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Managing Employees in Industry 4.0

Manufacturing Small and Medium Enterprises

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“They gave me this body
made of carbon fibre and metal alloys,
optical fibre and sophisticated plastic laminates,
polymers, polymers, high deserved polymers.
Do you know what I did? I gave my body for this experiment, mine!
And now everybody is interested in me; they are willing to explain to me
what until yesterday was exclusive for scientists,
for whom for whom for whom if not for me?
I am the nexus, you can ask me, you can ask me!
Of a human, I only have left the stomach and the brain.
Come and find out that scientists do not lie. Come and ask me.
Come to discover that every scientist differs from the other,
they never agree with each other,
that every scientist is right, but some more than others.
That they do not study for gold,
that they need the support,
because scepticism is their
daily bread, daily bread, daily bread.
This is a biblical expression,
Forget about it!
Sometimes scientists forgot what they have eaten,
Not even close to daily bread!”

“Ecce Robot” by Uochi Tochi, 2012, La Tempesta Dischi.

"Mi hanno dato questo corpo di fibra di carbonio e leghe di metalli,
fibra ottica e sofisticati laminati plastici,
polimeri, polimeri, meritatissimi polimeri.
Sapete cosa ho fatto?
Ho dato il mio corpo per questo esperimento, il mio!
E adesso tutti mi attendono, mi spiegano molto volentieri
ciò che fino a ieri
era esclusivo solo per chi studia, per chi, per chi,
per chi se non per me?
Sono la connessione, puoi chiedere a me, puoi chiedere a me!
Di umano mi rimangono lo stomaco e il cervello.
Vieni a scoprire che gli scienziati non mentono.
Vieni a chiedere a me.
Vieni a scoprire che gli scienziati sono diversi tra di loro,
non sono mai d'accordo tra di loro,
che hanno tutti ragione, chi più chi meno.
Che non studiano per ottenere l'oro,
che hanno bisogno di supporto perché lo scetticismo
è già il loro pane quotidiano, pane quotidiano, pane quotidiano,
è un'espressione di preghiera, la saltiamo!
A volte lo scienziato dimentica cos'ha mangiato,
Altro che pane quotidiano!"

"Ecce Robot" by Uochi Tochi, 2012, La Tempesta Dischi.

Abstract – English

Industry 4.0 is one of the most discussed and anticipated phenomena of the last period. Introduced initially in the Hanover Conference in 2011, this term, and its relative concept, has not yet found unanimous consensus within the scientific community. However, researchers commonly refers to Industry 4.0 as the fourth Industrial Revolution (Hermann & Pentek, 2015). Its main impact is on the industrial production system and the management of employees. Especially on this last issue, Industry 4.0 will have dramatic consequences. The automation will cause a loss of jobs between 400 and 800 million (Manyika, Lund, Chui, Bughin, & Woetzel, 2017) by 2030. The challenge of Industry 4.0 becomes of paramount importance for small and medium-sized enterprises (SMEs), which have already been competing in a globalised market for years and have harshly suffered from the financial crisis of 2008. The modest size and the limited investment possibilities require skilful use of resources, both economic and human. In this perspective, human resources management (HRM) has the delicate task of ensuring the implementation of the Industry 4.0.

To highlight the impact of industry 4.0 on companies and especially on HRM, this thesis present three literature reviews. In the absence of direct research on Industry 4.0 and HRM the purpose of these reviews was to highlight the role of HRM within the manufacturing sector. This dissertation contains the three research questions spreading from the literature reviews. Due to the exploratory nature of the study, Multiple Case Studies (Yin, 2009) were selected as the methodology for answering the research questions.

Five companies were analysed, four Italian and one Dutch. The interviews conducted led to the identification of six propositions. The results of this thesis point to the identifications of some HR practices which are a direct consequence of Industry 4.0 implementation. Moreover, the dissertation identified a framework that shows how companies have grown in maturity both in the application of 4.0 and the sophistication of practices. Companies have improved their practices along with the maturity of the Industry 4.0.

Abstract - Italiano

L'Industria 4.0 è uno dei fenomeni più anticipati ed attesi dell'ultimo periodo. Originariamente introdotto all'interno della conferenza di Hannover nel 2011, questo termine, ed il suo relativo concetto, non ha ancora trovato riscossione unanime all'interno della comunità scientifica. Tuttavia, Industria 4.0 viene comunemente definito come la quarta rivoluzione industriale (Hermann & Pentek, 2015). I suoi effetti ricadono sui sistemi di produzione industriale e la gestione delle risorse umane. Specialmente su quest'ultima tematica, Industria 4.0 avrà conseguenze grame. L'automazione causerà entro il 2030 una perdita di posti di lavoro compresa tra i 400 e gli 800 milioni (Manyika, Lund, Chui, Bughin, & Woetzel, 2017). La sfida dell'Industria 4.0 diventa di fondamentale importanza per le Piccole e Medie Imprese, le quali già da anni si trovano a competere in un mercato globalizzato e che molto hanno risentito della crisi finanziaria del 2008. La dimensione modesta e le scarse possibilità di investimento, richiedono un sapiente uso delle risorse, economiche e umane. In tale prospettiva, la gestione delle risorse umane ha il compito delicato di assicurare l'implementazione dell'Industria 4.0 nonché provvedere alle necessità aziendali.

Al fine di evidenziare l'impatto dell'Industria 4.0 sulle aziende e specialmente sulla gestione delle risorse umane, questa tesi ha condotto delle revisioni della letteratura. In assenza di letteratura diretta sul 4.0 e sulla gestione risorse umane, lo scopo di queste revisioni è stato quello di evidenziare il ruolo della gestione risorse umane all'interno del settore manifatturiero. In questo modo sono state identificate tre research questions.

Cinque aziende sono state analizzate, quattro italiane e una olandese. Le interviste condotte hanno portato all'identificazione di sei propositions, che hanno risposto alle research questions. I risultati di questa tesi portano all'identificazioni di alcune pratiche di gestione risorse umane che sono conseguenza diretta dell'implementazione dell'Industria 4.0. La tesi ha anche identificato un framework che mostra come le aziende siano cresciute in maturità sia relativa all'implementazione del 4.0 che della maturità delle pratiche.

Acknowledgements

Era il 1999 quando Oliver Stone diresse "Any Given Sunday", tra diversi momenti topici, uno dei più famosi è il discorso motivante del suo protagonista. Assieme a questo, è memorabile la frase "quattro secondi durano una vita, abbiamo tutt'una vita davanti". Questo dottorato è durato 3 anni, che sono un sacco di quattro secondi messi insieme. Un sacco di vite, un sacco di esperienze, i cui ricordi ed emozioni sono indissolubilmente legati alle persone con cui tali esperienze sono avvenute. Tre anni, tre città, due nazioni, molte persone che hanno incrociato la mia linea della vita, che hanno condiviso quattro secondi. Quattro secondi di gioia, di passione, di ansia, di difficoltà e via discorrendo fino a toccare tutte le emozioni raffigurate in "Inside Out".

Sebbene citare tutti uno per uno non sia possibile, voglio ringraziare calorosamente tutti coloro sentano di aver avuto un impatto nella mia vita, nel bene e nel male.

Tuttavia, alcune menzioni si rendono necessarie. Per primo desidero ringraziare Fabrizio ed Eleonora, per il grande supporto morale. Marcos per aver allietato le mie pause caffè. Un ringraziamento anche ai miei amici del cuore, che mi hanno sempre accolto con rinnovato amore nonostante la distanza. La mia famiglia per essere sempre stata un'ancora nei periodi di burrasca. E infine ringrazio Sara, la mia Penelope, che per quattro secondi lunghi tre anni ha sopportato il mio navigare a vista nel mare del dottorato.

It was 1999 when Oliver Stone directed "Any given Sunday", between several topical moments, one of the most famous is the motivating speech of the main character. Along with this is memorable the phrase "four seconds is a lifetime, we are a lifetime away". This PhD lasted three years, which are a lot of four seconds put together. Many lives, a lot of experiences, whose memories and emotions are indissolubly linked to the people with whom such experiences have occurred. Three years, three cities, two nations, many people who crossed my life, who shared four seconds. Four seconds of joy, passion, anxiety, difficulty and so on to touch all the emotions depicted in "Inside Out".

Although mentioning all one by one is not possible, I want to warmly thank all those who feel that they had an impact in my life, for better or for worse.

However, some mentions are necessary. First, I want to thank Fabrizio and Eleonora, for the tremendous moral support. Marcos for sharing my coffee breaks. To my best friends, who have always welcomed me with renewed love despite the distance. My family to have always been an anchor in times of Gale. Moreover, I want to thank Sara, my Penelope, who for four seconds long three years has endured my surf in the sea of the doctorate.

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Summary

1. Introduction

Industry 4.0 term appeared for the first time in 2011 at the Hannover Conference in Germany. It is a strategic plan developed by Germany; its goal is to develop high tech manufacturing companies (Hermann & Pentek, 2015; Schrauf & Berttram, 2016). Since its initial introduction different definitions and conceptualisation of Industry 4.0 keep spreading and, currently, despite the expectations, there is still no definition of Industry 4.0 which reached a unanimous consensus (Hermann & Pentek, 2015). The lack of consensus is related to Industry 4.0 being the first industrial revolution predicted through the signals coming from the market (Hermann & Pentek, 2015). Therefore, Industry 4.0 implementation effects are mostly hypothesis. Cyber-Physical System is one enabler of Industry 4.0 (Baheti & Gill, 2011). In such a new system, the interactions between humans and machines happen in new ways. Sensors allow communications between machines, and between machines and workers (Rüßmann et al., 2015). Even if this kind of Communication was impossible until last few years, it is now facilitated by the decreasing cost of sensors. Industry 4.0 requires firms to invest in implementing a set of technologies (e.g. Cloud, Additive Manufacturing, CyberSecurity, Big Data Analytics). Many companies took risks associated with being early adopters of these technologies. Industry 4.0 implementation should result in increased firm performance (Hermann, M.; Pentek, 2015; Rüßmann et al., 2015), due to improvement on the production side. Therefore, companies look at Industry 4.0 as a source of competitive advantage.

Along with opportunities, Industry 4.0 poses serious challenges (Seifert, 2018). The introduction of interconnected systems influences heavily the way employees work. Some studies predict that automation resulting from Industry 4.0 implementation will take away between 400 and 800 million jobs (Manyika, Lund, Chui, Bughin, & Woetzel, 2017). Therefore, dramatic questions arise about the future of work. The literature about Human Resource Management highlight workers' crucial role in companies (Pfeffer, 1994). Employees' work in Industry 4.0 firms is even more critical, especially for workers engaged in production processes. Supervising machines become the new focus of employees, as well as maintaining machines to avoid any stop in production.

Consequently, companies need more specialised workers, therefore pushing firms in competing for such a specialised workforce. HR function would need to assist managers

in implementing Industry 4.0. Another area needing HR assistance is related to the skills shortage (Dychtwald, Erickson, & Morison, 2006; Sheldon & Li, 2013). Companies need to invest in HR practices, while HR need to be effective in providing the technical skills needed to fill the skill-gaps.

Publications with a management perspective about Industry 4.0 are lacking. Moreover, most studies on this topic are targeting big corporation, therefore neglecting Small and Medium-Sized Enterprises (SMEs). In Italy, SMEs account for the 78.6% of the employment in the non-financial business sector. These data demonstrate the size and economic importance of the SMEs sector in general, with a particular focus on Italy. However, such importance does not emerge in the literature. Related to the Human Resource Management, most of the studies explore the relationship between High-Performance Work Practices (HPWPs) and performance (Huselid, 1995; McDuffie, 1995) in big companies. Fewer researches explored the impact of such practices on small and medium-sized firms. However, some authors (Wu, Bacon, & Hoque, 2014) suggest SMEs are adopting HPWP which also lead to improved performance (Faems, Sels, De Winne, & Maes, 2005; Sels et al., 2006; Way, 2002). However, combining SMEs could hinder the different response these firms have to HPWP (Baron, Hannan, Hsu, & Koçak, 2007).

1.1 Thesis overview

This thesis has the purpose of exploring HRM inside SMEs that are implementing Industry 4.0. It also looks at the impact Industry 4.0 has on HR practices. Industry 4.0 is one of the fastest growing research topics for both practitioners and academics (Hermann et al. 2015). Publications about this topic are booming in the last few years, Engineering and Computer Science scholars are the main contributors. Despite being on the rise, research papers with a managerial perspective are still less than Engineering and Computer Science.

This research is significant as the theme of Industry 4.0 draws the attention of both representatives of the economic life and academics. Practitioners are interested because Industry 4.0 will boost firms' efficiency. Academics' interest is related to the

consequences Industry 4.0 have in several disciplines, especially Human Resource Management (Sivathanu & Pillai, 2018), which is the focus of this Ph.D. thesis.

Prior research in this field is available only related to the engineering side of how to configure and create an Industry 4.0 running company. Since this topic is new, literature within the management field about this topic it is almost not existent. Only recently researchers have begun exploring the topic. In the past, manufacturing scholars posed attention to various production models such as Lean Management or Environmental Management (Jabbour, De Sousa Jabbour, Govindan, Teixeira, & De Souza Freitas, 2013). In these cases, HRM researchers focused on discovering which HRM practices were supporting the implementation of these production models.

To address the aim of the research was chosen a qualitative analysis based on multiple case studies (Yin, 2009). The objective of this study is discovering the impact Industry 4.0 has on Small and medium-sized enterprises.

1.2 Research interest's background area

Industry 4.0 concept was introduced at the Hannover conference in 2011. However, despite the support of the German government, this phenomenon does not have a clear and shared definition yet (Hermann & Pentek, 2015; Schrauf & Berttram, 2016). According to Hermann & Pentek (2015) the lack of agreement about what is and what impact could have Industry 4.0, led to a sophisticated development of the field. Terms such as Smart Production, Smart Manufacturing, Smart Factory, and Advanced Manufacturing are synonyms for Industry 4.0. Moreover, the authors identified Industry 4.0's key elements: Internet of Things, Internet of Services, Smart Factories, and Cyber-Physical Systems (CPS). According to Porter & Heppelmann (2014), IoT and IoS are not vital elements but a communication system that is used and fostered by CPS.

Schrauf & Berttram (2016) relied on the Industry 4.0 definition provided by the German government: "Industry 4.0 is best understood as a new level of organisational control over the entire value chain of the life cycle of products, it is geared towards increasingly individualised customer requirements". Moreover, Koch (2015) identified the expectations of managers related to Industry 4.0 implementation: the creation of

smart products, change of the business model, Horizontal cooperation, integration of data as well as big data analysis. Therefore, Industry 4.0 is about the creations of smart products, as well as new business models. Only through a change in the business model companies could fully benefit from Industry 4.0

Industry 4.0 is often indicated as the next industrial revolution. These high expectations further complicate the field's development.

The first industrial revolution dealt with kinetic and thermal energy (Deane, 1979). Electricity enabled the second industrial revolution (Mokyr, 1998), which allowed to mass produce goods. Moreover, this revolution changed the production model of many companies. The third industrial revolution is the most recent of the three, and computers enabled it (Jensen, 1993). Part of this dissertation found evidence of this third revolution in section 2.2.2, which analysed the period 1984-1995, in the middle of the computerisation era.

The fourth industrial revolution should be enabled by the Cyber-Physical System (J. Lee, Bagheri, & Kao, 2015) created, which will transform the role of the employees. Blue collars will no longer exist (Brynjolfsson, 1993), shifting from working with machines to supervising machines. Therefore, this creates severe challenges for HRM.

1.3 The key role of manufacturing SMEs

The thesis is carried considering manufacturing SMEs located in two main business contexts, i.e. Italy and Netherland, briefly discuss below.

Italian context. A research carried out by Boston Consulting (Michael et al., 2015) distinguished between "early adopters" (Germany, USA, Japan, South Korea) and "laggards" (Austria, Belgium, France, Italy and Spain). Early adopters countries have already started to implement Industry 4.0. On the contrary, countries that are slow in the adoption of new technologies are defined as laggards. Italy falls under this label due to the cost associated with the labour cost, the rigidity of the labour market, and the cost associated with the new machinery and the re-skilling process.

There are several reasons for Italy being among the Laggard countries. The crisis that hit the world in the last years harshly impacted on Italy as well. During the financial crisis, thousands of companies bankrupted leading to a high unemployment rate. Moreover, this crisis affected Italy's economic growth capacity. For several years the country struggled to grow. According to the Italian Institute for Statistics (ISTAT), in 2017 Italian GDP grew of 1,6% compared to 2016. Several factors contributed to the Italian recovery. The price of the raw materials is one of the most important due to the relevance of Italian industrial production.

Roland Bergers Consultants carried out another research about Industry 4.0 called "Think Act" (Blanchet, Rinn, Von Thaden, & De Thieulloy, 2014) where it was provided a readiness index that identified four clusters of organizations (i.e. Front-Runners, Potentialist, Traditionalist, Hesitators). These clusters are identified according to the relevance of the Manufacturing sector on the country GDP and on the general readiness to Industry 4.0. Similarly to Michael et al. (2015), Italy is positioned inside the "Hesitators" countries, which means a "lack a reliable industrial base. Many of them suffer from severe fiscal problems and are therefore not able to make their economies future-proof" (Blanchet, Rinn, Von Thaden, & De Thieulloy, 2014).

The productive Italian system is composed of two groups of companies: Multinational companies with huge turnover and Small-Medium Sized Enterprises (SMEs). SMEs suffered from the financial crisis the most. The crisis impacted them due to their small size and their business model (Bottoncini, Pasetto, & Rotondi, 2016). Therefore, these companies need to remain competitive to survive. Industry 4.0 could help firms to innovate, deliver high-quality products and remaining competitive (Rüßmann et al., 2015). However, due to the size of the Italian SMEs, it is quite often impossible to implement changes in the production process. Technological innovation requires much money which SMEs do not usually have. For similar reasons, the Italian SMEs also lacks attention to the Research and Development. The reasons mentioned above pushed the researcher's attention towards the impact Industry 4.0 have on SMEs. Therefore, the context of the study are manufacturing SMEs who started the implemention of Industry 4.0. For this purpose are analysed inside this Ph.D. thesis four Italian SMEs and one Dutch SME.

Netherland context. The SMEs are relevant also in the Netherlands, a recent report of the European Commission (Small Business Act, 2018) indicated Dutch SMEs to be responsible of the 67% of the employment in the private sector. Similarly to Italy, according to the above mentioned report "SMEs employment has still not fully recovered from the crisis, remaining at 2.0 % below the 2008 level" (Small Business Act, 2018). Dutch SMEs are positioned inside the "Potentialist" cluster (Blanchet, Rinn, Von Thaden, & De Thieulloy, 2014) which means "their industrial base has been weakening over the past few years" but companies are "modern and [have an] innovative mindset" (Blanchet, Rinn, Von Thaden, & De Thieulloy, 2014).

The small size of the case studies (four Italians and only one Dutch) do not allow to draw proper conclusion about any country-related difference such as the culture. Limitations and the possibilities for future research of this Ph.D. thesis, further analyse this situation.

1.4 Impact on HRM

The previous sections in this chapter provided information related to the thesis structure, introduced the concept of Industry 4.0 and motivated the researcher's interest in analysing SMEs.

Another area impacted by Industry 4.0 is the Human Resource Management (HRM). Industry 4.0 impact is prevalently a mix of expectations and hypothesises. However, the automation of the production process will impact on several actors, in several ways (Manyika et al., 2017; Rüßmann et al., 2015). Unemployment is one of the expected outcomes of this automation process (Tullini, 2017). Moreover, Industry 4.0 impact will be prominent on workers in line (Tiraboschi & Seghezzi, 2016). The HR function must provide solutions to companies implementing industry 4.0. Literature combining Industry 4.0 and HRM is still missing. However, it is since the 1980s that the fundamental role HRM plays in organizations is highlighted. Manufacturing firms who benefit from the computerisation or firms investing in environmental management (Jabbour, Santos, & Nagano, 2010), have dealt with the related issues. Therefore, this dissertation focuses on the HRM and investigate the literature of the manufacturing area. The literature

review on this topic allows understanding the central role played by the HR function. Moreover, it supports the identification of the research questions and the case studies investigation. The analysis of the data collected with the case studies, allow the identification of the impact Industry 4.0 had on the HR practices.

1.5 Chapter structure and thesis structure

The contribution of this research study is relevant to the management of SMEs who are implementing Industry 4.0. As anticipated, Industry 4.0 play a critical role in organisational growth. This research addresses several gaps emerged from the literature reviews, and thus it wants to shed light on the way the Industry 4.0 impact upon the management of the employees. Small and medium-sized enterprises were the type of firms selected for the analysis, 4 in north Italy, 1 in the south region of the Netherlands. The research study is organised into six chapters. Each chapter is organised into sections. Each section is organised in super-section. Each super-section has some sub-section.

Chapter One has just introduced the significance and relevance of Industry 4.0, along with the context under investigation. Moreover, this chapter as briefly introduced the reasons for the research interest in HRM.

Chapter Two reviews the literature on Human Resource Management and Industry 4.0, it explores the research issues in more depth. Moreover, in the second chapter, there are three sections. Each section analyses the literature adding new information needed to overcome the lack of study focusing on Industry 4.0. Two of the literature reviews were analysis with the bibliometric technique called co-word analysis (Cobo, 2011)

Chapter Three gives a detailed discussion of the methodology used in the study, focusing on the Cases Studies showing some extract from the Research Protocol. The chapter is divided into five sections: the choice of the methodology, Research Design, Data Collection, Data analysis, The quality of the research.

Chapter Four enfold the Within-case analysis. This chapter profoundly investigates five companies. Due to the sensitive nature of the data, the real name of the companies or interviewees is replaced by their initial letters. For each company, this chapter provides findings of the firm way of implementing Industry 4.0. It also shows if, and how, Industry 4.0 could impact HRM.

Chapter Five presents the Cross-case analysis, comparing the findings emerged from the previous chapter. Moreover, this chapter provides the six identified propositions.

Chapter Six concludes providing the contributions to theory and methodology, as well as managerial implications. Moreover, this chapter provides the limitations of the study and future research directions as well.

2. Literature Reviews and Research Questions

2.1 Overview of the chapter

The first section introduces the broad theme of Human Resource Management (HRM), in order to allow the identification of under-investigated areas. In particular, it explains what brought to the investigation of Industry 4.0 in Small and Medium Enterprises (SMEs). Moreover, it shows the lack of study surrounding HRM and Industry 4.0, especially combined. The importance of HR practices emerged from the literature reviews conducted. Therefore, this chapter also analyses the literature about High-Performance Working Practices (HPWP). One of the main aims of this chapter is the identification of the gaps spreading from the literature, which allow the subsequent identification of the research questions. The chapter ends with the definition of the research questions that this dissertation answers.

