 1(3), 248-266.

Liu, G., Shah, R., Schroeder, R.G., 2006. Linking Work Design to Mass Customization: A Sociotechnical Systems Perspective. Decision Sciences 37(4), 519-545.

Lockett, A., Thompson, S., Morgenstern, U., 2009. The development of the resource-based view of the firm: A critical appraisal. International Journal of Management Reviews 11(1), 9-28.

Lofthouse, V., 2006. Ecodesign tools for designers: defining the requirements. Journal of Cleaner Production 14(15/16), 1386-1395.

López-Gamero, M., Claver-Cortés, E., Molina-Azorín, J., 2008. Complementary Resources and Capabilities for an Ethical and Environmental Management: A Qual/Quan Study. Journal of Business Ethics 82(3), 701-732.

Malhotra, M.K., Mackelprang, A.W., 2012. Are internal manufacturing and external supply chain flexibilities complementary capabilities? Journal of Operations Management 30(3), 180-200.

Malhotra, N.K., 2002. Basic Marketing Research - application to contemporary issues. Prentice Hall, Upper Saddle River.

Marcus, A.A., Geffen, D., 1998. The Dialectics of Competency Acquisition: Pollution Prevention in Electric Generation. Strategic Management Journal 19(12), 1145-1168.

Maxwell, D., van der Vorst, R., 2003. Developing sustainable products and services. Journal of Cleaner Production 11(8), 883-895.

May, D.R., Flannery, B.L., 1995. Cutting waste with employee involvement teams. Business Horizon 38(5), 28-38.

McWilliams, A., Siegel, D., 2001. Corporate Social Responsibility: A Theory of the Firm Perspective. The Academy of Management Review 26(1), 117-127.

Miemczyk, J., 2008. An exploration of institutional constraints on developing end-of-life product recovery capabilities. International Journal of Production Economics 115(2), 272-282.

Mikkola, J.H., 2007. Management of Product Architecture Modularity for Mass Customization: Modeling and Theoretical Considerations. Engineering Management, IEEE Transactions on 54(1), 57-69.

Mikkola, J.H., Skjøtt-Larsen, T., 2004. Supply-chain integration: implications for mass customization, modularization and postponement strategies. Production Planning & Control 15(4), 352-361.

Miles, M.B., Huberman, A.M., 1994. Qualitative Data Analysis: an expanded sourcebook, 2nd ed. Sage Thousand Oaks, California.

Milgrom, P., Roberts, J., 1994. Complementarities and systems: Understanding japanese economic organization. Estudios Economicos 9(1), 3-42.

Milgrom, P., Roberts, J., 1995. Complementarities and fit strategy, structure, and organizational change in manufacturing. Journal of Accounting and Economics 19(2/3), 179-208.

Moorman, C., Slotegraaf, R.J., 1999. The Contingency Value of Complementary Capabilities in Product Development. Journal of Marketing Research 36(2), 239-257.

Morgan, L., Daniels, R., Kouvelis, P., 2001. Marketing/Manufacturing Trade-Offs in Product Line Management. IIE Transactions 33(11), 949-962.

Nelson, R.R., Winter, S.G., 1982. An Evolutionary Theory of Economic Change. Harvard University Press, Cambridge, MA.

Nielsen, K., Joergensen, K.A., Petersen, T.D., Taps, S.B., 2011. Supporting Sustainability and Personalization with Product Architecture 2011 World Conference on Mass Customization, Personalization, and Co-Creation, San Francisco

Pagell, M., 2004. Understanding the factors that enable and inhibit the integration of operations, purchasing and logistics. Journal of Operations Management 22(5), 459-487.

Pane Haden, S.S., Oyler, J.D., Humphreys, J.H., 2009. Historical, practical, and theoretical perspectives on green management. Management Decision 47(7), 1041-1055.

Parmigiani, A., Howard-Grenville, J., 2011. Routines Revisited: Exploring the Capabilities and Practice Perspectives. The Academy of Management Annals 5(1), 413-453.

Pedrazzoli, P., Canetta, L., Sorlini, M., Bettoni, A., Corti, D., Boër, C.R., 2011. Customization and Manufacturing Sustainability – General considerations and footwear investigation 2011 World Conference on Mass Customization, Personalization, and Co-Creation, San Francisco

Peng, D.X., Schroeder, R.G., Shah, R., 2008. Linking routines to operations capabilities: A new perspective. Journal of Operations Management 26(6), 730-748.

Pentland, B.T., Feldman, M.S., 2005. Organizational routines as a unit of analysis. Industrial and Corporate Change 14(5), 793-815.

Petersen, T.D., Nielsen, K., Taps, S., Jørgensen, K.A., 2011. Is Mass Customization Sustainable? , 2011 World Conference on Mass Customization, Personalization, and Co-Creation, San Francisco

Pettigrew, A.M., 1990. Longitudinal field research on change: theory and practice. Organization Science 1(3), 267-292.