2.2 Literature review about Human Resource Management

Megatrends influence Human Resource Management (HRM) and Manufacture (Rump, 2011; Ulrich and Dulebohn, 2015). The megatrends impact on the HR Functions determine changes in its structure, according to Ulrich (2005) they affect the "nature of HR". The most acknowledge trends in literature are: Economic trends; Political trends; Technological trends; Social trends; Environmental trends and Demographic trends (Ulrich, Kryscynski, Brockbank, & Ulrich, 2017). Recently, technological innovation is becoming crucial for manufacturing firms as well as HRM. New technologies (e.g.

Autonomous Robots, 3D printing) are changing the production. The adoption of these technologies is named differently: Smart Manufacturing (Kang et al., 2016), Industrial Internet of Things (Kiel, Müller, Arnold, & Voigt, 2017). However, one of the most famous is Industry 4.0 (Hermann, Pentek and Otto, 2016). According to many authors, Industry 4.0 has the potential to become the fourth industrial revolution. It also changes the way of managing employees. Industry 4.0 enables the creation of Cyber-Physical System (Meißner, 2015) in which blue collars shift from working in line, to supervise machines. The disruptive nature of Industry 4.0 requires HRM to be ready to face changes and to provide practitioners with solutions.

In order to understand what HRM should do, the best way is to analyse what are the crucial topics related to HRM in manufacturing companies. For this reason, this section focused on a literature review that investigates HRM and Manufacture, since the birth of HRM. However, to strengthen the results, no time limitations were posed. Therefore, the first identified paper is dated 1984. Due to the high numbers of publications retrieved, this literature was conducted using a co-word analysis (Cobo et al., 2011). Three periods of time were created in order to highlight the topics' evolution over time.

Moreover, the first period begins date is related to the first publications (1984). Second-period start date is related to Huselid (1995) seminal work. In order to facilitate comparisons, all the periods have a similar time length.

-First period: 1984 – 1994;
-Second period: 1995 – 2006;
-Third period: 2007 – 2017.

The analysis found HR practices to have a positive effect in implementing different kind of managerial model: Lean Management, Supply Chain, Total Quality and Environmental Management. While the link between HR and those models is developed, the role of technological innovation is often a marginal aspect that can be found related to new product development, while its role as revolution forces seems not debated. Moreover, a study linking HRM and Industry 4.0 is still lacking. Section 2.2.5 provides details about the results of this analysis

2.2.1 Co-word analysis

HRM literature attracts publications from authors belonging to different discipline (e.g. Management, Psychology, Sociology, Economics). Therefore, HRM is one of the fields of research containing the highest number of publications and is labelled as one of the most difficult to navigate (MacDougall, Baur, Novicevic, & Buckley, 2014). With this in mind, the selection of the keywords must be conducted with scrupulous attention. Choosing wrong or unfocused keywords could potentially lead to a high number of documents. Therefore, it would not be possible to draw proper conclusions. Interviews with Practitioners and Academics allowed to identify the keywords. The interviews were semi-structured and focused on discussion with different people from different background and different job-position, about the expectations related to Industry 4.0, and its impact as well. Table 1 provide information about the experts interviewed that allowed to better define the keywords.

Table 1 - People interview for defining keywords

Expert	Institution/Organization	Focus	Duration
IT Manager	Medium company operating in mechanical sector	Industry 4.0 Technologies	30 min
Operations Manager	Medium company operating in mechanical sector	Industry 4.0	1hour
HR Manager	Medium company operating in mechanical sector	Human Resource Management inside the firm	45 min
Full Professor	Italian University	Industry 4.0 and HRM	1hour
Associate Professor	Italian University	Industry 4.0 and HRM	1hour

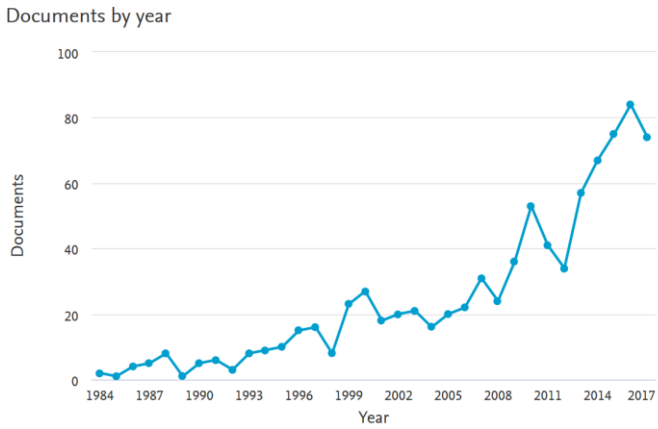
These interviews allowed the researcher to deepen the knowledge about the research topic of interest. Moreover, it allowed for a better selection of the proper keywords to use for querying the scientific databases. Table 2 shows the selected keywords.

Table 2 - Keywords searched

HRM Area	Context
"Human Resource Management"	"Supply Chain"; "Production"; "Factory"; "Manufacturing.

For answering the research purpose, the researcher did not put any time limitations. The research's context was limited to manufacturing companies. The keywords were searched in the title, abstract and keywords section of every publication. The only articles selected in the English language and peer-reviewed. Figure 1 shows the publications' trend of the full period. The generally positive trend in publications suggests the idea of manufacturing companies interested in the topic related to HRM.

Figure 1 - Documents by year - Full period



The analysis brought to the identification of several publications. Table 3 provides a list of the most cited articles, provide information about the publications name, the authors, the year of publications, the source and the number of citations.

Table 3 - Most cited article - full period

Article name	Authors	Year	Source	Citations
A framework for quality management research and an associated measurement instrument	Flynn, Schroeder, & Sakakibara.	1994	Journal of Operations Management 11(4), pp. 339-366	1096

Human resource management, manufacturing strategy, and firm performance	Youndt, Snell, Dean Jr., & Lepak.	1996	Academy of Management Journal 39(4), pp. 836-866	1084
Lean manufacturing: Context, practice bundles, and performance	Shah & Ward.	2003	Journal of Operations Management 21(2), pp. 129-149	1069
Integrating Strategic, Organizational, and Human Resource Perspectives on Mergers and Acquisitions: A Case Survey of Synergy Realization	Larsson & Finkelstein.	1999	Organization Science 10(1), pp. 1-26	568
The modern call centre: A multi-disciplinary perspective on operations management research	Aksin, Armony, & Mehrotra	2007	Production and Operations Management 16(6), pp. 665-688	347
The impact of human resource management practices on operational performance: Recognizing country and industry differences	Ahmad & Schroeder.	2003	Journal of Operations Management 21(1), pp. 19-43	320
Lean viewed as a philosophy	Bhasin & Burcher.	2006	Journal of Manufacturing Technology Management 17(1), pp. 56-72	311
Human resource management and performance	Wood	1999	International Journal of Management Reviews	293
Managing customers as human resources in service organisations	Bowen.	1986	Human Resource Management 25(3), pp. 371-383	264
The relationship between strategic priorities, management techniques and management accounting: An empirical investigation using a systems approach	Chenhall & Langfield-Smith.	1998	Accounting, Organizations and Society 23(3), pp. 243-264	261

The analysis is conducted with the use of the software Scimat (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2012). This software performs different tasks and type of analysis. Moreover, it can produce descriptive statistics and bibliometric technique

calculations with different unit of analysis (words, citation, authorship). Table 4 contains all the information, and parameters used to conduct the analysis.

Table 4 - Parameters used for the analysis

Period	Starting Date: January 1984 Collection Date: April 2017
Database	Scopus
Unit of analysis	Keywords
Data reduction threshold	5
Network reduction threshold	1
Matrix	Co-occurrence
Normalization	Equivalence Index
Cluster algorithm	Simple centre algorithm Min 3- Max 15
Document Mapper	Union Mapper
Quality index	H-index, Sum of citations
Analysis	Strategic Diagram

As for conducting this literature review, this dissertation adopts the methodology of Callon, Courtial, & Laville (1991) and Martínez, Cobo, Herrera, & Herrera-Viedma, (2015). Figure 2 depicts the eights steps of the co-word analysis adapted from Martínez et al. (2015) (i.e. Data Retrieval, Preprocessing, Network Extraction, Normalization, Mapping, Analysis, Visualization, Interpretation).

Figure 2 - Workflow of the analysis (Cobo, 2012)

Among all, the step named "Preprocessing" is crucial: since data may contain several issues (such as misspelling, duplication) secure the goodness of the data it is of great importance.

The analysis resulted in a map of clusters, which constitutes themes of research, placed in a strategic diagram (Callon et al., 1991), which use two factors: Centrality and Density.

Centrality refers to the number of links a cluster have with other clusters. When many links link to cluster, that cluster represents a crucial theme investigated by the academics. On the other hand, Density assesses the strength of the links between the keywords that compose the cluster, and it gives an idea of how will develop that field in the future. In other words, a field of research is composed of themes mapped by these two factors. Themes can be of four type (depicted in Figure 3).

1) *Motor themes:* strong centrality, strong density. Themes in this quadrant are well developed and central to the other clusters.

2) *Highly developed and isolated themes*: themes well developed inside, but with the low external connection.

3) *Emerging or declining themes:* themes in this quadrant are not developed, and they also have a reduced internal connection.

4) *Basic and transversal themes:* they are essential to the research field, but they do not possess a reasonable degree of development.

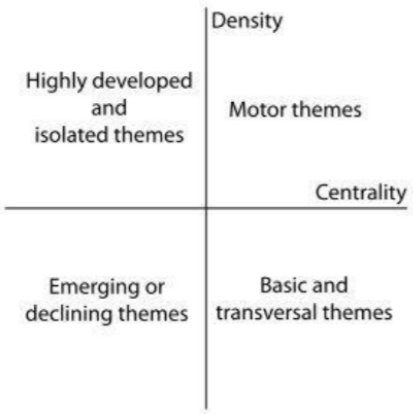


Figure 3 - Strategic Diagram

The analysis is completed adding a third dimension: the H-index. The H-index "depends on both the number of a scientist's publications and the impact of the papers on the scientist's peers"(Hirsch, 2005). In this way, clusters are displayed as balls, where the more prominent is the ball, the more critical is the cluster.

The division analysis' period in three sub-periods allowed to track changes over time. Figure 4 shows the evolution of the cluster. It is important to note from Figure 4 that three clusters in the first period (i.e. Management, Human-Resource-Management, and Manufacturing) vastly contributed to the development of the Personnel theme of

research. Moreover, the cluster in figure 4 supports the importance of HRM themes of research for manufacturing companies.

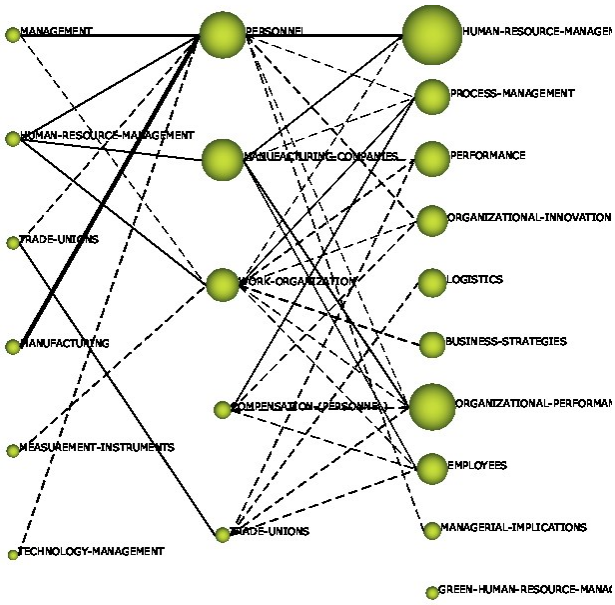


Figure 4 - Cluster evolution over time

Before investigating each period, another evidence about the importance of HRM could be drawn from the analysis of the keywords' distribution over time (Figure 5). The high number of new keywords entering in the second period (figure 5) indicate this period has the one contributing more to HRM's literature development. The third period shows the highest absolute number of keywords. However, only 170 keywords are new. The number of keywords suggests two things: the field is expanding towards a new topic while also paying attention to the already existing ones.

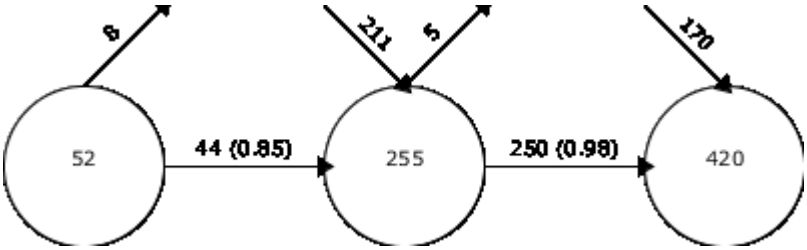


Figure 5 - Overlapping keywords

2.2.2 First period 1984- 1994

The literature in the first period shows fewer papers than the other two periods. Figure 6 shows the trend of publication over time. It contains the number of publications of each year, from 1984 to 1994. The interest in the research topic is generally positive and growing, with a fall back only in 1989. Moreover, the countries that are mostly interested in the development of this topic is the United States and the United Kingdom (Figure 7). Such a considerable interest of the United States and the UK towards the topic found legitimacy in the crucial role American and British researchers had in the development of the Human Resource Management (HRM) field, as well as the other employees' management approach.

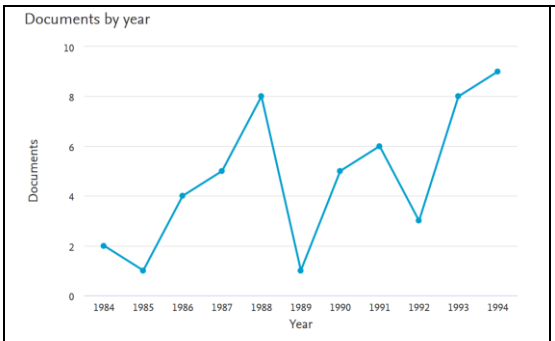


Figure 6 - Documents by Year - 1st Period

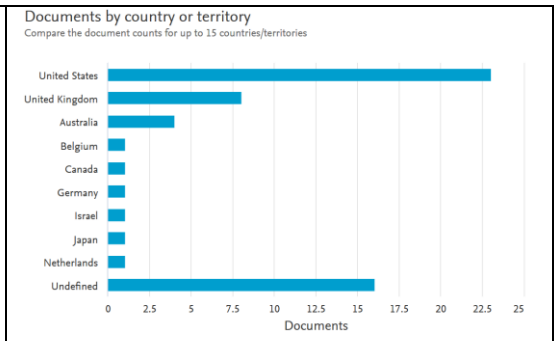


Figure 7 - Documents by Country - 1st Period

The co-word analysis conducted allowed the identification of six themes of research: namely: Management, Human-Resource-Management, Technology-Management, Measurement-Instruments, Manufacturing and, lastly, Trade-Unions. Figure 8 shows the strategic diagram obtained, which shows the different disposition of the themes in the different areas of the diagram. Themes' size is related to the H-index of every theme; each cluster shows the H-index number under the cluster's name. The H-index shows that the relevant topic is Management, Human-Resource-Management and Manufacturing, with the last two positioned in the motor themes quadrant. Moreover, all the clusters show an H-index low level; this could be related to different reasons such as the recent introduction of the Human Resource Management approach.

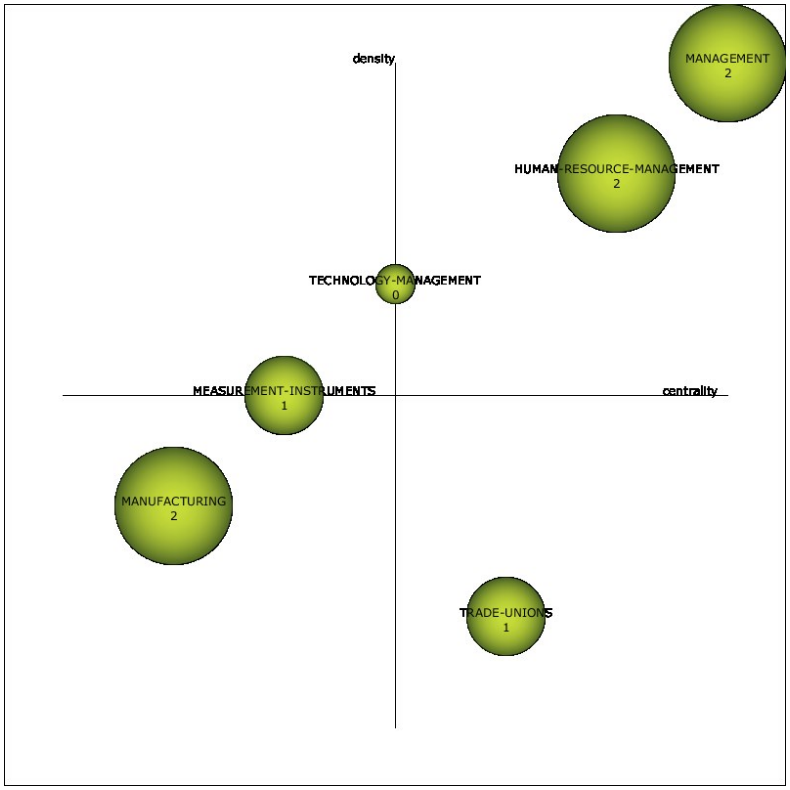


Figure 8 - Strategic Diagram of the 1st period

Evidence emerging from the analysis of the Strategic Diagram are supported by the literature of this historical period, which reflect the changes happened in the '80s. During this time computers started to be mass-adopted by companies, who were interested in automation and curious about the success of Japanese organisations. Therefore, during this first period of analysis (1984 – 1995) the topic that attracted the interests of the literature were: computerisation, automation and, in general, Japanese techniques of manufacturing (e.g. Lean Manufacturing, Just in time). Despite authors' interest in Japanese Manufacturing, actual papers made by Japanese researchers are lacking. Therefore, indicating Japanese firms to be the object of these researches. In the literature discussing Japanese production, HRM is often indicated as one of the crucial factors for the Just in Time model. Reason for the success of companies adopting Japanese production was not agreed by all the literature (Keys & Miller, 1984), while one of the critical success factors seem to be related to the human resource development maximisation (Hatvany & Pucik, 1981).

Moreover, the importance of HRM in Just in time production is highlighted by Deshpande, Golhar, & Stamm (1994), which found that a dedicated and specialised workforce is necessary, therefore "HRM strategies are suggested in staffing, training and

development, compensation and employee retention that will result in the development of a JIT workforce".

In general, the salience of HRM-related to three above mentioned topics is similar: according to Mathews (1993), low-value-added production, typical of the mass production system, push companies to remain in an industrial relations (IR) approach which has minimisation of the labour costs as the primary driver. Moreover, the author calls "new industrial relations" the approach that shifts the focus of the IR professionals from the cost minimisation towards the employees' skills formation. Focusing on IR is also the work of Kessler (1991)according to this author it is competitive pressure, along with labour market demands to push for the of commitment and flexibility inside firms. However, these implementations remain "patchy".

According to Gerwin, Sorge, & Warner (1986), the only way for a factory that mass adopted computers is with a balanced approach between humans and computers. Therefore, two HR practices are more important than others: training and teamwork, along with a view of the organisation closer to the socio-technical view (Trist, 1980). Furthermore, the importance of training appears also in the work of Flynn et al. (1994) which identified three forms of training (i.e. Job Training, Quality Training, Teamwork Training) among the "workforce management" to be related to the overall Quality Management. Training is also essential for managers (Crisp, 1984). Moreover, it is crucial to raise the attention of managers and to train them to be able to face the technological innovation (Crisp, 1984). Adler (1988) and Snell & Dean (1992) support the idea that HR strategies are of fundamental importance in the adoption of new technologies, and in general crucial for any technological innovation.

In conclusion, the first period saw an increase in the discussion about the Japanese manufacturing and the way in which HRM could contribute to its implementation. Along with this, the literature also showed some debate surrounding IR vs HRM.
Figure 9 to Figure 14 shows every topic that composed the themes of researched discussed until now. Furthermore, they seem to confirm what emerged from the analysis of the literature.

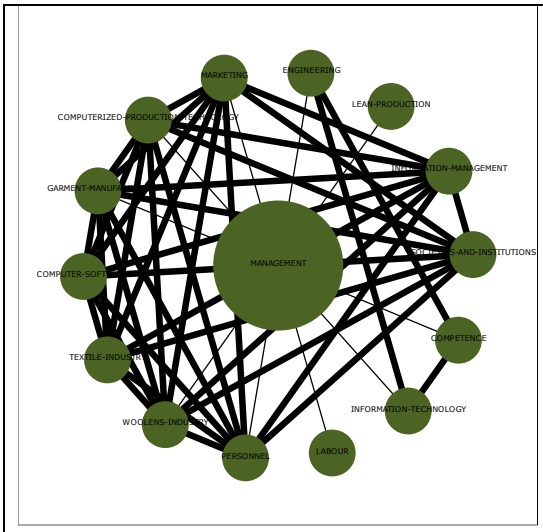


Figure 9 - Management Cluster

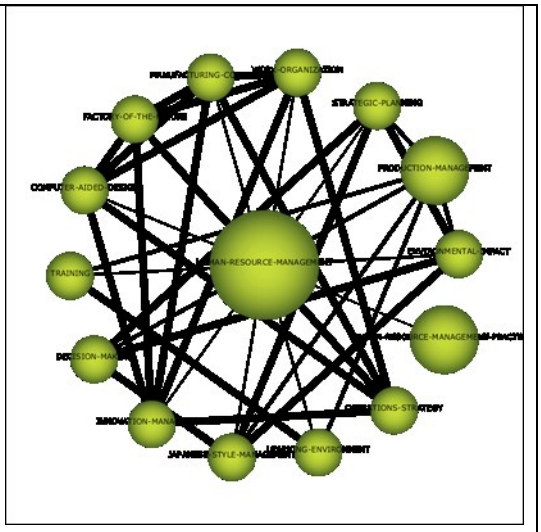


Figure 10 – Human-Resource-Management Cluster

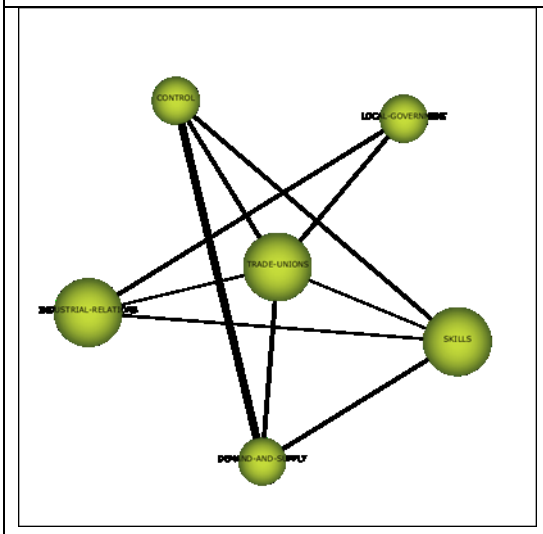


Figure 11 – Trade-Unions Cluster

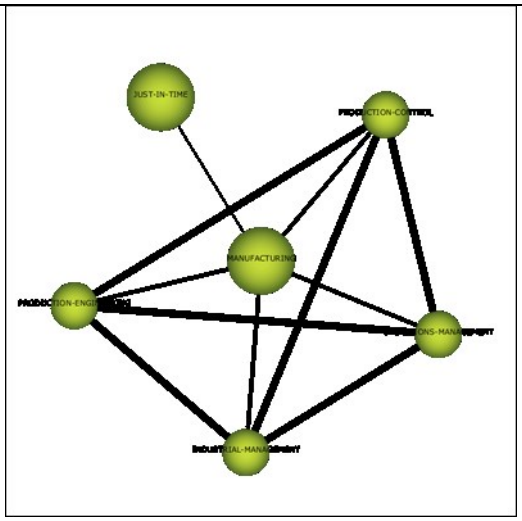


Figure 12 - Manufacturing Cluster

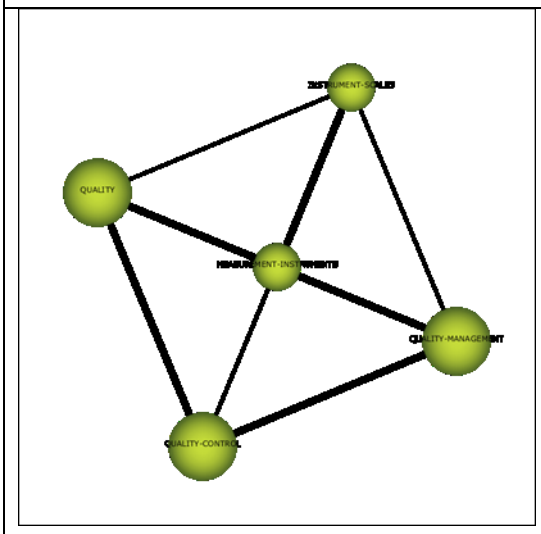


Figure 13 - Measurement-Instruments Cluster

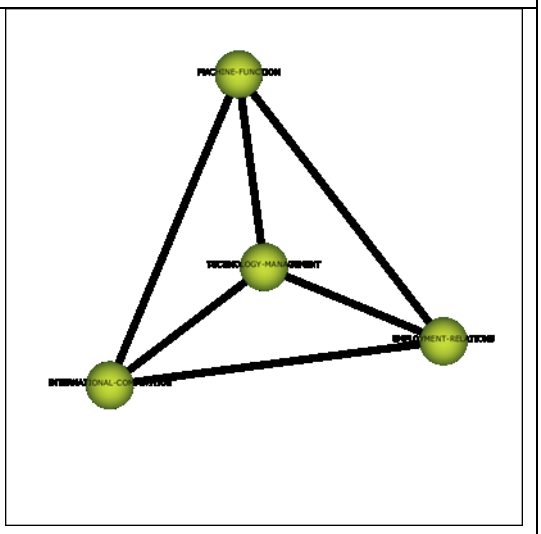


Figure 14 - Technology-Management Cluster

2.2.3 Second Period 1995- 2006

The literature in the second period shows an increasing number of publications compared to the previous one. Figure 15 shows the trend of publication over time and the number of publications associated with each year, from 1995 to 2006. The interest in the research is still growing, with a fall back only in 1998. For what concern the country interested in the development of HRM and Manufacture (Figure 16), the United States and the United Kingdom are the main contributors, as it was in the first period.

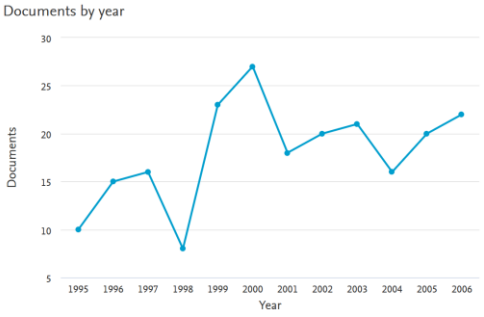


Figure 15 - Documents by Year - 2nd Period

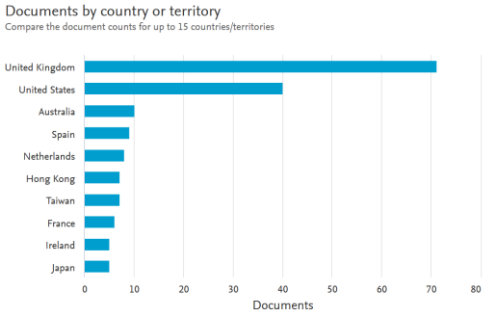


Figure 16 - Documents by Country - 2nd Period

The co-word analysis conducted allowed the identification of five themes of research: namely: Personnel, Manufacturing-Companies, Work-Organization, Compensation-(personnel) and Trade-Unions. The Strategic Diagram (Figure 17) shows the themes mentioned above. The size of the themes is related to the H-index of every theme, which is shown under the name of the cluster. The H-index grew exponentially compared to the previous period, with values switching from 4 to almost 30. The growth in the H-index indicates an increase and development of the themes inside the literature. Moreover, during the second period, there are more publications dedicated to the HRM and Manufacture topic. The most relevant topic are Personnel (which replaced Human Resource Management), Manufacturing-Companies and Work-Organization, with all the three of them positioned in the motor themes quadrant.

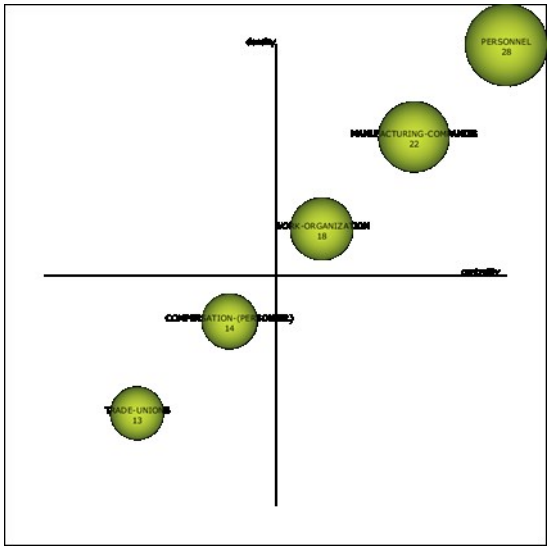


Figure 17 - Strategic Diagram 2nd period

As mentioned earlier, the number of papers available in the second period is higher than the previous one. Moreover, all the publications support the definition of some shared trajectory of research. One of the most discussed topics in the literature is the existence (and meaning) of the same HRM. Authors were generally providing contributions to support or undermine the novelty of HRM.

Along with this topic, the literature seems centred about the discussion of HRM's role inside manufacturing firms. In particular, HR practices and policies attracted the attention of practitioners and academics. Identifying practices that could foster innovation as well as allowing to succeed as Japanese companies became a priority.

Related to the first topic, many authors are critics of the HRM, among the authors present in this literature review there is the work of Duberley & Walley (1995). In this paper the authors claim strategic HRM to be only a business for universities who can train students or managers. The applicability of the HRM values to the organisations is little to not existent. Therefore this is testified by the number of practices that were conducted in a "reactive, opportunistic […] showing a little development from the standard modern approach identified as most common in the early 1980s". Of similar scepticism, the paper of Kolay & Sahu (1995) which found the value of the HR still to be proved and "the cost of inducing an employee into the organisation may not represent his value". Sparkling the fire of the debate around HRM is also Morris, Wilkinson, & Munday (2000) who labelled HRM as a "new model of personnel management". The confusion spreading from the different labels of HRM is evident from Figure 18 where

the "Personnel" is the label of the cluster. However, among the topics composing this cluster, there are "Industrial-relations" and "Human-Resource-Management". Such inter-relations suggests the idea that the literature is discussing the same concepts, with different perspectives.

Among the critics, there are also supporters of HRM (Poole & Jenkins, 1997). In a research about British manufacturing firms, Poole & Jenkins (1997) identified that "HRM applies to both manufacturing and non-manufacturing firms". Moreover, the research suggests that the adaptation of HRM is related to the business environment in which the organisations are operating, and only in little part to its industrial sector. Furthermore, the Tayloristic model spread over non-manufacturing organisations, becoming the working model also in these companies.

The second line of inquiry found in literature, as mentioned previously, is related to the interest of researchers on ways to improve productivity and efficiency. To grab the researchers' interest, as was already highlighted in the first period, is the Japanese Manufacturing. HR strategies, policies and practices were also found to be significant. Deshpande & Golhar (1996) investigated HRM practices in 69 manufacturing firms that were adopting Just in time production. The results show firms use selection instrument, workforce characteristics, recruitment sources. One of the most cited paper is the research carried out by Shah & Ward (2003) which identified four "bundles" of inter-related and internally consistent practices (i.e. just-in-time (JIT), total quality management (TQM), total preventive maintenance (TPM), and HRM. Morris et al. (2000), paid attention to the difference between Japanese personnel practices and the HRM ones. Japanese management is more systemic than HRM. Moreover, it is aligned with the production, while the HRM has at its heart the business strategy. In the same year, Power & Sohal (2000) highlighted the importance of practices focused on the human development that can unleash the human potential, therefore enabling JIT.

The HRM practices identified by Pfeffer (1998) usually called High-Performance Working Practices, were also found to have positive effects on operations (Ahmad, Schroeder, & Sinha, 2003). Similar to the HPWP, Jayaram, Droge, & Vickery (1999) identified five group of HR practices (i.e. top management commitment, Communication of goals, Training and Cross-Functional teams) that lead to superior

performance in the manufacturing settings according to strategic priorities of the manufacturing settings which are: quality, flexibility, cost and time.

In a quantitative study about the productivity of US companies versus Japanese one Ichniowski & Shaw (1999) identified Japanese firms as able of outperforming the American ones. However, US firms who adopt innovative HR practices, which are based on the one used by the Japanese firms, can reach the same productivity level. Despite this research, some authors (Bhasin & Burcher, 2006) believe the success of Japanese manufacturing being related not only to HR practices or technical innovation but also to the culture of the firm. Unions opposed the implementation of new HRM policies because they were not included in the decision regarding which policies to adopt (Camuffo & Volpato, 1995). About the union Wood (1996) did not find their presence to be incompatible with HRM practices, especially the one fostering the creation of a high commitment.

Chen, Liaw, & Lee (2003) related firm productivity to 12 factors namely: Flexible working hours, HR planning, Employment System, Career Management, Performance assessment, Education and training, Labor Insurance, Occupational Safety, Benefit system, Labor Management relations, Labor turnover management, Human Relations

Some segment of the workforce raised resistance to the implementation of HRM policies. Furthermore, previous practices identified as a key success factor may overshadow the welcoming of new ones (Camuffo, 1995). About the policies, there is also some scepticism (Lowe, Delbridge, & Oliver, 1997) about their universal way of achieving higher manufacturing performance. Moreover, it seems the context to play a more critical role. According to (Siegel, Waldman, & Youngdahl, 1997), there is little direct empirical evidence about the positive effect of HR strategies and technological innovations. Moreover, the research conducted by Siegel identified the effects of the adoption of Advance Manufacturing Technique (AMT), which are an "overall downsizing of the firm and a shift in labour composition in favour of workers with higher skill levels".

In conclusion, during this second period of analysis, there was an increase in the discussion about the importance of the HRM for manufacturing firms. A lot of this literature focused directly on the HR practices, while other researches focused on policies and strategies. However, the analysis of these last two found only limited room. The

Japanese Manufacturing once again sparkled the most of the researchers' attention. Therefore many studied tried to highlight the way in which western manufacturing firms could replicate the success of the Asian firms.

Figure 18 to Figure 22 shows every topic that composed the themes of research in this second period, the visual analysis of this cluster confirms what emerged from the discussion above-mentioned.

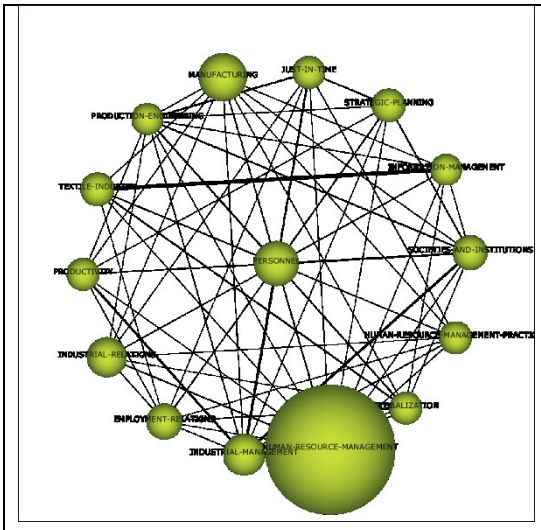


Figure 18 - Personnel Cluster

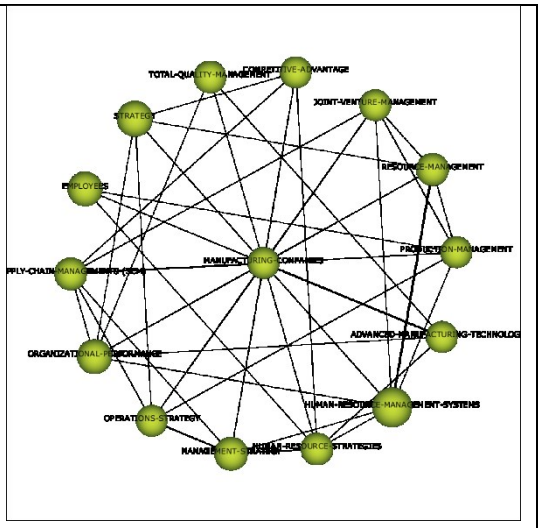


Figure 19 - Manufacturing-Companies

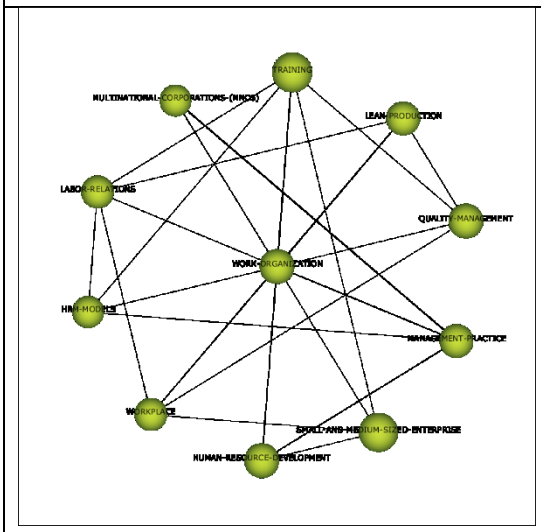


Figure 20 - Work-Organization Cluster

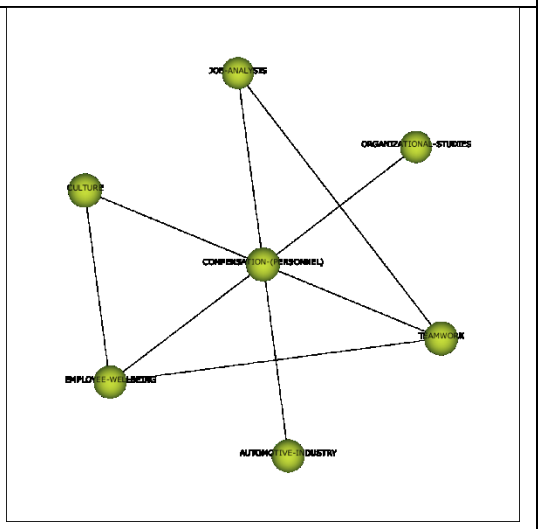


Figure 21 - Compensation-(Personnel) Cluster

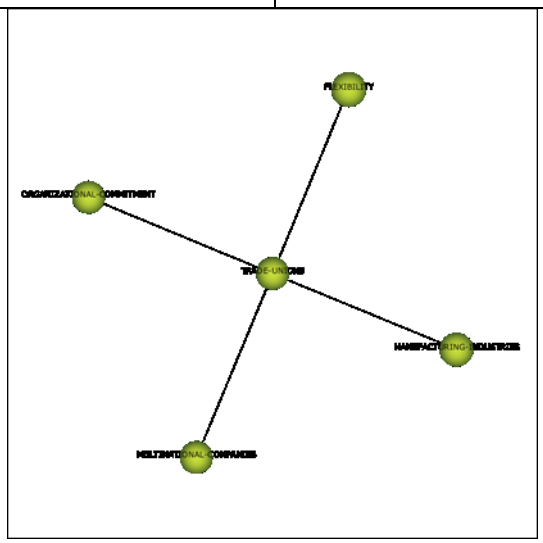


Figure 22 - Trade-Unions Cluster

2.2.4 Third Period 2007 – 2017

The third and last period of this literature review analyses the literature in the years between 2007-1017. The descriptive statistics depicted in Figure 23 and Figure 24 show the number of publications for the researched keywords and the documents by country. Figure 23 shows that the interest in the topic grew exponentially with only a drop in publication in the year 2012. However, the general trend is positive.

When looking at the documents by country or territory (Figure 24) the considerations made in the first two periods, are confirmed in this third one. The United States and the United Kingdom are once again hosting most of the researches; however many contributions are coming from Asian countries such as India, Malaysia and China. Disruptively with the past, Japan is out of this top ten. However, this did not affect the topic under discussion, which in most cases remained Japanese manufacturing.

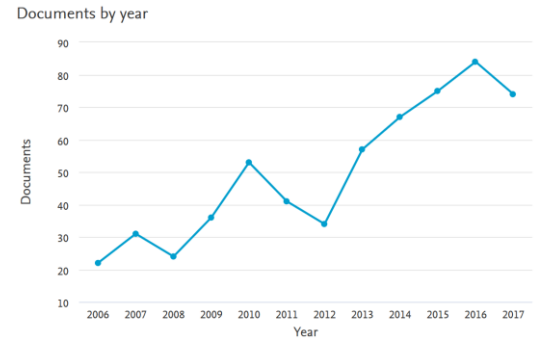


Figure 23 - Documents by year - third period

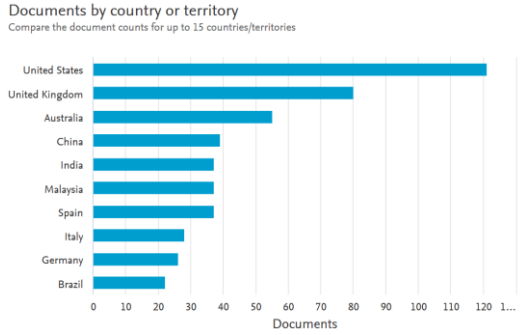


Figure 24 - Documents by country - Third period

The general interest in the HRM is also showing by the journals that host researches on this topic. Table 5 shows that among seven journals with the highest number of articles, five come from the operations management research field while only two are related to the HRM.

Table 5 - Journal with the highest number of papers related to HRM

Journal Name	Number of articles per journal
International Journal of Human Resource Management	55
International Journal of Production Research	21
Journal of Cleaner Production	21
International Journal of Operations and Production Management	13
International Journal of Manpower	12

International Journal of Production Economics	11
TQM Journal	10

The co-word analysis conducted allowed the identification of ten themes of research: namely: Human-Resource-Management, Process-Management, Organizational-Innovation, Performance, Logistics, Green-Human-Resource-Management, Business Strategies, Organizational-Performance, Employees, Managerial-Implications. Figure 25 - Strategic Diagram of the analysis shows the Strategic Diagram in which the themes mentioned above are positioned. The size of the themes is related to the H-index of every theme, which is shown under the name of the cluster. Regarding the H-index, seven of the ten clusters have a value around 20, which indicate the themes to be well connected and investigated by the literature which is also testified by the higher number of papers present in this third period.

Four themes of research are collocated inside the "motor themes" area of the Strategic Diagram (Figure 25). Section 2.2.1 provides info about the quadrants' meaning. The "motor themes" refer to themes that are internally well developed. Organizational Innovation, Performance, Human resource management and Process Management are in this area. The bottom left quadrant refers to the declining themes. Business Strategies, Employees, Organizational Performance and Managerial Implications are inside this quadrant. Green Human Resource Management is a less developed and poor connected theme of research.

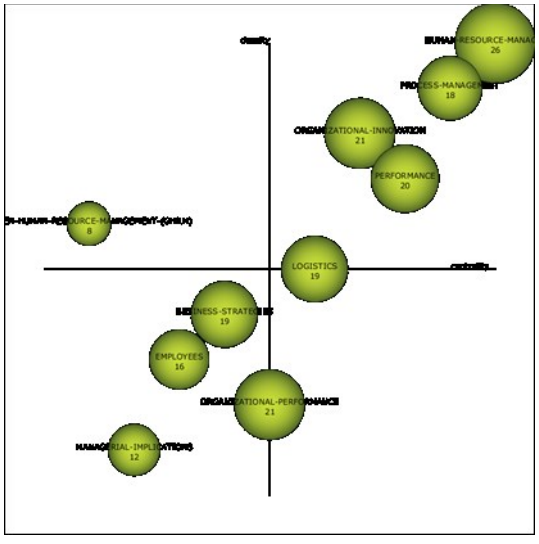


Figure 25 - Strategic Diagram of the analysis

It is also interesting to take a look at the number of articles each cluster have. Table 6 shows these numbers of article. All the topics related to the cluster are essential element investigated in the field of Operations Management. Figure 26 to Figure 35 shows ten clusters.

As shown in Figure 26, "Human Resource Management" is the most crucial research theme of this period. Its location is in the upper right quadrant of the strategic diagram. The topic of HRM is related to Lean Management (LM), Supply Chain Management (SCM) and Environmental Management (EM). Regarding the HRM-SCM relation, articles connecting the two topics were lacking, and there is an increasing trend in publications only in recent years. The HRM-SCM relation discusses mainly the importance of HRM in securing the SCM implementation. Some authors focus on the HR practices (Jabbour & De Sousa Jabbour, 2016; Menon, 2012) others on the HR system (Smith-Doerflein, Tracey, & Tan, 2011). Aligning the HR department with IT and SC leads to competitive advantage (Dao, Langella, & Carbo, 2011) while aligning all the soft variables in the organisation results in proper SCM implementation (Shub & Stonebraker, 2009). HR practices' flexible job description, teamwork and training impact positively on the SCM implementation (Menon, 2012).