Pine, B.J.II, 1993. Mass customization – The New Frontier in Business Competition. Harvard Business School Press, Cambridge MA.

Pine, B.J.II, Victor, B., Boynton, A.C., 1993. Making Mass Customization Work. Harvard Business Review 71(5), 108-118.

Porter, M.E., van der Linde, C., 1995. Green and Competitive: Ending the Stalemate. Harvard Business Review 73(5), 120-134.

Powell, T.C., Dent-Micallef, A., 1997. Information technology as competitive advantage: the role of human, business, and technology resources. Strategic Management Journal 18(5), 375-405.

Premkumar, G., Ramamurthy, K., Saunders, C.S., 2005. Information Processing View of Organizations: An Exploratory Examination of Fit in the Context of Interorganizational Relationships. Journal of Management Information Systems 22(1), 257-294.

Roxas, B., Lindsay, V., 2012. Social Desirability Bias in Survey Research on Sustainable Development in Small Firms: an Exploratory Analysis of Survey Mode Effect. Business Strategy and the Environment 21(4), 223-235.

Rungtusanatham, M.J., Salvador, F., 2008. From Mass Production to Mass Customization: Hindrance Factors, Structural Inertia, and Transition Hazard. Production and Operations Management 17(3), 385-396.

Russo, M.V., Fouts, P.A., 1997. A Resource-Based Perspective on Corporate Environmental Performance and Profitability. Academy of Management Journal 40(3), 534-559.

Salvador, F., De Holan, P.M., Piller, F., 2009. Cracking the Code of Mass Customization. MIT Sloan Management Review 50(3), 71-78.

Salvador, F., Rungtusanatham, M., Akpinar, A., Forza, C., 2008. Strategic capabilities for mass customization: theoretical synthesis and empirical evidence. Academy of Management Proceedings, 1-6.

Salvato, C., 2009. Capabilities Unveiled: The Role of Ordinary Activities in the Evolution of Product Development Processes. Organization Science 20(2), 384-409.

Salvato, C., Rerup, C., 2011. Beyond Collective Entities: Multilevel Research on Organizational Routines and Capabilities. Journal of Management.

Sarkis, J., Zhu, Q., Lai, K.-h., 2011. An organizational theoretic review of green supply chain management literature. International Journal of Production Economics 130(1), 1-15.

Scandura, T.A., Williams, E.A., 2000. Research Methodology in Management: Current Practices, Trends, and Implications for Future Research. The Academy of Management Journal 43(6), 1248-1264.

Schilling, M.A., 2000. Toward a General Modular Systems Theory and Its Application to Interfirm Product Modularity. The Academy of Management Review 25(2), 312-334.

Scott, W.R., 1965. Field methods in the study of organizations, in: March, J.G. (Ed.), Handbook of organizations. Rand McNally, Chicago, pp. 261-304.

Selladurai, R.S., 2004. Mass customization in operations management: oxymoron or reality? Omega 32(4), 295-300.

Sethi, A.K., Sethi, S.P., 1990. Flexibility in manufacturing: a survey. International Journal of Flexible Manufacturing Systems 2(4), 289-328.

Seuring, S., 2010. Sustainability management beyond corporate boundaries. Journal of Cleaner Production 18(10/11), 1118-1119.

Seuring, S., 2012. A review of modeling approaches for sustainable supply chain management. Decision Support Systems. Doi: 10.1016/j.dss.2012.05.053

Sharfman, M.P., Shaft, T.M., Anex, R.P., 2009. The road to cooperative supply-chain environmental management: trust and uncertainty among pro-active firms. Business Strategy and the Environment 18(1), 1-13.

Sharma, S., Vredenburg, H., 1998. Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. Strategic Management Journal 19(8), 729-753.

Simon, M., Poole, S., Sweatman, A., Evans, S., Bhamra, T., McAloone, T., 2000. Environmental priorities in strategic product development. Business Strategy and the Environment 9(6), 367-377.

Simpson, D., Samson, D., 2010. Environmental strategy and low waste operations: exploring complementarities. Business Strategy and the Environment 19(2), 104-118.

Skaar, C., Fet, A.M., 2012. Accountability in the Value Chain: From Environmental Product Declaration (EPD) to CSR Product Declaration. Corporate Social Responsibility and Environmental Management 19(4), 228–239.

Sofer, C., 1961. The organization from within: a comparative study of social institutions based on sociotherapeutic approach Tavistock, London.

Squire, B., Brown, S., Readman, J., Bessant, J., 2006a. The Impact of Mass Customisation on Manufacturing Trade-offs. Production & Operations Management 15(1), 10-21.

Squire, B., Cousins, P.D., Brown, S., 2006b. Collaborating for customisation: an extended resource-based view of the firm. International Journal of Productivity and Quality Management 1(1), 8-25.