Table 6 - Cluster's analytics

Name of the cluster	Number of articles	Article's H-index	Sum of citations
Human-Resource-Management	209	26	1698
Process-Management	39	18	325
Performance	44	21	594
Organizational-Innovation	28	20	433
Logistics	20	19	215
Business-strategies	22	19	265
Organizational-performance	55	21	638
Employees	32	16	188
Managerial-implications	6	12	16
Green-human-resource-management (GHRM)	4	8	4

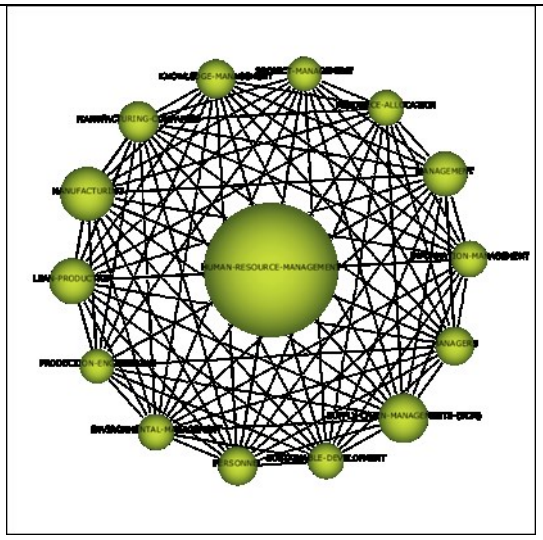


Figure 26 - Human-Resource-Management Cluster

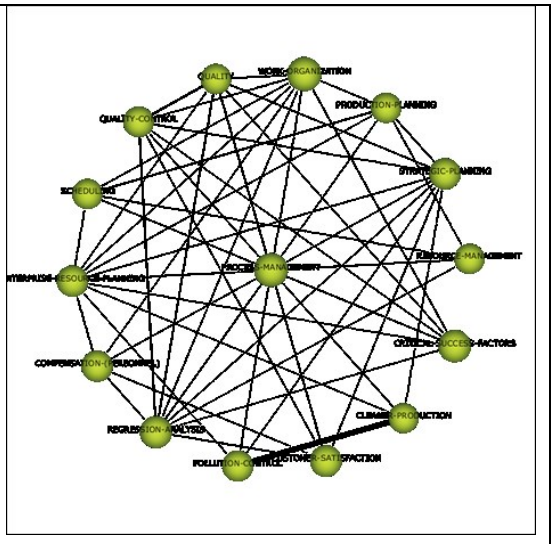


Figure 27 - Process-Management Cluster

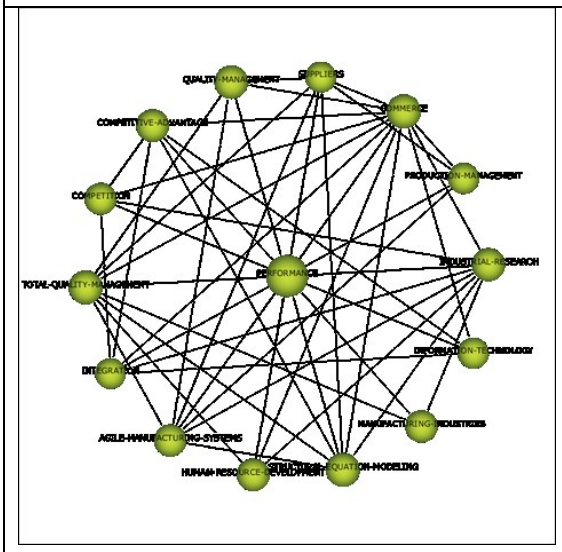


Figure 28 - Performance Cluster

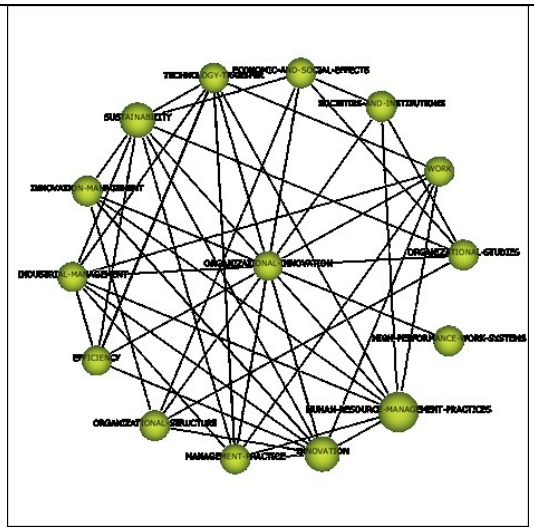


Figure 29 – Organizational-Innovation Cluster

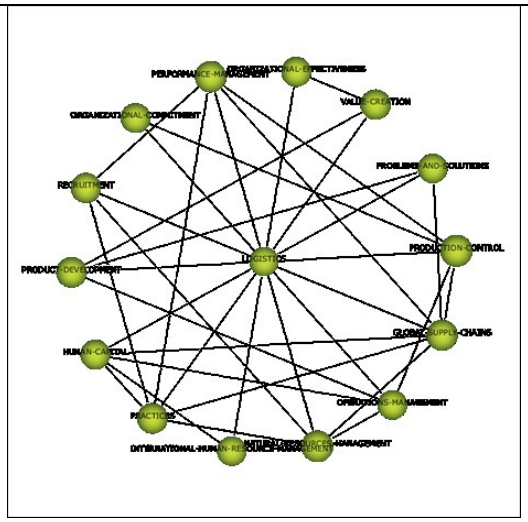


Figure 30 - Logistics Cluster

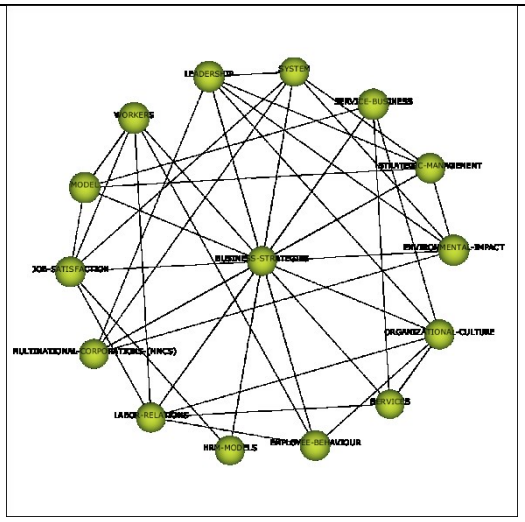


Figure 31 - Business-Strategies Cluster

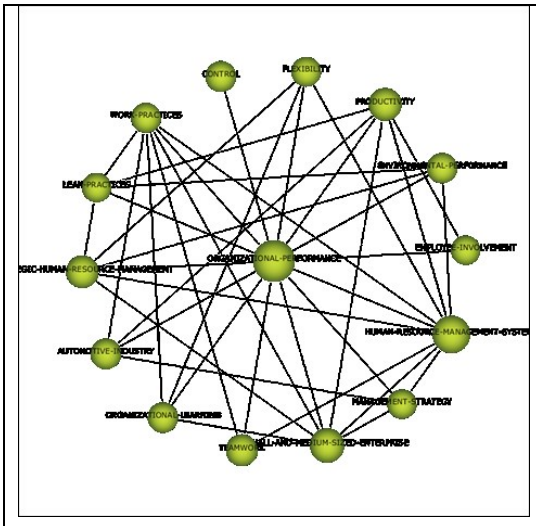


Figure 32 - Organizational-Performance Cluster

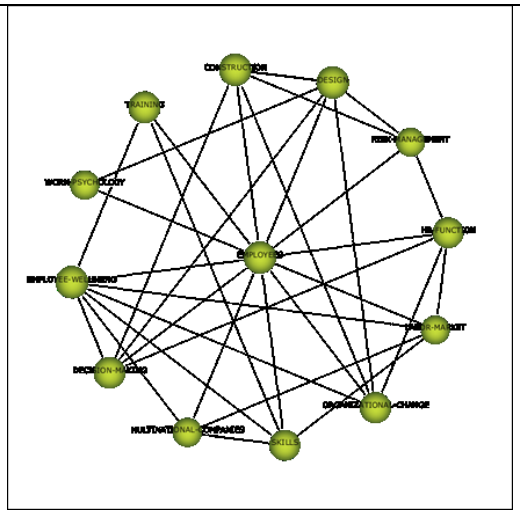


Figure 33 - Employees

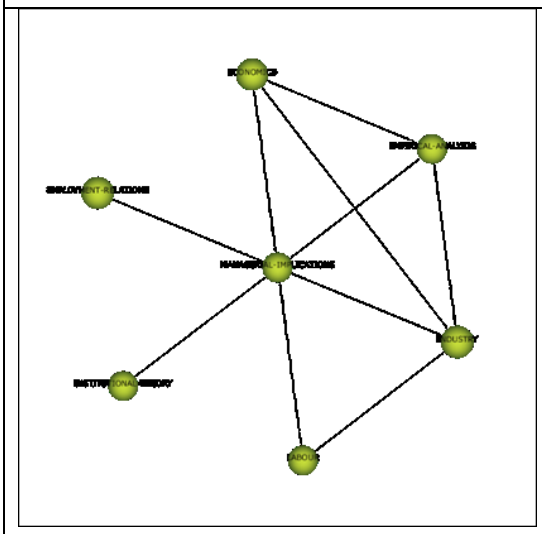


Figure 34 - Managerial-Implications Cluster

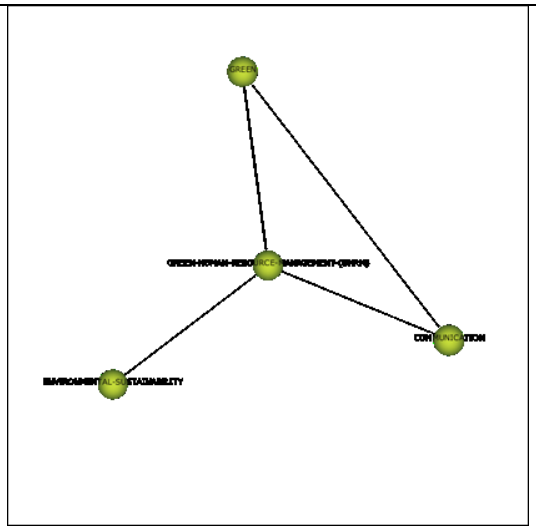


Figure 35 - Green-Human-Resource-Management Cluster

Also, the role of Organizational Culture is crucial for HRM, that is "the most important human factor that must be addressed by the HR department" (Jabbour & De Sousa Jabbour, 2016). Human Resource Management discussion around Lean Management focuses on the implementation of LM, made possible by the HR practices. These practices are important in securing the successful integration of LM; companies should have certain HR practices (Liker & Ballé, 2013) and, actually, they often adopt common HR best practices (Jürgens & Krzywdzinski, 2013). Recruiting, performance evaluation, benefit, training and rewards are all linked to LM (Jabbour et al., 2013), with the last two considered success factors for the LM implementation. When HR practices

focus on security, there are fewer accidents on the job so that "lean it is not mean" (Longoni, Pagell, Johnston, & Veltri, 2013). HRM is thus considered an important factor in the implementation of Supply Chain, Lean Management, and Environmental Management. While the literature discusses HR practices, what is missing is the role of the technological innovation in the manufacturing sector. The lack of this topic from the literature of manufacturing comes with a big surprise since many authors and researchers believe huge changes will occur due to an increase in technology innovation. The technology adoption will push traditional production to smart factory or Cyber-Physical System. HR practices are also the most discussed topic inside the theme "Process Management". In particular HR practices facilitate the adoption of Quality Management. Leadership, strategic planning and human resource development are associated with Quality models (Teh, Yong, Arumugam, & Ooi, 2009). Those practices were also found to have a negative impact on role conflict (Lenka, Suar, & Mohapatra, 2010; Teh et al., 2009). Moreover, job satisfaction influences customer satisfaction (Lenka et al., 2010). Starting from the same premise Feng, Wang, & Prajogo (2014) describes the importance of service training and employee empowerment in order to have better employee satisfaction related to customer satisfaction. The impact of HR practices on implementing Total Quality Management (TQM) is underlined by Kuei, Madu, & Lin (2011) and Konecny & Thun (2011). The former focuses on the value added by skills, training, diversity management and leadership in the implementation of TQM, while the latter suggests that HR practices have "potential to improve plant performance", also Bayo-Moriones, Merino-Díaz-De-Cerio, Antonio Escamilla-De-León, & Mary Selvam (2011) claim that HR practices affect the development of quality management inside companies. Since its birth, Human Resource Management is strictly linked to performance. Many authors investigate this relationship, which is also defined as the "holy grail" of the field. In the theme "Performance", the performance is often related to the HR practices, but not all the authors agree to the impact and positive effect of those. For De Menezes, Wood, & Gelade (2010) the integrations of HR practices "result in superior firm performance". Leadership plays an important role (Laohavichien, Fredendall, & Cantrell, 2011; Wickramasinghe & Garusinghe, 2010). For Jacobs, Yu, & Chavez (2016) the performance must "establish effective internal communication processes and stimulate employee satisfaction". Of a different opinion, the results from

Bevilacqua, Ciarapica, & De Sanctis (2017) where the lean practices do not find any associations with growth in performance, while product mix variety and time effectiveness do it. Zhang & Yang (2016) do not find any associations between green practices (which include HR green practices) and financial performance, but the authors find associations between green practices and operational performance due to the reduction in pollution and waste, which are mainly caused by inefficiencies. HRM is important also for the development of "Organizational Innovation", which is also the last cluster of the motor themes. The organisational innovation seems to be affected by several factors. Ling & Nasurdin (2010) affirms that there is a connection between the HR practices. However only training has a major association with product innovation, process innovation and administrative innovation. Also, Santangelo & Pini (2011) describe a positive association between HR practices and technological innovation. Jürgens & Krzywdzinski (2013) claims the importance of training and reward system to boost knowledge sharing and thus fostering technological, while Bourke & Crowley (2015) find that firm adopting certain HR practices perform better – regarding technological innovation – than other companies who do not have them. On the importance of training debate also Kok & Ligthart (2014) who assert that training boost work flexibility, which enhances new product innovation, that is also found to be affected by hard corporate identity Staub, Kaynak, & Gok (2016). Other factors that seem related to technological innovation are the "combination of diverse perspective", cultural differences, the decision to outsource the function to "promote technological innovation" (Mazzanti, Sandro, & Paolo, 2009) adoption of Top Management Team (Prasad & Martens, 2015). The lack of innovation stands out as one of the factors related to the poor competitiveness of companies (Antonioli, Mancinelli, & Mazzanti, 2013). In the cluster named "Logistics" is discussed the human resource dimensions of successful global supply-chain management; the growing importance of HRM in the management of supply chains is presented as a combination of resource-based (e.g. internal), market-based (e.g. external) and dynamic capabilities perspectives. Also, selection, training and assessing the new 'breed' of global supply-chain managers are explored. The first cluster in the "peripheral and underdeveloped area" is the one named "Business Strategies". Several publications show the importance of those strategies, in particular, Calabrese (2012) states that the field of operations' management and human resources'

management is related, and he underlines the chance of contextually considering human resources and operation management. In the last years, there is an increased interest in the wellbeing of the employees and in the job satisfaction, what HRM should do to reach a higher level of both is what research tries to find. The cluster named "Employee" has a strong focus on employee well-being and job satisfaction. In particular, Menon (2012) find some HR practices (i.e. Teamwork, training, flexible work description, reward system) that could impact the satisfaction level of the employees. The different needs of a new generation of employees were the focus of Zhu, Xie, Warner, & Guo (2015), the authors find that the involvement of the workforce in the processes of decision making, supervision and management, impact on their satisfaction. Another important factor influencing the job satisfaction is Lean Six Sigma, its dimensions (Define, Measure, Analyze, Improve, and Control/Define, Measure, Analyze, Design, and Validate, 5S and Kanban) "positively influences employees' performance, described by employee satisfaction, absenteeism, salaries and benefits, employees' commitment and employee turnover rate" (Brkic & Tomic, 2016). Of marginal importance is the need for the HR function of having "appropriate governance principles" (Farndale, Paauwe, & Boselie, 2010), the fact that the International Framework agreements could lead to high commitment (Sydow & Frenkel, 2013) and the role of employees' skills regarding supplier integration (Huo, Han, Chen, & Zhao, 2015). The cluster named "managerial implications" shows the importance of the HR practices in "predicting labour disputes" with managerial style "turned out to be a useful predictor". The literature of this cluster highlights, implication regarding the adoption of Six Sigma as a whole, which is influenced by the organisation's structure. The theme "Green Human Resource Management" is made of "practices aligned with environmental sustainability goals and which aim at developing employees' abilities, motivation and commitment, and involvement in support of those goals at the firm level". Green HRM has a positive impact on environmental performance. Rajiani, Musa, & Hardjono (2016) points out the difficulty in measuring the HRM output since there is a "polarisation between "Best fit" and "best practice".

2.2.5 Conclusions

This literature review provided evidence about HR crucial role. Generally, HR practices are essential to the implementation of Supply Chain Management, Lean Management and Environmental Management. These approaches need HR support, at both the strategy and the practices' level. SCM, LM and EM are present in the HRM literature since many articles address the question of how to integrate these approaches successfully. Other researches focus on the HR practices needed; the HR-system adopted the importance of team and the importance of leadership. From a quantitative point of view, this also finds supports by both the descriptive statistics. The analysis provided various results spreading from the co-word analysis. Moreover, the disposition inside strategic diagram's (Callon, 1991) "Motor themes" quadrant, allowed the identification of the most important and developed theme of research.

However, despite all the interest in the HRM, none of the research was conducted on Industry 4.0 companies, which is the object of this dissertation.

2.3 HRM in manufacturing SMEs

This section provides further investigation about the crucial role of HRM. In particular, this literature review, conducted narratively, highlight the importance of HRM even for SMEs. The need for conducting such a review, rely on the fact bigger companies were the subject of almost every study in the previous review. Therefore, this review aims to discover the importance of HRM for SMEs.

Speaking of HRM inside manufacturing firms, the discussion could not ignore the researches about the Tayloristic approach that changed the industrial management (Nelson, 1981). The Tayloristic approach is named after Frederick W. Taylor, generally acknowledged as the father of the scientific method. According to Taylor, the organisation should be run in a scientific way, and the management follows rigorous principles (Elliot, 1990), with employees treated as machines (Salaman, 1992). The Tayloristic model try to achieve efficiency by controlling the workforce (Walton, 1985), so that is possible to define an incentive system as well as a sanction one (Miller, 1992), however in literature there is some scepticism about the incentive system, which usually

relies only on money (Braverman, 1998). Moreover, Analoui (1998) criticised viewing people as only one other kind of resources.

The Tayloristic approach remained dominant until the 80s-90s (Noon and Blyton, 1997), as it also emerged in the first part of this literature review which highlighted the predominance of studies surrounding the Japanese manufacturing, therefore indicating a shift between the Fordist and post-Fordist type of production. Such a shift spread from different factors such as changed customers request and enable the presence of women in production (Benson & Lawler, 2003) therefore indicating a shift also in the management of employees.

It is therefore during the 1980s that the term and the related concept of High performing system appear in literature, which studies that showed a positive impacted of such practices on the performances of manufacturing firms. In 1985, Walton also pushed for the development of high commitment workplace, which has teams at their core and the jobs are broader in order to avoid alienation. These actions are labelled as the one belonging to the job-enrichment practice. Such a belief is opposed to the control-way dictated by Taylor and indicate that employees can self-regulate (Wood & Albanese, 1995). According to Lawler (1986), the sustained competitive advantage could be reached only through high commitment.

The definitive change in the management of employees happened with the birth of HRM (Cappelli & Neumark, 2001), as a consequence many companies re-labelled their industrial relations and personnel division to become HRM department, therefore indicating the employees as a precious value. After a period of debate about the newness of this approach, reported in section 2.2.1. and 2.2.2, literature started to spread and to investigate the effects of HR practices. The investigation brought to the identification of a set of practices named High-Performance Working Practices (that help firm in achieving some different results, among all the most important, is superior performance, reduce turnover and market value (Huselid, 1995)

2.3.1. High-Performance Working Practices

High-Performance Working Practices – refers to a set of HR practices that are seen as a potential source of competitive advantage for enterprises (Huselid, 1995).

The HPWP main contributions is a shift if the work organisation, which challenge the scientific approach adopted by many managers. However, HPWP has been conceptualised in different ways by different authors. One of the most famous theorisations is the one proposed by Pfeffer (1998). The author identified seven HR practices: employment security, selective hiring of new personnel, self-managed teams and decentralization of decision making as the basic principles of organizational design, comparatively high compensation contingent on organizational performance, extensive training, reduced status distinctions and barriers, including dress, language, office arrangements and wage differences across levels and extensive sharing of financial and performance information throughout the organization.

According to Pfeffer, every kind of organisations could benefit from the adoption of the practices, because these practices will improve the discretionary effort of the employees and give them improved skills. Therefore these companies outperform their competitors (Pfeffer, 1994)

The terms high commitment, high involvement and high performance are generally used interchangeably (Boxall & Macky, 2009), however, according to Legge (1995), HPWP is more related (and adopted) by firms that have as main objectives the goal of reaching higher productivity. Due to this theory-lacking HPWP stream of research was defined by Guest (1997) as "atheoretical". Moreover, the authors wondered about the reason behind the higher performance of the firms adopting HPWP and to label this link as a "black box" (Wright & Gardner, 2008)

The HPWP is divided into two approaches the first one called the integrationist approach and the second one the isolationist approach. The integrationist one, emphasises the unitary and mutually reinforcing nature of individual HRM practices (Beltrán-Martín, Roca-Puig, Escrig-Tena, & Bou-Llusar, 2008). The isolationist one claim that the effect of the individual practices is hindered by the analysis of the practices combined (Boxall, Ang, & Bartram, 2011)

Another line of debate is related to the outcomes of the HPWP implementation, with authors divided between the mutual gain perspective (Macduffie, 1995) and a critical perspective (Godard, 2001). In the mutual gains, as suggested by the name, the introduction of HPWP results in a win-win situation for both the organisations and the employees. On the contrary, the critical perspective (Macky & Boxall, 2008) which is built around the labour process theory (White, 2005), suggest this to results in work intensification and generally in a reduce employee wellbeing.

Despite the lack of consensus of which practices should be included in the bundle, this study takes into consideration the HPWP as they were formalised by Pfeffer (1998) since they were found to be parsimonious and still valid (Delery & Roumpi, 2017)

The adoption of HPWP within SMEs is again something debate by the literature, which view two opposite team of supporter, the one that claims HPWP harm SMEs (Marlow, 2006) and the one that suggests having a similar effect of what happens in large firms.

There are several reasons behind the lack of adoption of HPWP in SMEs this is related to the cost associated with performing the practices (Storey, 1994), the small nature of the firms allows better management which avoids the formalisation of practices (Gibb, 2000). The need for formalising practices seems to become bigger once companies reach more than 20 employees (Roberts & Sawbridge, 1992). Moreover, once the firms start growing, they improve their managerial practices (Kotey & Slade, 2005).

2.4 Industry 4.0 Literature Review

2.4.1 Understanding the industry 4.0 phenomenon

This section aims in shedding light upon Industry 4.0 before conducting the literature review. Despite the high expectations, Industry 4.0 researches are missing a shared definition. Inside this dissertation, Industry 4.0 concept refers to a:

Potential disruptive phenomenon, especially for its consequences on the employees. Industry 4.0 is studied as a new organisational model based on the implementation of several technologies (i.e. Cloud, Additive Manufacturing, Cyber Security, Big Data Analytics, Simulation and Augmented Reality, Horizontal and Vertical Integration) that works together for the improvement of organisational performance. In this context, the management of employees is a key enabler to benefit from Industry 4.0.

New technologies' implementation could reduce costs. The savings come from, capital costs, workforce costs, and energetic costs. Each of them is briefly described below:

-*Capital costs:* automation and value chain's optimisation reduce capital costs;

-*Energetic costs:* energy's consumption could be reduced with the efficient and intelligent use of the resources, checking what happens in the production.

-*Workforce costs:* automation reduce the number of employees low skilled but increase the number of specialised workers.

Industry 4.0 attracts companies' interest since it could lead to increase productivity by up to 30%. Companies' performance could increase due to a reduction of the resource used. Moreover, Industry 4.0 foster:

-*Flexibility:* technologies adoption will automate several lines of production. Automation will impact on the ability of the firm to reprogram lines easily.

-*Reduction of the lead time:* the technologies ability to operate flawlessly will reduce the lead time.

-*Small batches:* clients ask more than ever for small batches; therefore, this element is crucial for firms' survival. Automated lines and an interconnected factory enable the production on small batches.

-*Workplace:* changes in the production will impact the workplace. Thus, it is mandatory for firms to attract and retain valuable employees.

-*Efficiency:* complete tracking of capital cost, as explained above, is enabled by Industry 4.0. (Heng, 2014)

Technologies comprised in the Industry 4.0 phenomenon were already available. According to Baur & Wee (2015), the technologies' adoption will be slowed down by companies' need for keeping costs low. Industry 4.0 technologies such as the Internet of Things, could have an economic impact of 1 trillion dollars (Davies, 2015). Big data will allow for gathering useful data about several indicators, such as the life of the product (Manyka, 2015).

Industry 4.0 affect the project, planning and the management of the production. It was already mentioned a reduction in the lead time and the ability to work with small batches (Heng, 2014). For implementing the smart factory, the focus must remain on HRM since Employees are affected by such changes. Therefore, the need for HR to deal with these challenges. Workers should learn how to work in Cyber-Physical Systems. Working in such an environment requires a clear relationship between the human and the system (Gorecky, Schmitt, Loskyll, & Zuhlke, 2014).

Moreover, employees' task working in Industry 4.0 workplace will require them to: supervise, maintain and set-up the machines. Employees will work more effectively thanks to accessing real-time information even from remote locations. However, the production in small batches pushes employees to be careful in their supervision activities. Stopping machines will result in severe damages to the production. Therefore, the acquisition of supervision skill should be one of the areas attracting the majority of the investment.

Working in such scenario require to invest in training and recruitment. Industry 4.0 technologies could support the training process by providing a digital platform with access to all employees' data. However, this could not be enough. Apprenticeships' costs and times are reduced (Tjahjono, 2009). Researches about employees' interaction with the new environment are still lacking. Therefore, contributions on this topic are expected.

2.4.2 Industry 4.0 enablers

This section provides information about the enablers of Industry 4.0. In the literature, there are several technologies indicated as enablers of Industry 4.0 (i.e. Cyber-physical System, Visual Computing, Internet of Things, Industrial Network, Cloud, Sensors, Rfid, Big Data, Maintenance, Mass Customization, Business Model). Sensors and software solutions are not present as considered crucial component already adopted or included in other technologies.

-*Cyber Physic System (CPS):* CPS is a system in which computers communicate with each other, while also checking and collecting data in real time (Lu, 2017). This CPS system relies on technologies that allow the creation of the extended network. Moreover, the CPS architecture is composed of Smart Connection, Data-to-information, Cyber level, Cognition level, Configuration level (J. Lee et al., 2015). CPS flaws are entirely managed by the system, therefore ensuring the correct flaw of the production (Lee, 2008). Building a CPS system requires specialised IT technicians, these requirements represent challenges for the HR function.

- *Visual Computing:* Industry 4.0 is enabled by handling the production visually. The visualisation means controlling the flow of the materials, having a 3D scan of the production facility (Posada et al., 2015). The virtual model allows testing every possible road, allowing to compare the different costs of all the possible ways of producing. Moreover, the augmented reality allows a visual approach which supports the different aspects of the company life.

- *Embedded Controllers:* Connection of every machine is at the heart of the Smart Factory. Therefore, each machine has embedded controllers. These controllers enable the communication between machines and with the company's network.

-*Internet of Things:* is created by all the devices connected. The objects provide services to users communicating in real time with each other. The requirements for it are compatibility, modularity and scalability (Wan, Cai, & Zhou, 2015).

In this way, it is possible to control the system, the machines and even the workforce, from a remote location. The performance is collected in real time, and the data provided allow to act and decision that increase the productivity and the efficiency (Bughin, Chui, & Manyika, 2013).

- *RFID:* enables objects to become smart (Gilchrist, 2016). They are integrated into raw materials, components or final products. The receiver must be close to the RFID:

RFID can provide information about the status of the production queue, the status of the delivery, the status of the warehouse, the conditions of the components or alerting if errors occur.

-*Industrial network:* The industrial network is a crucial component: the communication happens between mobile devices. It is the connection of every device without using any cables, capable of working every day of the week without any time limitations, without any interruption nor issues to the network. (Wan, Cai, & Zhou, 2015). The choice of the technology to adopt depends on the evaluation criteria, such as the error tolerance, the longevity of the protocol. (X. Li et al., 2017)

-*Cloud:* is a series of services delivered through an internet connection which allow the use of the software as a service and that allow to store and access data from different and remote location through a connection to the server. (Wan, Cai, & Zhou, 2015)

The Cloud services could be distinguished from IaaS (Infrastructure as a Service), Paas (Platform as a Service), SaaS (software as a Service). Cloud is the crucial enabler for the Internet of Services; this allows new possibilities of work and business models to the companies who implement them (Hermann, M.; Pentek, 2015).

-*Big Data:* the term used for defining a vast quantity of data that are analysed in a short time, with the goal of obtaining good results. This service is gaining much attention nowadays by the companies, which look at the "data mining" (the elaboration of this

information has this name) as a source for improving the production, the efficiency and also as a way to improve the relationship with their stakeholder. (Wan, Cai, & Zhou, 2015)

-*Maintenance:* keep track of the errors, so that it is possible to find the cause of the malfunction and also allow the predictive maintenance. The analysis allows predicting the shift and the management of these transfer, with less waste and in real time.

-*Mass customisation:* possibility of improving the competition providing every customer with a customised solution. The flexibility and the integration of these systems allow performing advanced analysis (J. Li, Tao, Cheng, & Zhao, 2015).

-*Business model:* the analysis of the performance and transactions support future decisions. The opportunity of offering new services and products it is proposed by the systems based on the data elaborated that come from the users.

-*Automation:* allows deciding how and where to implements the automation of the factory. (Bughin et al., 2013)

2.4.3 The different labels of industry 4.0

The Industry 4.0 phenomenon is a topic that, as emerged in the previous sections, generates debate in the scientific world. Therefore, there is not a clear and accepted standard definition. The division and the different names given to this topic can also be traced in the labels the different countries gave. In order to give more clarity about the phenomenon under study, this section provided by means of a co-words analysis, insights about the following phenomena: Smart Manufacturing, Smart Industry, Fabbrica Intelligente, Nouvelle Industrielle, Smart Factory, Made in China 2025, Catapult, Industrial Value Chain, Produktion 2030, Industria Conectada, Prumysil 4.0, Advance Manufacturing Partnership, Produtech, I4MS, Made in Belgium, Industrie 4.0, Make in India.

2.4.3.1 Smart Manufacturing

Smart manufacturing is a label generally used as a synonym of industry 4.0 with no link to any specific government plan. According to Scopus, this label accounts for more than 200 peer-reviewed papers published in international journals, of which only 20 are related to the Business and Management area.

2.4.3.2 Smart Industry

Smart Industry (Ministry of Economic Affairs, 2014) is an Action Agenda developed by the Netherlands whose aim is to allow companies to become more competitive. Moreover, this term is used by the Dutch as a synonymous of Industry 4.0. The Smart Industry plan spread from the desire of the Netherlands to become a frontrunner country regarding firms implementing industry 4.0.

The Field labs foster the adoption of the new technologies. Currently, there are 32 of them in all the country. The goal of this Fieldlab is to enable companies to learn about Smart Industry solution and to support them in the implementation. Moreover, the Fieldlab provide companies with a useful connection to universities and research centres do better develop the potential of these firms.

2.4.3.3 Fabbrica Intelligente

Fabbrica Intelligente (CFI, 2012) is the Italian Governmental plan designed for improving the manufacturing industry. The goal of the plan is to foster the implementation of advanced manufacturing technique such as Industry 4.0 Moreover the plan aim in supporting competitive advantage of Italian firs, which will be also able to develop a strategy that foster the research and innovation so that it is possible for companies to transform their business model and the products they offer.

2.4.3.4 Nouvelle France Industrielle

Nouvelle France Industrielle (Ministère du Redressement productif, 2013) focuses on bringing French Industry to embrace the possibilities offered by the digital transformation. In order to achieve such a transformation, the NFI is centred with nine industrial solutions: new resources (e.g. use of recycled materials), sustainable city (e.g. smart grid), ecological mobility (e.g. charging station), transport of tomorrow (e.g. airships and drones), medicine of the future (e.g. digital health), data economy (eg. Big data), smart objects (e.g. robotics), digital trust (e.g. cybersecurity), intelligent food (e.g. functional food), industry of the future.

2.4.3.5 Smart Factory or Manufacturing Innovation 3.0

Smart Factory, also called "Innovation in manufacturing industry 3.0" (APO, 2014), is a Korean governmental plan created to raise the industrial competitiveness of Korean manufacturing firms. The policies designed by the plan aimed at fostering the IT implementation, so that smart factory is enabled. Through these actions the Korean government wish to transform the composition of its manufacturing sector, allowing companies to transform their production lines. Some firms already implemented the new factories; however, the level of adoption is still low due to several factors, one of this identified by the same Korean Government being related to old policies which posed a significant obstacle to the smart factory implementation. Therefore, the plan designed by the Korean government wish to overcome these obstacles and to enable the Smart Factory implementation.

2.4.3.6 Made in China 2025

Made in China 2025 (Li, 2018) is a strategic plan of China whose aim is to upgrade Chinese Industry by moving the country manufacturing up the value chain. The plan focuses on high-tech fields including the pharmaceutical industry which is presently the purview of foreign companies.

2.4.3.7 Catapult

Catapult (HVM, 2017) is the program designed by the UK in order to push manufacturing companies to innovate. This program is composed of the presence of

Catapult centres disseminated along all the UK territory, in a strategic location which has the potential to generate growth in critical global markets. Moreover, the Catapult offers seven world-class centres for the industrial innovation, which are combined in one, to allow companies to foster the transformation towards the more automated workplace.

2.4.3.8 Industrial Value Chain Initiative (IVI)

The Japanese Government sponsors the industrial Value Chain Initiative (IVRA, 2018), and it is also known as "Connected! Manufacturing", combines IT and manufacturing technologies to transform firms operating in the industrial sector. The main focus is on how the Internet of Things affects human-centric manufacturing. Moreover, the Japanese initiative main goal is building collaboration between companies that could foster the birth of connected system architecture.

2.4.3.9 Produktion 2030

Produktion 2030 (Digital Transformation Monitor, 2017b) is a set of policies sponsored by the Swedish government who wish manufacturing firms operating in the country could become a leader in the sustainable manufacturing. The lines of actions for achieving such a goal are three: net technologies adoption, new knowledge creation and the establishment of a good partnership. The plan is seen as key for allowing firms to stay competitive and successful in the global market. The interest Sweden has in fostering the transformation of its manufacturing firms is related to the fact that the country has the highest rate of manufacturing companies per capita.

2.4.3.10 Industria Conectada

Industria Conectada (Buisán & Valdés, 2017) is the Spanish strategic plan to foster the implementation of Industry 4.0. The plan includes several lines of actions: guarantee the

development of the competencies needed by the Industry 4.0 companies, raise the awareness through better communication, train the employees. It also promotes multidisciplinary collaboration, promotes the enablers of industry 4.0, encourages the development of the previously-mentioned enablers, supports the technological adoption of the company as well as the Industry 4.0 implementation. Lastly, foster Industry 4.0 research project.

2.4.3.11 Prumysl 4.0

Prumysl 4.0 (MPO, 2016) is the name given to the Czech strategic plan carried out at the National level, for enabling the digital transformation of manufacturing firms. The term Prumysl 4.0 translation in English is "Industry 4.0".

The Action plan includes measures to support cybersecurity, investment, standardisation, education, regulatory framework, applied research and human resources development.

2.4.3.12 Advanced Manufacturing Partnership

The Advanced Manufacturing Partnership (AMP, 2017), also called Advance Manufacturing 2.0, is a strategic plan drawn by the USA, whose aim is to create highly valuable jobs by increasing the competitiveness of manufacturing companies. The increased competitiveness of the firms is also targeted to small and medium-sized enterprises, through the creation of a platform that host content about the advanced manufacturing technologies. Moreover, the US government wish to achieve good results to achieve US Leadership in the adoption of robots.

2.4.3.13 Produtech

Produtech is the strategic plan designed by Portugal (Rocha, 2017) to internationalise the manufacturing firms of the country. Moreover, the plan pushes for the adoption of

innovative manufacturing technologies, while also fostering the sustainable development of the firms. Three main lines compose the action plan: cooperation (e.g. new forms of cooperation between companies and client); innovation (e.g. boosting a short and long termed projects); internationalisation (e.g. cooperation networks).

2.4.3.14 I4MS

I4MS (EC, 2016) is the acronym identified by the European Union for the "Innovation for Manufacturing Small and Medium-sized Enterprises" plan. The goals of this initiative are: to help SMEs in embracing the digital innovations, fostering partnership and collaborations between firms, especially with a start-up. In this manner, it becomes possible for testing innovative solutions. By doing so, it should be possible to transfer knowledge and to overcome the skills shortage in SMEs, while also providing the ability to change the business model and offer improved products to customers.

2.4.3.15 Made Different

Made Different (Digital Transformation Monitor, 2017a) is the strategic plan drawn by the Belgium government as a response to the challenges posed by the globalisation and the changes in customers need. Therefore, it becomes of the utmost importance for Belgium firms to be able to guarantee top quality in their products, as well as be able to produce in small batches while being sustainable. In order to face the situation, the line of action contained in the Made Different plan lays on seven fundamental changes (e.g. social innovation, technological innovation, new production technologies) that could turn firms into Factory of the Future.

2.4.3.16 Platform Industrie 4.0

Platform Industrie 4.0 (Blumentritt, 2018) is the name of the platform created by the German government. In the platform took part several experts in the field of business and science, and unions as well. The goal of the platform is the creation of a policy that can push for the adoption of Industry 4.0. In order to achieve such a task, the platform also hosts norms and standard with the aim of identifying the gap and provide solutions to companies in order to increase the interoperability and communication of a different set of technologies.

2.4.3.17 Make in India

Make in India (Young, 2016) strategic plan was developed by the Indian Government as a response to the critical situation of India in 2013, which almost pushed the country on the edge of the economic failure. The plan appointed, provide a line of actions on 25 economic sectors (from the Automotive sector to the Wellness), with the aim of attracting foreigners' investment, therefore creating new job opportunities. Moreover, the plan wishes to attract companies by pushing Indian firms to adopt advanced manufacturing technique that leads to the "zero defect, zero effect" policy.

2.4.4 Co-word analysis

The best way to conduct a review in this area was through a bibliometric analysis due to all the different labels used for referring to Industry 4.0. The parameters of the analysis are shown below in Scopus was the database used for conducting the Query. No time limitations were posed, in order to reach old and new publications. The reliability of this literature review was strengthen including in the analysis only peer-reviewed articles. Including conference papers inside the analysis would have undermined the robustness of the research, due to the lack of scientific rigour these publications might have. Another limitation during the paper selection phase is the English language of the paper. Investigating Industry 4.0 with a managerial perspective is the aim of the literature. Therefore, the category of interest was limited to Scopus' "Business, Management and Accounting".

Figure 2 follows the steps identified by Cobo (2011), which are: Research Design, Compilation of bibliometric Data, Analysis, Visualization, Interpretation. Each of this step is further explained below.

- Research Design: this step focuses on the choice of the bibliometric method, which should be based on the identified research question;

- Compilation of bibliometric data: this second step focuses on the identification of the proper database to utilise.

- Analysis: this step focuses on the actual analysis to perform, as well as the software to adopt for carrying out such an analysis;

- Visualization: this step focuses on the method to adopt in order to display data in a faithful and useful way;

- Interpretation: the last step, is also the most important. During the interpretation phase, the researchers give meaning to the results.

The bibliometric technique adopted for conducting this analysis is the co-word analysis. The way co-word analysis works was explained in section 2.2.1. However, this analysis supports the identification of the theme of research that composes the literature, as well as their importance.

Scopus was the database used for conducting the Query. No time limitations were posed, in order to reach old and new publications. The reliability of this literature review was strengthen including in the analysis only peer-reviewed articles. Another limitation during the paper selection phase is the English language of the paper. Investigating Industry 4.0 with a managerial perspective is the aim of the literature. Therefore, the category of interest was limited to Scopus' "Business, Management and Accounting".

Table 7 - Parameters of the analysis

Keywords Searched	Smart Manufacturing; Smart Industry; Fabbrica Intelligente; Nouvelle France Industrielle; Smart Factory; Manufacturing Innovation 3.0; Made in China 2025; Catapult; Industrial Value Chain Initiative (IVI); Produktion 2030; Industria Conectada; Prumysl 4.0; Advanced Manufacturing Partnership; Produtech; I4MS; Made Different; Platform Industrie 4.0; Make in India
Database	Scopus
Time Limitations	None
Category Limitations	Business, Management, Accounting
Source	Peer-reviewed Article
Language	English
Date of query	November 2017
Number of documents	117

Differently from the co-word analysis showed in section 2.2, the software used for carrying out the analysis is VosViewer (van Eck & Waltman, 2010). The software was chosen due to its reliability. Moreover, it allows display data in three different graphics: Network Visualization, Density Visualization, Overlay Visualization. Network Visualization shows every keyword with an associated colour. Keywords with the same colour compose a cluster.

The keywords collected were analysed, Table 8 - Keywords analytics shows the twenty most important keywords that emerges from the bibliometric analysis along with the occurrences and the total link strength. From the analysis of the data in Table 8, it emerges which are the most crucial topics clearly: Industry 4.0, Manufacture, Internet of Things, Cyber-Physical System, Supply Chain Management and Human Resource Management. Despite the definition of nine main clusters of keywords, the keywords appear to be very close.

Table 8 - Keywords analytics

Keywords	Occurrences	Total link strength
Industry 4.0	28	47
Manufacture	19	62
Internet of Things	12	41
Cyber-physical systems	10	34
Supply Chain Management	9	39
Management	8	9
Smart Manufacturing	7	19
Make in India	7	4
Decision Making	6	32
Embedded Systems	6	28
Big Data	5	25
Automation	4	22
Smart Factory	4	17
Human Resource Management	4	10
Radio Frequency Identification	3	20
Optimization	3	19
Design/Methodology/approach	3	16
Shopfloor	3	16
Agile Manufacturing Systems	3	15
Industrial revolutions	3	14

2.4.5 Major themes of research about industry 4.0

The analysis of the data starts with the discussion about the keywords' disposition inside the Network Visualization Figure 36. Many conclusions could be drawn by looking

at the keywords: the first is related to the fact keywords are close to each other. This support the belief that all the different governmental plan enlisted in section 2.4.3 are discussing the same subject. However, this research could not identify the reason for the existence of these different labels.

A second conclusion related to the Network Visualization is that keyword associated with the "Make in India" initiative is more distant than the others. Section 2.4.17 summarised the importance of this plan for Indian companies. The plan's birth is related to the economic failure India faced in 2013. Therefore, the "Make in India" initiative covers different aspects that could explain why the topic is not well connected to others; the only two connections are Manufacture and Total Quality Management.