Strauss, A., Corbin, J., 1990. Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Sage Publications, Newbury Park, CA.

Surroca, J., Tribó, J.A., Waddock, S., 2010. Corporate responsibility and financial performance: the role of intangible resources. Strategic Management Journal 31(5), 463-490.

Swink, M., Hegarty, W.H., 1998. Core manufacturing capabilities and their links to product differentiation. International Journal of Operations & Production Management 18(4), 374-396.

Tarì, J.J., José, F.M.-A., 2010. Integration of quality management and environmental management systems: Similarities and the role of the EFQM model. The TQM Journal 22(6), 687-701.

Teece, D.J., 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy 15(6), 285-305.

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18(7), 509-533.

Trentin, A., Forza, C., Perin, E., 2012a. Organisation design strategies for mass customisation: an information-processing-view perspective. International Journal of Production Research 50(14), 3860-3877.

Trentin, A., Perin, E., Forza, C., 2011. Overcoming the customization-responsiveness squeeze by using product configurators: Beyond anecdotal evidence. Computers in Industry 62(3), 260-268.

Trentin, A., Perin, E., Forza, C., 2012b. Product configurator impact on product quality. International Journal of Production Economics 135(2), 850-859.

Tseng, M.M., Jiao, J., 1998. Concurrent design for mass customization. Business Process Management Journal 4(1), 10-24.

Tu, Q., Vonderembse, M.A., Ragu-Nathan, T.S., 2001. The impact of time-based manufacturing practices on mass customization and value to customer. Journal of Operations Management 19(2), 201–217.

Tu, Q., Vonderembse, M.A., Ragu-Nathan, T.S., Ragu-Nathan, B., 2004. Measuring Modularity-Based Manufacturing Practices and Their Impact on Mass Customization Capability: A Customer-Driven Perspective. Decision Sciences 35(2), 147-168.

Ulrich, K., 1995. The role of product architecture in the manufacturing firm. Research Policy 24(3), 419-440.

Upton, D.M., 1994. The Management of Manufacturing Flexibility. California Management Review 36(2), 72-89.

Vachon, S., 2007. Green supply chain practices and the selection of environmental technologies. International Journal of Production Research 45(18/19), 4357-4379.

Van de Ven, A.H., Poole, M.S., 1990. Methods for Studying Innovation Development in the Minnesota Innovation Research Program. Organization Science 1(3), 313-335.

van Kleef, J.A.G., Roome, N.J., 2007. Developing capabilities and competence for sustainable business management as innovation: a research agenda. Journal of Cleaner Production 15(1), 38-51.

Van Maanen, J., 1979. The Fact of Fiction in Organizational Ethnography. Administrative Science Quarterly 24(4), 539-550.

von Hippel, E., Katz, R., 2002. Shifting Innovation to Users via Toolkits. Management Science 48(7), 821-833.

Voss, C., Tsikriktsis, N., Frohlich, M., 2002. Case research in operations management. International Journal of Operations & Production Management 22(2), 195-219.

Walker, O.C.Jr, Ruekert, R.W., 1987. Marketing's Role in the Implementation of Business Strategies: A Critical Review and Conceptual Framework. Journal of Marketing 51(3), 15-33.

Whetten, D.A., 1989. What Constitutes a Theoretical Contribution? The Academy of Management Review 14(4), 490-495.

Winter, S.G., 2000. The Satisficing Principle in Capability Learning. Strategic Management Journal 21(10/11), 981-996.

Winter, S.G., 2003. Understanding Dynamic Capabilities. Strategic Management Journal 24(10), 991-995.

Wong, C.W.Y., Lai, K.H., Shang, K.C., Lu, C.S., Leung, T.K.P., 2012. Green operations and the moderating role of environmental management capability of suppliers on manufacturing firm performance. International Journal of Production Economics 140(1), 283-294.

Yin, R.K., 2009. Case Study Research: Design and Methods, Fourth Edition ed. SAGE Publications, Thousand Oaks, CA.

Zander, U., Kogut, B., 1995. Knowledge and the Speed of the Transfer and Imitation of Organizational Capabilities: An Empirical Test. Organization Science 6(1), 76-92.

Zhang, X., Huang, G.Q., Humphreys, P.K., Botta-Genoulaz, V., 2010. Simultaneous configuration of platform products and manufacturing supply chains: comparative investigation into impacts of different supply chain coordination schemes. Production Planning & Control 21(6), 609-627.

Zhang, X., Huang, G.Q., Humphreys, P.K., Botta-Genoulaz, V.r., 2008. Simultaneous configuration of platform products and manufacturing supply chains: comparative investigation into impacts of different supply chain coordination schemes. Production Planning & Control 21(6), 609-627.

Zipkin, P., 2001. The Limits of Mass Customization. MIT Sloan Management Review 42(3), 81-87.

WRITING THE THESIS

"Piled Higher and Deeper" by Jorge Cham
www.phdcomics.com