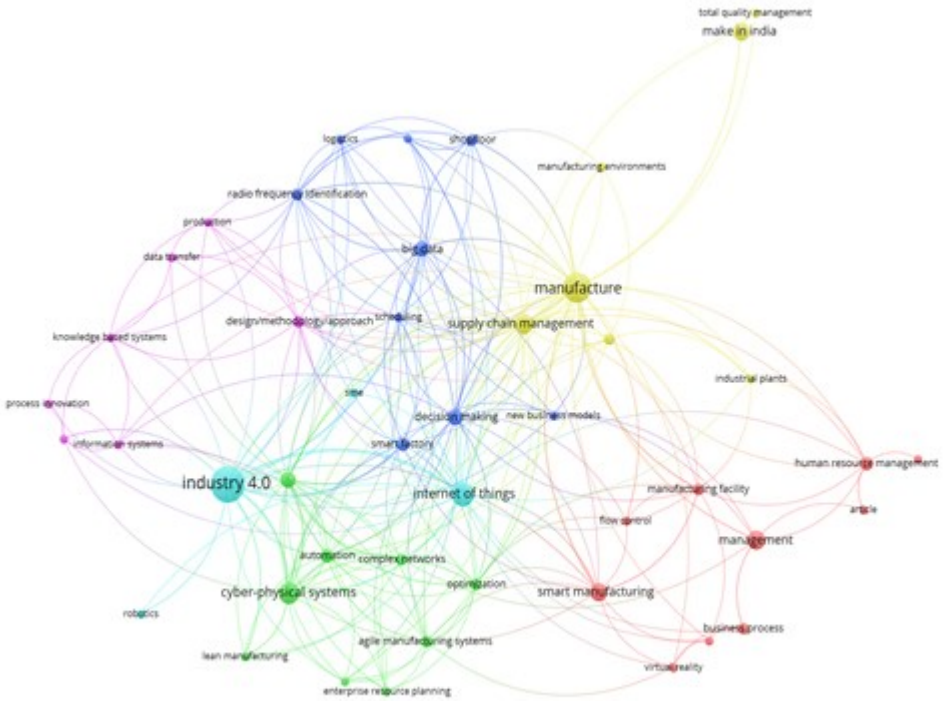


Figure 36 – Network Visualization

Industry 4.0 is the most crucial topic along with the Manufacture one. Researches are directly investigating the Industry 4.0 topic focused on different aspects; this testifies to the multi-faced nature of this theme. Moreover, Industry 4.0 is in an initial stage (Strange & Zucchella, 2017). Theorin et al. (2017) identified a system architecture for Industry 4.0, while Sommer (2015) showed that this innovation could harm companies especially

SMEs: the smaller the companies, the more critical their survival could be. The Manufacture topic is also closely related to the Supply Chain Management. Many pubblications tried to improve the supply chain of manufacturing companies. These companies are now facing the challenges posed by Industry 4.0, which is supposed to profoundly change the Supply Chain Management (Kovács & Kot, 2016). Moreover, the implementation produce shift, among all, in the processes' speed (Ivanov, Dolgui, Sokolov, Werner, & Ivanova, 2016).

Furthermore, it is worth to notice the almost complete absence from the map of the different labels listed in Table I. This highlight the fact that, despite the differences in the name used to refer to the phenomenon called "industry 4.0", the discussion inside the literature is on similar topics, which underlie that the object of the research is usually the same.

A certain degree of importance is generated by the topics which involve a system perspective: Lean Manufacturing, Agile Manufacturing, Enterprise Resource Planning. These keywords are strongly associated with Industry 4.0, and their disposition on the map is between Cyber-Physical System, Smart Manufacturing and Internet of Things, which indicates how central these topics are. In particular Sanders, Elangeswaran, & Wulfsberg (2016) identified that "committing into Industry 4.0 makes a factory lean beside being smart", while Kolberg, Knobloch, & Zühlke (2017) sees Industry 4.0 as the possibility to implement the Lean Automation in the factories.

Lastly, it is interesting to note that almost all the keywords are new, as the Industry 4.0 terms appeared for the first time in 2013. Only two keywords are older than the others. The first one is Data Transfer, which relates to the Radio Frequency Identification (RFID). This technology is a vital component of the digitalisation of the manufacturing companies (Jondral, 2016) as it allows the transformation of ordinary object or products into smart ones (Zhong et al., 2015)

The other keyword is "Human Resource Management" (HRM) which is a crucial topic. It is recognised by several authors to play an essential part in enforcing the successful implementation of Industry 4.0. Its association with Manufacture and Supply Chain Management (Fig. 1) remind the importance of this organisational function in assuring the excellent implementation of productive models (e.g. Lean Management, Green Management, Environmental Management).

Moreover, HRM is also recognised crucial in supporting the improvement of the operational processes in manufacturing enterprises. The research of Do, Yeh, & Madsen (2016) also confirms this. The authors underline the relevance of HR flexibility and its impact on organisational innovation and culture.

The critical role played by the HR department, is also noticeable by the worries that surround the Industry 4.0 topic. In November 2017, the consulting firm McKinsey highlights in its report that almost 800 million jobs are at risk due to the implementation of new technologies. This considerable change will push for the automation, expelling from the market jobs with almost no added value. However, this technologies' implementation is creating a skills shortage which brings the HR department to choose whether is beneficial for companies to acquire those needed skills on the market or to train the old employees from the inside. On this topic, the research of Lewis (2014) shows the importance of overtraining (in an advanced manufacturing environment) to ensure high-quality apprenticeships of new personnel. There is also room for concern due to the "job polarisation" that could be created by industry 4.0 (Hirsch-Kreinsen, 2016). The job polarisation is the creation of two kinds of works: one with routinised tasks and the others more focused on problem-solving. According to this view, the low skilled task will be replaced by automation.

The last finding that emerges from the analysis of the literature on the Industry 4.0 is the lack of theory connected to this topic. The researchers adopted a practitioners' perspective more than a theoretical one. This lack of theory supporting Industry 4.0 serves as another clue in understanding how fragmented is the field in this beginning stage.

2.5 Gaps and Research Questions

This chapter showed the three literature reviews conducted. Moreover, these reviews aimed at the identification of the research gaps and the subsequent research questions.

The first literature review analysed the topic of HRM in manufacturing firms, the second the role of HRM in SMEs, while the third focused on framing the Industry 4.0 phenomenon.

The first literature review highlighted the importance of the HRM practices. The HR practices were found necessary in securing the successful implementation of Lean Management and Environmental Management. However, despite the crucial role played by HRM, the industry 4.0 was not among the topic discussed. The lack of publications about these two topics is related to the novelty of Industry 4.0.

The second analysis spread from the conclusion of the first ones. Many studies were focusing only on big companies. In order to grab a better understanding of the topic under investigation, this second analysis focused on understanding the role of HRM in SMEs. The findings of this analysis suggest that the HR practices have similar effects on SMEs. However, the adoption of the HR practices is often hinder or resisted by management for different reasons. Moreover, the literature did not address the phenomenon of Industry 4.0 in SMEs, for the same reason identified in the first literature review.

The third and last analysis conducted concerned the understanding of the Industry 4.0 phenomenon. Moreover, the analysis' goal was to highlight the similarities between the different labels. The analysis was carried out through the use of co-words analysis technique. The analysis took into consideration the 618 authors' keywords of the selected publications, the outcomes are objectives and not based on subjective interpretation of the authors. A first conclusion spreading from this review is the general absence of papers exploring Industry 4.0 with a managerial perspective. Moreover, HRM contributions to this topic are lacking. Results from this analysis suggested the different labels of Industry 4.0 to be referring to the same concept because all the keywords are close to each other.

It was then possible to identify the research gaps, which are shown in Table 9.

Table 9 - Identified Gaps

Gap	Description
#1	No evidence about the adopted approach for managing employees inside Industry 4.0 manufacturing companies
#2	No evidence of best practices about managing employees in Industry 4.0 manufacturing companies
#3	No evidence of the skills required by the new workforce

#4	No Italian case studies
#5	No studies on SMEs

From the identification of the gaps (table 9) were drawn three research questions. The research questions are provided below.

The first research questions spread from the lack of study about the way in which employees are managed inside manufacturing SMEs that are adopting Industry 4.0. The first and third literature conducted showed the absence of evidence about the HRM approach adopted by such firms. Therefore, the first identified research question is:

RQ1: What is the approach used for managing employees in manufacturing SMEs that are implementing industry 4.0?

The second research questions aim to check whether Industry 4.0 impact on manufacturing SMEs Moreover, it was highlighted with the first literature review how the birth of the HRM happened in the same time of the "computerisation" era. The HRM appearance and growth in importance lead to many companies renaming (or adopting) their Industrial relations/Personnel department. Furthermore, nowadays HRM is an overarching label hosting several approaches to the management of employees (e.g. green human resource management, strategic human resource management.) Industry 4.0 is described by many as a disruptive phenomenon that would have serious implication for HR. Whether it would configure a shift in the management approach like the one caused by computerisation is the object of the second research question.

RQ2: What is changing in managing employees after the adoption of Industry 4.0?

The third and last research questions identified in this dissertation spread from the analysis of all the three conducted literature. The importance of the HR practices is acknowledged since Huselid study in 1995. Researches show the importance of HR

practices for implementing production models such as Lean Management or Environmental Management.

Therefore, this is the identified third research questions:

RQ3: What are the main practices about managing employees in Industry 4.0 manufacturing SMEs?

2.6 Definitions adopted in this Ph.D. thesis

After reviewing the literature about Human Resource Management (HRM), deepening the understanding of the HRM role played inside manufacturing SMEs, and literature on the Industry 4.0, this section provides the definition adopted by the researcher in studying the research questions previously defined.

-Human Resource Management

When it comes to Human Resource Management, different definitions are possible to describe this approach in managing employees. This research view HRM as "the managerial utilisation of the efforts, knowledge, capabilities and committed behaviours which people contribute to an authoritatively co-ordinated human enterprise as part of an employment exchange (or more temporary contractual arrangement) to carry out work tasks in a way which enables the enterprise to continue into the future." (Watson, 2010)

-High Performance Working Practices

Numerous studies have contributed to the development of High-Performance Working Practices (HPWP), Baker, 1999; Betcherman, 1994, Guest, 1997; Hutchinson, 2000, Pfeffer 1994, 1996, 1998, just to cite few authors. A general definition is missing (Armstrong, 2014), the set of practices "vary from a project to the other" (Kroon, Van De Voorde, & Timmers, 2013). Inside this Ph.D. thesis, when referring to HPWP the definition provided by Pfeffer (1998) is adopted. According to the author, seven dimensions (or practices) are the reason why companies are successful, and therefore are called HPWP. The identified practices are: Employment Security; Selective Hiring of new personnel; Self-managed teams and decentralization of decision making as a basic principle in organization design; comparatively high compensation contingent on performance; Extensive training; Reduce status distinction and barriers, including dress, language, office arrangements, and wage differences across levels; Extensive sharing of financial and performance information throughout the organization. Each of these seven practices is defined below.

2.6.1 Employment Security

The Employment security deals with the kind of work contractualization offered to the employees. According to Pfeffer (1998), long term contract should be used instead of short time contract. By doing so, employees will feel as part of the organization and contribute to reach better performance. On the organization side, the long term contract is also a limit that could treat the flexibility of the companies, therefore the risk of becoming heavier push the organization in be careful in the selection and to correctly select new staff members.

2.6.2 Selective Hiring of new personnel

Selective Hiring refers to the recruitment of talented people who could deliver superior performance. There are several ways to achieve such a result, one of this in to ensure having a proper pool of candidates and be clear about what are the critical skills they are looking for. However soft shills should not be under looked, "organizations should screen primarily on important attributes that are difficult to change through training and should emphasize qualities that actually differentiate among those in the applicant pool" (Pfeffer, 1998).

2.6.3 Self-managed teams and decentralization as basic elements of organizational design

Self-managed teams refer to the organization of the employees into teams that are able to take decisions. According to Pfeffer (1998) this is a critical component. Self-managed teams "enjoy greater autonomy and discretion, and this effect translates into intrinsic rewards and job satisfaction" (Pfeffer, 1998).

2.6.4 High Compensation Contingent on Organizational Performance

Compensation contingent on performance takes different forms: "gain sharing, profit sharing, stock ownership, pay for skill, individual or team incentives" (Pfeffer, 1998).

2.6.5 Training

According to Pfeffer (1998), Training is "an essential component of HPWS because these systems rely on front-line employee skills and initiative to identify and resolve problems, to initiate changes in work methods, and to take responsibility for quality.

2.6.6 Reduction of status differences

The reduction of status differences aims at enhancing commitment and the performance of the employees. This could be tackled in many ways, "symbolically, through the use of language and labels, physical space, and dress, and substantively, in the reduction of the organization's degree of wage inequality, particularly across levels.

2.6.7 Information Sharing

"Information sharing is an essential component of high-performance work systems. The sharing of information on such things as financial performance, strategy, and operational measures conveys to the organization's people that they are trusted" (Pfeffer & Veiga, 1999)

2.6.8 Industry 4.0

Industry 4.0 lacks a shared definition by both academics and practitioners. When referring to Industry 4.0 inside this Ph.D. thesis, the researcher acknowledges the disruptive potential of the phenomenon, especially for its consequences on the employees. Industry 4.0 is studied as a new organisational model based on the implementation of several technologies (i.e. Cloud, Additive Manufacturing, Cyber Security, Big Data Analytics, Simulation and Augmented Reality, Horizontal and Vertical Integration) that works together for the improvement of organisational performance. In this context, the management of employees is a key enabler to benefit from Industry 4.0.

3. Methodology

3.1 Overview of the chapter

This chapter is fundamental to the development of this dissertation. Knowledge must be generated through a structured process; therefore, this chapter aims to demonstrate that only the proper research methods were used for carrying out the thesis. For this reason, this chapter provides a full explanation of the reasons which brought to choose the qualitative approach over the quantitative one. Emphasis is put on shedding light on the multiple case studies. Moreover, the selection is carried out referring to the most famous and cited authors dealing with qualitative research. The chapter also defines how the research questions led to the identified propositions, showing how data are collected and designed.

Furthermore, this chapter also provides information about the validity and reliability of the research design. A dedicated paragraph is given to this topic since the validity, and the reliability represents a significant aspect of qualitative research, therefore deserving detailed investigation.

3.2 The choice of the method

The choice of method required the definition of the philosophical stand adopted in this Ph.D. thesis, which reflects the values, the rules and the reality perception that guide the action and belief of the researcher. The scientific literature about this topic identified two central philosophical standpoints called "positivism" and "social constructionism". According to the definitions provided by Easterby-Smith (2003), the positivism sees the world as already established, its attributes and characteristic could be analysed through an object and formal inquiry. Positivism emphasises the measures and the way to assess the phenomenon; it is not interested in the significate behind the phenomenon under investigation. Therefore, there is no trace of subjectivism and the methodology adopted is quantitative.

In the social-constructionism, the reality is described as a social construct instead of something already existing and objectively determined. In this view, the individuals give meaning to the reality through the significance they gave to specific constructs. Researchers working under social constructionism are more interested in understanding why certain phenomena or conditions occurred. In order to grasp this, qualitative methodology is the one that responds to the needs of the research (Collins and Hussey, 2003).

The difference between the positivism and social constructionism approach, are significant and absolute only in theory, as ideal types. Therefore the Ph.D. thesis could rely on both the approach. However, due to the personal preference and the philosophical view of the researcher the thesis is empirical research, that relies on social constructionism. This approach is the proper one that allows for the correct comprehension of the phenomenon under study. Moreover, Industry 4.0 and Human Resource Management as well as the studying of Small and Medium Sized Enterprises, push the researcher to comprehend the interaction between several factors. The phenomenon under investigation must be analysed inside its natural context. Moreover, the history of the organisations, as well as their organisational culture, are important factors influencing the Human Resource Management and the Industry 4.0 implementation.

3.2.1 Research paradigm

Eisenhardt (1989) and Yin (2009) are two of the most relevant and widely accepted authors that contributed with their works to the development and support of the field of qualitative research methods. In order to define the methodology for this dissertation the work of the two above mentioned authors were used as a reference point. According to Yin (2009), the first and most important condition for differentiating among the various research methods is to classify the type of research questions being asked. Yin distinguishes between "why" and "how" questions. According to this author, these kinds of questions are likely to be answered through case studies. However, these two kinds of questions refer to Explanatory case studies. For conducting exploratory case studies, a certain type of "what" questions could be asked and answered using case studies. As

partially explained above, there may be exploratory, descriptive or explanatory case studies.

Two are the criteria identified by Yin (2009) that pushed in this thesis for the adoption of the case study method. The first one is the extent of control over behavioural events, while the second is the degree of focus on contemporary as opposed to historical events. A case study is preferred in examining recent or contemporary events, and since Industry 4.0 is a new topic, the choice of this method fit the object of the dissertation.

About the adoption of case studies are Halinen & Törnroos (2005) these authors suggest using case studies because such a method "is more suitable for the study of business networks". Flyvbjerg (2011) view a case study as a study that demarcates the boundaries, identifying the unit of investigation, is intensive, producing rich, detailed information, evolves and is focused on the context of the case. Moreover, Yin (2009) indicate when case studies should be preferred over the conduction of quantitative analysis: when the researcher wants to understand a real-life phenomenon in depth, like the industry 4.0 impact on the HR function in this thesis. Understanding this would result in understanding critical contextual conditions which are contingent on the phenomenon under study. Indeed, case studies could allow conducting research where it would be too difficult or complicated for a survey to succeed. Moreover, the use of case studies, especially multiple case studies, allow understanding of the real-life context in which the phenomenon under investigation happens. Furthermore, case studies allow to explain certain topics descriptively and, lastly, when the situation to be investigated is unclear and has no single set of outcomes (Yin, 2009).

3.2.2 The case study Method

This dissertation used a case study approach to obtain empirical insights into the impact of Industry 4.0 on the HRM practices. As Stake (2005) observed: "a case study is not a methodological choice but a choice of what is to be studied". A case study approach particularly fits the research questions and the nature of this thesis, which is exploratory and want to understand how Industry 4.0 impact on the HR practices. Yin (2009) identified the different phases for conducting the case studies: definition and design of the research, data collection, data analysis and the conclusion.

The first phase identified by Yin (2009) focus on the clarification about the aim of the study. This would result in the selection of the most suitable cases in order to provide an answer to the study's research questions. During this step, a research protocol that supports the case analysis is developed.

The second phase sees the researcher conducting interviews for each selected case. Interviews allow researchers to increase steadily their experience about how to carry out the data collection.

The third phase spread from the data collection; these data are then analysed for each case. Every case which consists of a whole study, the analysis tries to bond together the evidence regarding the facts and conclusions for the case: "each case's conclusions are then considered to be the information needing replication by other individual cases" (Yin, 2009).

The last step is the Cross Case analysis; this analysis leads to the conclusions and implications of the research. Both the individual cases and multiple-case results can and should be the focus of a summary report. For each case, a case study report is prepared, the report should indicate how and why a particular proposition is demonstrated (or not demonstrated). Across cases, "the report should indicate the extent of the replication logic and why certain cases are predicted to have certain results, whereas other cases, if any, are predicted to have contrasting results" (Yin, 2009).

3.2.3 Retrospective longitudinal analysis

Time limitations related to the duration of the Ph.D. did not allow for conducting a longitudinal case study. Such a method needs a researcher to remain in the organisations over an extended period. Therefore this was not possible. Instead, a retrospective approach as adopted. This method relies on the participants' memories. Using a retrospective approach was possible even because the Industry 4.0 implementation started in every company only a couple of years ago. Only one of the firms under investigation started its implementation a little earlier: seven years ago. It was therefore assumed that respondents' memories were reasonably accurate, with them being able of recalling the changes occurred over time easily. In order to ensure the strengthen the analysis, a convergent approach was also taken. A convergent approach tries to link the

respondents' answers with secondary data, in order to check and confirm that the events being told are accurate and reliable.

3.3 Research Design

3.3.1 Cases Selection

According to Yin (2009), the selection of cases is the most crucial aspect, and this should not be done as a statistical sampling process. The selection of the cases should prefer the investigations of an organisation that will allow researchers to shed lights on the phenomenon under study and that will also allow researchers to answer the research questions. In order to strengthen this case selection phase a pool of case studies could be useful to select among them which cases to investigate. This dissertation focuses on the impact industry 4.0 had on SMEs and on the HR practices that are influenced or that lead to a better implementation of industry 4.0. In this study, the level of maturity reflects the degree to which industry 4.0 is implemented. Consequently, are selected companies that implemented industry 4.0 for at least two years and that are operating within the mechanical sector. The country is not a variable of relevance for this research since the Ph.D. thesis do not aims in establishing or understanding any country related difference. Table 10 contain the summary of the selection criteria.

Table 10 - Selection Criteria

Selection Criteria	-Small and Medium Sized Companies; -Manufacturing companies; -Engaged in Industry 4.0 implementation for at least 2 years.

Considered these selection criteria, we first carried out a few interviews with key informants who could give us some suggestions about potential cases. They were some HR Manager and some Entrepreneur/Managers.

After conducting these preliminary interviews, it was then possible to identify the five cases that were used for this thesis, that were meeting the selection criteria listed in Table 10.

3.3.1 Data collection protocol

According to Yin (2009), the data collection protocol is intended to guide researchers in carrying out the data collection from each case. Table 11 presents information about the protocol sections along with the contents expected and used in the study. Furthermore, the table provides for each section theoretical issues, and practical actions carried out in this dissertation, showing the backbone of the research protocol that will be shown later on.

At the core of the data collection protocol, there are the case study questions. For this reason, defining which questions to include and how to structure the questions required carrying out a pilot study. For the pilot study was chosen a company (CPS) operating in the mechanical sector, in the north east area of Italy. The company is a small firm that embraced Industry 4.0 in 2014. Moreover, the CEO and the IT Manager attended several conferences and workshop for deepening their understanding about Industry 4.0. The pilot study aimed at improving the quality of the Research Protocol; the people interviewed were the Owner of the Company, the IT Manager, and the HRM Manager. These respondents possessed many information about Industry 4.0 and had a complete view of the organizations. Therefore, from these interviews were obtained precious insights.

Further information about the questions and the interviews are provided in chapter 3.3.1. The first draft of the protocol was shared with key informants that checked in advance the overall quality of the identified questions. After the first revision made by these key informants, the protocol was applied to the pilot mentioned above case. One company The rationale behind the use of a pilot case is to check if the questions cover the topic under investigation in all its complexity, according to the nature of the study and the research purpose. Moreover, the pilot data conducted return a significant amount of information about the issues under investigations. The information collected allowed gaining considerable insights into the underlying issues being studied and therefore, the

final research design was informed both by prevailing theories and by a set of empirical observations.

Table 11 - Guidelines for the preparation of the data collection protocol (adapted from Yin, 2009)

Protocol section	Contents	Contents in the study
Overview of the case study project	Background information about the project, the issues being investigated, and the relevant readings about the issues	- Visit the website of the companies. - Search for materials published on the Internet or provided by previous key informants
Field procedures	Plan the data collection to - Gain access to critical organisations alternatively, interviewees - Have sufficient resources while in the field - Make a clear schedule of the data collection activities to be completed within a period - Provide for unanticipated events	- Contacts with potential key informants to be interviewed - Scheduling of interviews from January to July 2018 - Organize with a recording device moreover, a notebook to bring during the interviews
Case study questions	They represent a reminder of the information that needs to be collected and why; each question should be accompanied by a list of likely sources of evidence	- Preparation of the semi structured questionnaire - Sharing with key informants - Pilot case study
Guide for the case study report	Description of a research design, apparatus and data collection procedures; presentation of the data collected; analysis of the data; discussion of findings and conclusions	- Draft for each case - Use of matrices and schemes to identify patterns - Revision by key informants

In order to gather a clear picture of the firm under investigation, the developed protocol included six area of investigations, related to the impact Industry 4.0 should have and on the research interests/research questions identified: Preliminary information,

Technologies, Products, Business Processes, Human Resource Management and Business Models. After the development of the protocol and the use of the protocol in a pilot case study, the information about its ability to support the interviews was checked and improved with the insight emerged from the pilot case.

Here Below in Table 12 an extract of the Research Protocol used for carrying out the interviews:

Table 12 - Extract of the Research Protocol

Dimension	Example of questions
Preliminary Information	• What is the company's vision/mission? How do you believe they will change in the future? What could hinder/promote change? • In which organisational area do you spend most of your business budget? (production, promotion) • In the formulation of your business strategy, do you pay more attention to the aspects related to cost, quality or innovation? (Cost reduction, product innovation, quality certification) [Schuler Jackson, 1987] • Is the business strategy regularly reviewed? How is it related to business plans? (understand if the awareness of this strategy is prevalent in the organisation)
Technologies	Which of the following technologies did you implement in the company? • Advanced manufacturing (i.e. robot collaborative e rapidamente interconnessi) • Additive manufacturing (es. Stampanti 3d connesse a software di sviluppo digitali) • Augmented reality (realità aumentata a supporto processi produttivi) • Simulation (es. simulazione tra macchine interconnessi per ottimizzare i processi) • Horizontal/vertical Integration (delle informazioni)

	• Industrial internet (comunicazione tra processi e prodotti) • Cybersecurity • Cloud • Big data & analytics
Products	•Did the technologies mentioned above allow us to create new products or innovate existing products? Which? o Digitalization of products, Product integration into other systems o Products able to interact with the external environment o Products that can predict or detect anomalies • Did the technologies mentioned above allow us to create new services or innovate existing services? Which? To whom (customers, suppliers, partners) o Traceability of the product (during production, distribution or all life) • What features do these new types of products have? (descriptive, diagnostic, predictive, prescriptive skills)
Business Processes	• What is measured by the company? (finance, people, using tools or framework, how often) • How is the collected data/information analysed? • How do you think the company's key performance can be improved? • How is the information used to support decision making? • How is information/data collected on the external environment?
Human Resource Management	• What are the main corporate values? • How are the skills distributed within the company? (newly hired, senior) • What is the level of staff turnover?

	• How training is managed (internal, external, areas, frequency) • Is the work environment designed with the needs of the workers in mind? • Is the HR function involved in defining a business strategy? o If so, how? o Have you considered the option to outsource HR? Yes/no for what reason? • Do you use specific software for human resource management? • What are the main activities carried out by HR? o Which activities employ the most HR time? • Do you define an HR strategy? o What is the adopted HR strategy? • Which HR practices are used? Alternatively, Do you expect to change?

3.4 Data collection

3.4.1 Interviews

The method chosen in any research must align with the desired outcome, a way for which method to choose depends on what the question is. Based on the data collection protocol, ten in-depth interviews with key respondents (i.e., CEO, Managing Director, HR Manager, Sales Manager) were carried out. Respondents were asked about industry 4.0 implementation, asking for their opinions about events and how Industry 4.0 impacted on the organisation, especially concerning the HR practices/HR function.

As far as interviews about Industry 4.0 are concerned, more than one informant for each company was interviewed, investigator triangulation (Patton, 2002) was established. Respondents were interviewed more than once, with a period between the different interviews of a couple of months. By doing so, it was possible to capture aspects related to the ongoing implementation of the Industry 4.0. Moreover, this gave time for companies to improve their maturity regarding adoption, increasing the chances of Industry 4.0 to affect organisations' life.

According to the time the interviewee scheduled for answering researcher's questions, each interview lasted between forty minutes and one and a half hour. All interviews were recorded with a microphone after receiving authorisation from the respondents to do so. Table 13 shows some details about the interviewed people.

According to Yin (2009), when doing qualitative interviews, there are six factors to take into consideration: Speaking in a modest amount, being non-directive, staying neutral, establishing and maintaining rapport, use an interview guide, Analysis when interviewing. This chapter provides a summary of each of these factors.

-Speak in modest amounts. Interviewers should speak less that respondents, for ensuring this would not happen a good way of conducting the interview is for asking an open question. This should be enough to avoid dead-end answers. It is of importance when doing qualitative interviews to speak less than the respondent.

-Being nondirective. The researchers should avoid confirming his findings and should always pay attention to allow the respondents to express their ideas and thoughts about the questions prompted.

-Staying neutral. Along with not trying to confirm researchers' findings by a biased line of questioning, researchers should also avoid expressing their ideas on different topics. Failing to do so, could lead to respondents' bias, as a reaction of feeling approved or disapproved by the researchers' comments/ideas. This would hinder any meaningful thought that is the researchers' aim to discover. Therefore, remaining neutral is always a must. Even when prompted by respondents, researchers should avoid sharing their ideas.

-Establishing and maintaining rapport. This point refers to the ability of the researchers to get in touch with the respondents, to familiarise with them by using among all, eye contact. This should allow receiving honest answers, which was of great importance for this dissertation because the Industry 4.0 hype could lead respondents' in emphasising the impact it had.

-Use an interview guide. This point refers to supporting the questions' protocol having an interview guide that highlight the delicate questions, in order to ensure the respondents' answers will prove insights into these questions. Using an interview guide will strengthen the research (Bryman & Bell, 2011).

-Analysing when interviewing. Although this point could seem as opposed to what has been said until now, the analysis of the data starts during the interviews. Due to the unstructured nature of the interviews, this means researchers should be able to ask follow-up questions on time and point. Otherwise, the respondents could lose focus and having an open line of questioning. Meaningful answers could never be provided to researchers if the right questions are not prompted on time.

Company name	Who was Interviewed	Plant Visited	Duration	N* of Visits
Company A	Managing Director IT Specialist	Yes	1h 30 Each	3
Company B	CEO Sales Manager	Yes	1h 30 Each	3
Company C	CEO HR Manager	Yes	1h 30 Each	3
Company D	CEO HR Manager	Yes	40 min Each	2
Company E	Director F Director S	Yes	1h Each	1

Table 13 - Interviews performed

A clarification about any relations between the researcher and the interviewee should be provided: none of them was known before conducting the study for any personal or professional reason. Moreover, the criteria for the cases selection were already provided in paragraph 3.2.1. The number of respondents was decided along with the proceeding of the interviews, by doing so, the interviews were ended only after reaching the saturation point. Once reached the saturation threshold, the interviews were stopped because the topic was considered exhausted (Charmaz, 2006), saturation occurred after ten interviews. Kvale & Brinkmann (2009) suggest the number of interviews it is not so important; the focus of the researcher should be on conducting fewer interviews so that it is possible to analyse them more closely. Creswell, Hanson, Clark Plano, & Morales (2007) suggests that eight to ten interviews are enough for reaching the saturation level, which supports the number used in this doctoral thesis.

3.4.2 Other source of evidence

The interviews are not the only way a researcher could gain evidence about the companies under investigation. Yin (2009) identified five other possible sources of evidence: direct observations, documentation, participant-observation, archival records and physical artefacts (Yin, 2009). The different sources are highly complementary; therefore, in order to achieve higher quality in the research more sources should be used. In particular, the following sources of evidence were used inside this dissertation in so that was possible to strengthen the data collection phase:

-Documents: administrative documents, respondents personal documents, articles in newspapers, public announcements and company website along with the internet;

-Archival records: organizational records, "public use files" (i.e. statistical data);

-Direct observation: observations of meetings, classrooms, field visits;

-Physical artefacts: physical evidence of the industry 4.0 implementation.

Using the multiple sources of evidence explained above would foster the development of converging lines of inquiry, as well as a process of triangulation and corroboration which differs from the investigator triangulation cited in the previous paragraph. This one is called data triangulation (Patton, 2002).

3.4.3 Case study database

A database containing all the required information about the conducted case studies was created. For each case was created an excel data sheet containing all answers from the different interviews to the questions contained in the research protocol. The database creation is one of the methods for overcoming the shortcomings case study suffer, which

is the lack of a formal database differing from the written report because these reports are usually the only source of data collection. The Data collection phase, as explained in the previous paragraph about the different source of evidence, may lead to the collection of documents, notes, tabular materials and narratives. All of these containing valuable information for the sake of the research, which needs to be stored for the following examination. Therefore, every critical reader would not be able of checking the data collected in a structured way without the creation of a case study database that links the different evidence with the finding ad that allows putting order between the collected materials.

3.5 Data analysis

Data analysis consists of data reduction, data display, conclusion drawing and verification (Miles, Huberman, & Saldaña, 2014). The importance of this phase is testified by Eisenhardt (1989) words: "Analysing data is the heart of building theories from case studies, but it is both the most difficult and the least codified part of the process".

When analysing data two different, but complementary, techniques are possible. The main distinction between these two is that the within-case analysis aims to "become intimately familiar with every single case as a stand-alone entity" (Miles et al., 2014). The cross-case analysis aims to "go beyond initial impressions, especially through the use of structured and diverse lenses on the data", allowing the researcher to compare the different findings identified in each case, and to confront them in a structured way that could support the drawing of the conclusions. This paragraph provides further details about the Within-case analysis and the Cross-case analysis that were briefly explained above.

3.5.1 The Within-case analysis

The Within-case analysis rationale is to allow researchers to become familiar with data so that would become possible to draw preliminary theory, while also allowing to emerge the unique patterns of each case. This before researchers push to generalise patterns across cases. The Within-case analysis does not have a standard format to use, however, at the heart of this method there is a detailed case study report for every case.

The report consists of descriptions which help researchers to deal with the massive amount of data usually present in this phase of the analysis. Useful critical incident charts, networks, time-ordered matrices, event listing, and taxonomies. In order to provide consistent and reliable background information about every case, the researcher collected information from documents, websites and other sources about the five cases investigated in this dissertation. Collecting data from that documents allowed the researcher to deepen the understanding of what is needed for cross-case analysis.

After retrieving all the documents, the researcher was able to look for explanation and causality. In order to establish causality, it could be created a causal network that "display [..] the most important independent and dependent variables in a field study and of the relationships among them" (Miles et al., 2014). For better allowing the analysis of the results, quotes from respondents were added to provide accountability and to highlight the crucial points.

The write-up of each industry 4.0 implementation was audited by feeding each case description back to the key respondents of every firm (the CEOs of the investigated SMEs) to confirm accuracy and further clarify understanding (Patton, 2002).

The within-case analysis was the first level of analysis of the data and was reviewed as part of the supervision process. Moreover, it allowed identifying some emerging patterns while also building the familiarity of the researcher with each case before the cross-case comparisons (Eisenhardt, 1989).

Chapter Four is dedicated to the Within-case analysis and the subsequent analysis concerning each case; it provides evidence about the industry 4.0 in every company along with the investigations about the High-Performance Working Practices.

3.5.2 The Cross-case analysis

As mentioned in the previous paragraph, Within-case analysis was the first step in analysing data. Moreover, the Within-case analysis allowed the researcher to become familiar with the data collected and also to draw some pattern. The Cross-case analysis is the next step conducted, the purpose of the Cross-case analysis is to develop a deeper understanding of the industry 4.0 impact upon HRM in manufacturing Small and Medium Enterprises. The analysis followed the guidelines provided by Eisenhardt (1989),

Patton (2002) and Miles, Huberman, & Saldaña (2014). The Cross-case process involved the comparison of the five-case study, comparing all the data collected from all of them. By doing so, it was possible to examine the similarities and differences across multiple cases. One of the potential shortcomings of conducting case studies, and in particular of the Cross-case analysis is the possibility of reaching premature or even false conclusions. Eisenhardt (1989) suggest looking at the data in many different ways as a possibility for reducing such a shortcoming. For these reasons, the systematic search for cross-case patterns is a crucial, but delicate, step in case research. However, it is also essential for enhancing the generalizability of the identified conclusions (Voss, Tsikriktsis, & Frohlich, 2002). The effective tactics suggested in the previous literature (Eisenhardt, 1989) are very diversified, but the most common and used in this study are:

-selecting HR practices, and then looking for within-group similarities coupled with intergroup differences, widening this technique also to matrices in order to compare several categories at once;

-selecting pairs of cases for which listing the similarities and differences about the HR practices affected by Industry 4.0 between each pair;

-Multiple data sources allowed to build more reliable results, this increased the overall reliability of the dissertation. As an example, field notes were analysed separately, and this process aided in corroborating and strengthening findings

In this study, data were displayed in matrices and schemes, which enabled the definition of concepts and exploration of causal connections between organisational and managerial factors in order to understand how industry 4.0 impact on HRM in SMEs. This was done through the identification of multiple instances and the patterns that emerged.

Where findings conflicted, a more in-depth examination and probing of the data took place to understand the reason why. It involved comparing occurrences across the cases. In order to facilitate this process, the researcher took notes to support the identification of the conclusions along with why these occurred. At the end of this extensive process which aimed at providing strong results, it was possible for the researcher to identify conclusions. The conclusions spread from the different analyses that lead to the creation of six different propositions, that should be tested with future research, as explained in

chapter 6.6 – opportunities for future research. Chapter Five is devoted explicitly to the cross-case examination and the identification of the six propositions.

3.6 The quality of the research design

Yin (2009) identified four tests that establish the quality of case studies research, along with several tactics to use for addressing these four tests. The tests are: Construct Validity, Internal Validity, External Validity and Reliability. For each of this test is provided with a brief explanation.

-Construct validity: identifying correct operational measures for the concepts being studied and avoiding subjective judgements in collecting the data;

-Internal validity: seeking to establish a causal relationship between variables, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships;

-External validity: defining the domain to which a study's findings can be generalised;
-Reliability: demonstrating that the operations of a study –such as the data collection procedures– can be repeated, with the same results.
Table 14 presents the four tests with the respective tactics carried out in the study in order to enhance the quality of the research.

The researcher used multiple sources of evidence to increase construct-validity. Moreover, the researcher did not limit the interviews to a single respondent per firm; different employees were involved (as shown in Table 13). Internal reports, company briefings and press releases provided the secondary data.

For what concern the external validity, cases were selected so that they could produce contrary results but for predictable reasons (theoretical replication), predict similar results (literal replication).

Internal validity is not possible in the exploratory case study, therefore did not find room inside this research whose aim is to shed light instead of building causal relations between variables.
Lastly, Reliability was ensured with a careful building of the research case study protocol and database (Yin, 2009).

Table 14 - Case Study Tactics Adopted

Tests	Case Study tactics in literature	Tactics adopted for the study
Construct Validity	Use multiple sources of evidence Establish a chain of evidence Review draft, case study report	Multiple sources of evidence were used: Report, Industrial Documents, Observation and Semi-Structured Interviews A chain of evidence was established in order to allow an external observer to follow the derivation of any evidence. Every document was classified and linked to the topic of interest The Draft of the protocol was approved by practitioners and researchers working on the topic of industry 4.0 and Human Resource Management.
External Validity	Use theory in single case studies Use replication logic in multiple case studies	Replication Logic 5 case studies with literal replication
Reliability	Use the case study protocol Develop a case study database	A case study protocol was developed from the reviewed literature, highlighting the most critical dimensions of analysis for supporting the interviews.

4. Within case analysis

4.1 Overview of the chapter

This chapter is made up of six section focusing on the Within-Case analysis. Each section provides a detailed description of the cases included in this dissertation. Every section is divided into eleven parts: the first one gives preliminary information about the firms in order to allow readers to grab a general idea about the company. The sequent paragraph describes the birth of the company and its general characteristics, such as the business model, paying more attention to the evolution over time. The other parts shown in greater details some specific aspects which are particularly relevant to the aim of this study according to the identified research questions.

For this reason, emphasising the way in which Industry 4.0 was implemented as well as the HRM. Also, all the High-Performance Working Practices were analysed. Quotes by interviewed people are included in each paragraph in order to support the evidence with more strength.

4.2 Company A

This section provides a summary of Company A so to give a clear view of the essential information before analysing in depth the Industry 4.0 implementation and HR practices. This information is summarised in Table 15 below.

Company A (C.A) is an Italian company located in the North-East part of the peninsula, whose core business is producing rivets. Its interest in Industry 4.0 raise after its Owner attended the Hannover Conference in 2011. There, he discovered issues and challenges related to the concept of Industry 4.0. With the company still recovering from the 2008 financial crisis that halved the turnover, the Owner decided to adopt Industry 4.0. Increasing the firm's efficiency along with overall better performance are the two main reason for Industry 4.0 implementation.

Moreover, the Owner wanted to enter the Automotive market. Monitoring many parameters about the rivets (such as the batch number and the item number) was essential for entering the Automotive market. Therefore, the choice of implementing Industry 4.0. Along with the implementation of the Industry 4.0 the company grew in its size. The number of employees almost doubled in less than ten years. These changes increased the managerial complexity of the firm and pushed the management to think about how to implement Industry 4.0 while keeping the organisation lean. The need for focusing on the HRM spread from this.

Table 15 - Company A major indicators

Country	Location	Turnover	Employees	Sector	Generation	Production model
IT	Veneto Region	7 million	40	Mechanical	2nd	Lean

4.2.1 Company's Evolution

Company A (CA) is a small firm that operates in the mechanical sector and was founded in 1990 by two brothers. CA focused on the production of rivets, and its located

in the Veneto Region. Since its birth, CA sold rivets to different players, both Italian and foreigners.

In 2003, CA bought an area of 22 square kilometres upon which built a new plant. The facility measures approximately 6 square kilometres. The same plant also hosts the company warehouse for the Italian market, there 5 thousand pallets might be hosted.

In 2008 there was a change in the governance of the company switching from a family member to another. The founder of the company left the role of managing director in favour of his son. The son graduated in Management Engineering; moreover, he received specialised training to take on the leadership of the company. Right after this change in the chain of command, the 2008 financial crisis hit CA. It almost stopped the production while reducing the turnover by more than 50%.

2009 is a breaking year for CA, during this year the company changed its production model leaving the mass production. CA also changed its business model, delivering value in two manners: problem-solving and providing customised solutions about rivets. The investments in new technologies were the enabler of these changes in the production system and the business model of the company.

In 2012 CA decided to keep investing in technological innovations. Moreover, the Managing Director decided to push for the Industry 4.0 implementation.

The technological innovation pursued, allowed the company to enter the Automotive market, which was one of the wishes and strategic choices operated by the new Managing Director. Entering the Automotive market presented many issues to CA. Usually, in this market, there is a great need for reliable partners who can offer the best security for the products offered. CA focused on obtaining quality certifications: in this case, CA focused on ISO/TS and IATF certification.

In 2014, CA acquired one Israeli company in order to increase the knowledge about the production of rivets. The Italian plant hosted the Israeli machinery. Moving the Israeli machines allowed CA to enlarge the rivets' portfolio, adding new solutions that were required by the Automotive Market.

In 2016, CA built a new plant side by side with the old one, in order to facilitate the operations. The company used the available land bought in 1990. This area also hosts the headquarters of the company.

According to the official website of CA since 2017 the company has one clear mission:

> *"Become the Competence Centre for every company in the world that would like to adopt any rivets. By doing so, we aim to become a market leader also in the services related to the products like the design, the production, and the ability to provide data about the products."*
>
> Official Documentation

At the moment (2018) CA produce more than 500 million rivets a year. Foreigners' orders account for the 80% of CA turnover. For this reason, there are five warehouses in Europe: Poland, Cech Republic, Croatia, Slovakia and Russia. The presence of the warehouses across Europe support the distributions of the goods across the world.

4.2.2 Industry 4.0 in Company A

The first step that CA took for becoming an Industry 4.0 company was introducing in the company a Manufacturing Execution System (MES). The MES "provides a common user interface and data management system". Figure 37 supply evidence about how the MES implementation was carried out inside CA.

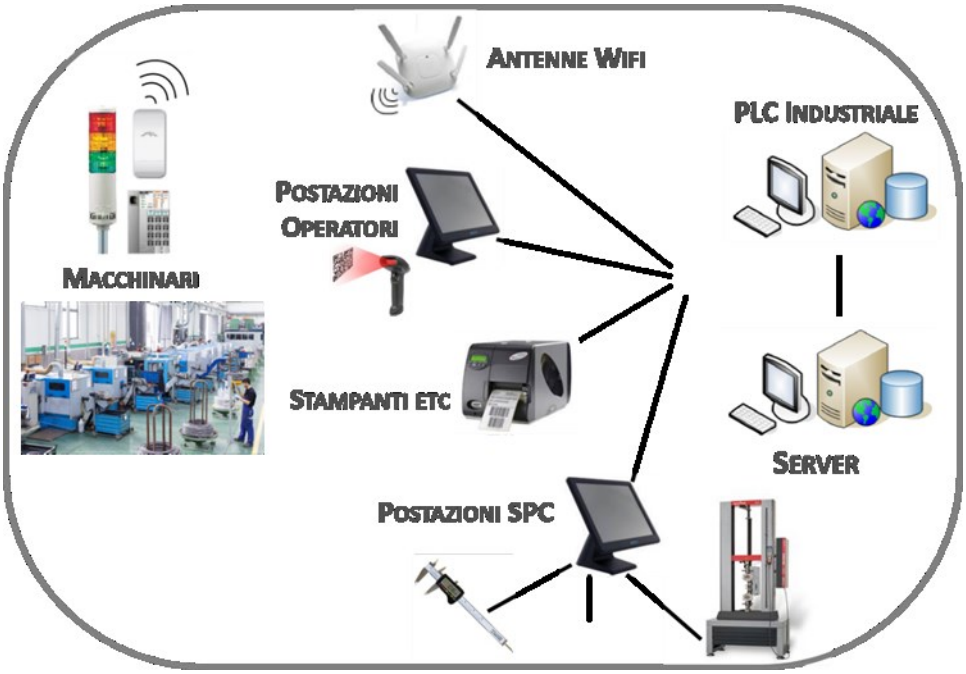


Figure 37 - MES implementation – an internal document of the firm

The MES concept was born from the demand on the manufacturing enterprise to fulfil the requirements of markets. These requirements are: reactivity, quality, respect of standards, reduction in cost and deadlines. As such, the functions of MES are primarily turned towards manufacturing activities" (Saenz de Ugarte, Artiba, & Pellerin, 2009). The firm's expectation of the MES implementation was: tracking of the products, allow the Digital Quality Management (DQM) and the Production Rules.

> *"In 2008 we were heavily hit by the financial crisis, so we decided to change our strategy, and we looked at the automotive market like the one that had the potentiality of drag us out of the swamp. However, the companies operating in that sector requires much information, they want secure and reliable data, like which raw material has been used in the products."*
>
> Managing Director of CA

Related to the tracking of the products – a must for entering the automotive market – the introduction of the MES aimed at monitoring the materials used, the operators, the quality and the productive process of the company. Related to the DQM is the coding of every product in the portfolio with every machine that should be used. This information is stored inside the MES' database. In the database were also stored the operative instructions about the production.

The database allowed CA also to implement the Statistical Process Control (SPC) (Figure 38 - Statistical Process Control in CA) which "is a tool that measures and achieves quality control, providing managers from a wide range of industries with the ability to take appropriate actions for business success" (Oakland, 2007). CA aimed with the implementation of the SPC in monitoring and visualising the trend of several parameters among all the most important were "cp" and "cpk" (Chan, Cheng, & Spiring, 1988). By setting the range of the variables under investigations, the system is also able to warn the user in case the production cycle is going out of the range. In this way, the firm can react to the situation before a malfunction happens, so that the company can promptly react.

Figure 38 - Statistical Process Control in CA

Having completed the implementation of this tool, CA focused its attention and effort in order to make it worth: increase the efficiency of the company. In order to improve performance, the firm focused on the Overall Equipment Effectiveness (OEE). OEE is "a tool that measures different types of production losses and indicates areas of process improvement. […] OEE has evolved leading to other tools like total equipment effectiveness performance, production equipment effectiveness, overall factory effectiveness, overall plant effectiveness, and overall asset effectiveness" (Muchiri & Pintelon, 2008).

In order to make the OEE effective, CA identified the possible causes of malfunction (Figure 39 – Cause of malfunction), this was then coded into the system. The information was stored using the MES database, so that is possible to access this information. Figure 39 – Cause of malfunction reveals the different code used by CA for addressing these malfunctions. Along with the errors the table also includes coding for other events that caused the stop of the machinery. It could be the cause of the maintenance of some mechanical component (code 101 to 116 in Figure 39 – Cause of malfunction). CA went further with the implementation of the OEE; by connecting everything with their MES, the OEE has real-time capabilities which support many decisions of the management.

CA decided to push its hunt for efficiency; this was enhanced even further by implementing the Single Minute Exchange of Die (SMED). The SMED is a Japanese process-based innovation initially developed by Shingo (1985), its goal is to shortening and unravel the setup time during change-over.

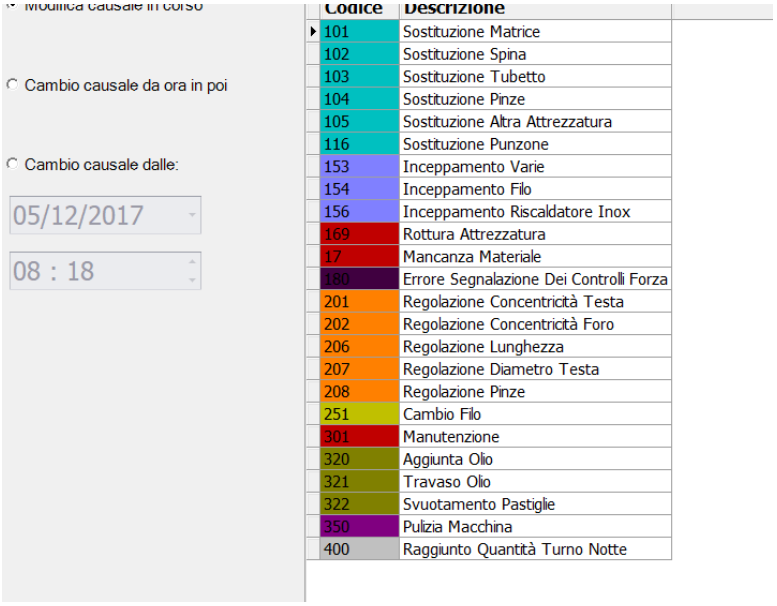


Figure 39 – Cause of malfunction

SMED "makes it possible to respond to fluctuations in demand and results in lead time reductions, while also eliminating wastefulness during change-over and diminishing lot sizes" (Carrizo Moreira & Campos Silva Pais, 2011). As a direct result of this implementation, CA was able to identify the areas that deserved attention or improvement. By working on these areas, the number of pieces produced increased.

> *"If we kept relying on the old way of doing things, we would have died under a ton of sheets."*
>
> Managing Director

With a brand-new ability to collect and elaborating data, CA shifted its effort. Boosting competitiveness creating a consistent and effective environment become CA's focus. For this reason, CA introduced a Product Data Management (PDM) tool. PDM is "a system [that] integrate and manage all applications, information, and processes that define a product, from design to manufacture, and to end-user support" (Tony Liu & William Xu, 2001; Vaughan, Leming, Liu, & Jaselskis, 2013). PDM allows managing different and heterogeneous kind of information such as documents and files. At the same time, it allows to acquire, and store information related to the work processes required for the development of the products (e.g. design, build, support, distribute, and maintain products). By doing so, it became possible to access all the capabilities (E. Miller,

1998) that are offered by a PDM such as Data Vault, Process Management, Product Management, Parts Management, Program Management. About the production. CA took total control of the production workflow especially by electronically handling the bills of materials. Moreover, CA was also able to gather information about the availability of the parts required for the production and to know its use or allocation perfectly. Lastly, the PDM enforced the coordination of different resources used in the production (e.g. resource scheduling, project tracking).

The last project pursued by CA is the implementation of an Enterprise Resource Planning (ERP) software. ERP "provides two major benefits […]: (1) a unified enterprise view of the business that encompasses all functions and departments; and (2) an enterprise database where all business transactions are entered, recorded, processed, monitored, and reported" (Umble, Haft, & Umble, 2003). Using the words of the Operations Manager:

> *"In the last years, we have implemented many things, but all of these systems are different, and they do not communicate with each other. They have only a few points in common; this is one of the reasons why we decided to implement an ERP software."*
>
> *Operations Manager*

According to Dillon (1999), the ERP establish a new connected environment push (and require) for cooperation between all the functions/department of the organisation. Moreover, the ERP allows reaching the goals of CA while also improving the relations with the stakeholders.

Figure 40 and Figure 41 show the adopted system for CA and show the dashboard for both desktop computer and mobile devices. The implementation of this software took almost two years in the life of CA, and its implementation just finished in June 2018.

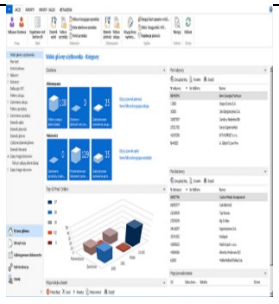


Figure 40 - desktop view

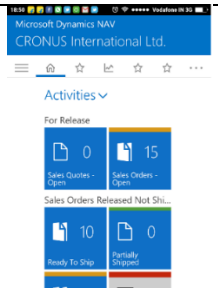


Figure 41 - mobile view

The company is still perfectionating the software due to some issues that showed up only after the implementation. Despite this, the software is 100% operative; this finds support in the words of the IT Manager.

> *"The new system and software implemented bring to us many improvements, but also many changes. These changes must be supported, or we will fail."*
>
> *IT Manager*

4.2.3 HRM in Company A

Figure 42 - CA workers in line

CA started focusing on the management of its employee as a reaction to the challenges posed by the automation. Figure 42 shows CA's employees working in line, interacting with machines. Several issues arise from all the technological innovations implemented in CA: skills formation and recruitment are the two hottest topics, this is confirmed by the Managing Director's words:

> *"We are worried about the skills formation of our employees because the formation process is not fast enough. Automation requires such technical roles that we do not find*

the right people to meet our demands. The situation is so critical that there is a war going on, between our competitors and us. We steal workers to each other, and the situation is even worse if we look at the recruitment of the talent, with the same vicious dynamics applying."

Managing Director of the CA

The tough situation was described as "critical" and the recruitment of the technical workers as "war". The use of such dramatic words could be explained by using the words of its MD again:

"For completely mastering the duties enlisted in the job description, a worker requires years. We only have six months to train them."

Managing Director

4.2.3.1 Extensive Training

Related to the first topic, CA is dealing with the skills shortage in three ways: frontal teaching activities, e-learning and coaching.

"Never stop learning it is not a catch phrase it is a way of living the organisation, and for us is a necessity."

Managing Director

The frontal teaching activities are the traditional form of training performed in CA since its foundation. This kind of formation is the first one that occurs and its condensed in the first days/weeks of the working experience of the employees. These activities are performed in such a way since they also provide information about the security of the workplace (that are mandatory, as prescribed by the Italian Labour Law).

The E-learning and coaching activities are performed together after the ending of the frontal teaching activities. In this way, it is possible for the workers to link the theory to the practice. Despite this way of proceeding apply to everyone, administrative and staff workers usually spend more time on the e-learning platform. In order to make more effective this learning process, CA bought several high-quality courses designed, offered

and delivered by a consultancy firm. The learning platform of the consultancy firm hosts the courses. Every user has unique login credentials; CA and the same workers can check courses' situation. On the opposite, workers in production experience more hours of frontal training and coaching. The coaching time for these workers in line lasts until six months after the hiring of the employees. Moreover, the coaching is reduced progressively after three months, so that employees start working more independently day by day.

4.2.3.2 Selective Hiring

Another possibility for solving the skills shortage is the recruitment of new people. CA grew in its employees' number by more than 40% in the last few years. The firm prefers hiring young talent over seasoned workers, according to the MD this preference rise from the better fit that young workers have with the digital environment. It is also related to the unsuccessful inclusion of a 60-year-old employee who did not keep the pace of change.

> *"Usually we hire young people because we are a dynamic company and we are relentlessly improving and changing everything. Employees call me "Mr. big change". Once we hired an employee who was sixty, so he was close to the pension. He was laid out by his company that was downsizing, and later on, went out of business. This person had much technical experience, so we hired him immediately. After only four months, the person resigned. He felt that he was not able to keep the pace of our changes. From that time on, we focused more and more on young people. That said, if tomorrow a 40-year-old with all the technical experience required to knock to my door looking for a job, I will be more than welcome to include him in our team. However, we should check and support him".*
>
> Managing Director

The recruitment process is performed using five methods: word of mouths, spontaneous application, recruitment agency, head hunting, partnership. CA heavily used word of mouths method for hiring low-skilled workers. At that time, the firm was quite steady, and there was no need for hiring new employees. Thus the recruitment of

the people occurred only after a vacancy; moreover, only a few times in all the firm's history employees left the company.

With such a few position openings, and with a stable environment, the recruitment process was carried out by the Founder of the company. The things started to change after 2008; the new Managing Director used for continuous technological improvements. These innovations also lead to the use of spontaneous applications as a source of recruitment. The applications were collected through the company website and stored in the system. CA preferred the word of mouth and the spontaneous applications because they were cost-effective. However, shortly after the technological innovations, the pool of potential candidates contained in the company's system was no longer meeting the firm's expectation. Therefore this pushed the CA to recruit differently by using agencies and head-hunting firms. The recruitment agencies provided firms with suitable candidates. Their effectiveness is way higher since traditional and cheapest form of recruiting are usually biased to local candidates. On the other hand, this service costs some money.

> *"Our use of head hunting is limited since this kind of firm charge you thousands of euros for providing you with the shortlist of the candidates."*
>
> Managing Director

Due to the increase in technical skills required for some positions CA used the help of a well-known head-hunting firm. The rationale behind this choice is that there are technical positions in which the company urged support. CA could not afford to hire junior profile or to wait for the skills training. The experience with the head-hunting firms is generally positive for CA. However, headhunting bills pushed CA to use the services provided by these companies only for specific technical position.

The last source of recruitment is through the creation of a partnership with the High School. CA pursued this path in two ways. The first thing was to contact all the High School nearby the headquarters, in particular, the ones that train students in dealing with mechanical or mechatronic components.

"We all do the same thing, we ask schools for hosting some interns, and then if the boy is skilled, we offer him to work with us."

Managing Director

Since the competition between the companies is high, CA started the same type of partnership with other schools situated in the south part of Italy. For facilitating workers to move from the south of Italy to the North, the company also provided employees with an apartment for the initial period.

4.2.3.3 Employment Security

The type of work contracts of the employees is pretty much contingent on the position and the seniority. For line workers, usually, CA use in the word of the MD the "good faith" method: they ask the workers to work two days without receiving any money. After these two days, if the employee is worth of it, he/she receives another contract which lasts a few months up to one year, after this usually comes a permanent contract. In case the employee is young, CA uses the type of work contract called "apprenticeship", which give some benefit to the company (such as the minor cost for the employer). This general way of proceedings is not always applied, especially for staff and administrative workers. Since the war for talent mentioned earlier is being fought for almost every employee, CA tries to attract valuable people by paying them 10% more than what is paid by competitors.

4.2.3.4 Pay contingent on performance

The topic of the contingent salary based on the performance of the employee is a topic discussed inside CA in the last few years, and its implementation is ongoing. All the new software and sensors inserted in the firm for the implementation of the Industry 4.0, allowed CA to gain access to several and different parameters related to the employees, including their performance. The contingent salary is only referred to the amount of the 14^{th}-month salary (in Italy there could be 13 or 14-month salary depending on the type of work contract, which is related to other factors such the industry sector).

> *"We have just finished setting the details of the contingent performance systems, and we are dealing with the unions for implementing it. The employees will be able to obtain up to 1500€."*
>
> Managing Director

CA set in 1500€ the maximum reachable amount of money that could be earned by employees. The full implementation is standing by, waiting for the approval of the unions, but it is pretty close to the final implementation. One of the main concerns for this implementation was the ability to identify all the relevant indicators of the employees' performance while being able to motivate them in doing better.

> *"The formula for calculating this extra pay is long and complex, and it refers to reaching the individual goals as well as the company goals so that anyone does not only look at his work."*
>
> Managing Director

For this reason, CA spent many efforts in creating a formula upon which calculating the achievement of the goals that could minimise the possible adverse outcomes. In order to boost the overall performance, both of the employees' and of the company, part of the formula is also related to the performance of the company and to the performance of the team/department in which the employees are working. According to CA, this should raise the attention of the workers on the company's goal.

4.2.3.5 Sharing of financial information

The only information shared inside CA is the one related to the production, while the financial performance is always kept classified. Only the overall turnover is disclosed at the end of the year, which is also one information that could easily be accessed by anyone. The reason behind this behaviour is related to the culture (at the national level) behind the sharing of this financial information, for a long-time entrepreneur do not find convenient to expose the money they make, especially during the 60-70, when the fight between employers and employees working in the industrial sector, was really hard, and the relationship between them precarious. Concluding it is not for the untrustworthiness

of its employee that CA is not disclosing this information, but because this is more a habit in the life of the organisation that was not touched by all the changes happened after the starting of the industry 4.0 implementation.

4.2.3.6 Reduce status differences

Since the beginning of its story, CA tried to lower the barrier and the differences between the workers and the management, or, more in general, between and with all the employees. One of the ways for achieving this result is the absence of a dress code or an imposition on the way one must look. Despite this freedom, a worker in line must meet what is prescribed by law about the security of the workplace, and thus they need helmets and unique dress provided by CA, which differentiate them from the administrative and staff workers.

> *"Despite our fast-growing pace, we are still able to meet after working hours to drink something together."*
>
> Managing Director

One of the leverages used for reducing the status differences is the dinner together before some holiday, such as Christmas or Easter, in which everyone is invited to the dinner, with also families and or relatives, so that everybody gets to know each other a little bit more.

4.2.3.7 Self-Managed Teams

Since the introduction of the lean production inside CA use of teamwork as slightly increased. This way of working particularly affected workers in line, who still have restrictions on their autonomy spreading from the time and type of production. By meeting the quality certification (ISO, IATFS) demands, CA also pushed for working in a team for improving their operations and obtaining the certification needed for entering the Automotive Industry. For this reason, the son of the founder, and still managing director of the firm, left in the hand of skilled employees the choice to undertake many strategic decisions.

4.2.4 Main Evidence

Company A undertook a vital plan about the Industry 4.0 implementation, which began in 2012 and it is still undergoing, this attracted a lot of management's energies to its development. Company A started with the implementation of an MES, continued with allowing the company to become smart, which ultimately lead to the Industry 4.0 implementation. This phenomenon profoundly affected the management of the employees as well, its consequences are visible on different levels. In particular training, selective hiring and pay contingent on performance appears to be the most impacted ones. The hiring of the employees changed profoundly, with the firm trying to maximise successful hiring by using various methods: increasing the step of the selection, outsourcing the recruitment phase to work agency, signing an agreement with high-school and universities. As a result, a previous technique for selecting the personnel (i.e. word of mouth) in the past, were deprecated and fell into the oblivion of the disuse.

Similarly, the impact of Industry 4.0 seems to be on training, in both its conceptualisation and its delivery. Recruitment and training are tightly interconnected, the decision of the Managing Director of emphasising the training role inside Company A, spread from recognising the inadequate skills level of the hired employees, notwithstanding of all the efforts put in the selection. Company A decided to invest in an HR information system that could support the training delivery by allowing e-learning. Moreover, the HR information system is also serving the purpose of creating a Performance Management. The firm is interested in checking the performance of its employees. It wishes to link a contingent part of the salary to the performance. In particular, Company A created a sophisticated algorithm for calculating the targeted performance level every employee should accomplish. The firm spent months on defining such an algorithm, as a result of this work the firm is now waiting to sign an agreement with the labour unions. Such an agreement will allow employees to get the 14^{th} salary utterly contingent on performance.

The pay contingent on the performance in Company A is enabled by Industry 4.0 and by the willingness of the firm to improve the performance of its employees. Consideration of the strategic value of such a reward-system did not appear in the belief of the management, the application as the management conceptualises it, respond more to the control of the employees.

4.3 Company B

This paragraph provides a summary of Company B so to give a clear view of the essential primary information before analysing in depth the information about Industry 4.0 implementation and HR practices. This information is summarised in Table 16 below.

Company B (CB) is an Italian company located in the Friuli Venezia Giulia a region in the North-East part of the Italian peninsula, it was founded in 1977, and the same family still owns it. The two sons of the Founder have now taken over the management of the firm. In particular, the male son, who studied mechanical engineering and worked in multinational companies before landing in the family business, is currently the Managing Director. The daughter, who studied economics and business administration, is more focused on the administrative task.

CB operates in the manufacturing sector by producing mechanical components. Its interest in Industry 4.0 spread from the passion of its Owner for the technological innovations and the pursuit of a connected smart enterprise. In his vision, this could become the source of motivation for himself and employees as well. As a result, last year the turnover of the company grew by more than 20%.

At the moment the facility measures 2400 square meters, it hosts 24 CNC machines, which for the most part is new, and in total 42 people are employed. The number of employees boomed in the last two year, growing from 20 to 42. This super-fast growth and the implementation of the industry 4.0 posed severe challenges for CB.

Table 16 - Company B - Major Indicators

Country	Location	Turnover	Employees	Sector	Generation	Production model
IT	Friuli Venezia Giulia Region	5 million	42	Mechanical	2nd	Lean

4.3.1 Company's evolution

Company B evolution, particularly regarding technological implementation, stayed the same for several years. Most of the changes happened under the new Managing

Director of the firm. In the last six years CB focused the research activity on the following topics:

-2010-2016: Aerogenerator development for domestic applications or wind farms:

The Aerogenerator development project for domestic applications or small wind farms concerned the construction of three wind turbines (2.8 kW - 3.5 kW - 4.5 kW). Subsequently, "turnkey" solutions were developed, including all the system components, including wind turbines, support structures, control electronics, accumulation systems for off-grid solutions. The project allowed the CB to familiarise with concepts of "design for X", design with a focus on the product lifecycle to improve the quality and reduce the costs and time required to realise a project.

-2014-2015: Development of an M.P.S. Monitoring Protection System: this is one environmental monitoring and data acquisition control unit, complementary to the managing site's production capability for both environmental and plant monitoring, guaranteeing plant safety and remote accessibility.

-2015-2016: Expansion and improvement of production processes to Lean: methodology in which CB invested regarding training and professional growth of internal staff.

- 2017: A collaboration is currently underway with the University of Florence, Faculty of Engineering, regarding the study of a digital interface for connecting CNC machines. CB is also part of a research project being commissioned from the Catholic University of the Sacred Heart in Milan, Faculty of Psychology, to verify the impact of digital technologies in the Industry 4.0 scenario concerning the wellbeing of workers.

4.3.2 HRM in Company B

4.3.2.1 Selective hiring of new personnel.

Company CB is focusing more and more on the selection process because the quality of the hired employees must continuously rise to meet all the novelty introduced with the Industry 4.0. In particular, CB is investing in the selection of the specialised workers in line, due to the increased productivity of the firm, that grew by more than 50% in the last three years. Traditionally the recruitment activity was performed internally by the

founder of the company and relied on word of mouth and the spontaneous application of the candidates.

> *"We are struggling in finding employees with the proper technical skills, that is why we often ask recruiting agencies. However, we are not fully satisfied with the quality of the employees provided. This is why we look at a partnership with high-schools."*
>
> Sales Manager

Nowadays, the recruitment process is delivered both internally and externally: the choice of whether "make or buy" depends on the position researched and on the workload of the MD and Sales Manager (SM). The SM has the complete trust of the management. He worked inside CB for the last ten years; he had the chance of working with both the founder of the company and his successor. The SM works closely with the MD and supports his leadership, especially in the development of strategic plans. The employee also views the SM as a vice-MD due to his involvement in every aspect of the life of the organisation.

> *"When we have the opportunity we still recruit people through word of mouth, because it is cheap, and because we do not have such a turnover or demanding job description. Also, when you are referencing someone, you are putting your face for this person, and so you usually recommend people that are worthy."*
>
> Managing Director

According to the world of the MD, CB is increasing its use of the services provided by the recruitment agency. This way of recruiting is used mainly to find technical positions that are rare due to the lack of the competencies in the Italian environment. Another reason for the outsourcing of this process is the fact that in the last years the company doubled the number of employees, and thus this activity required much time. The industry 4.0 implementation mainly occupied the MD's and the SM's time. For these reasons, it was difficult for them to find the time for carrying out these activities.

Another difference with the past is the number of steps to become successful employees of CB. During the times of the founder, this recruiting activity only took one step, the interview with the candidate was only focused on understanding if he was right

to work. The decision was up to the founder of CB and his subjectivity. Nowadays the recruiting is taking more steps in an effort of allowing only quality employees to enter the firm. The firm is performing three steps of selection, and they follow guidelines for conducting the interview. In this way, the interviews are more structured and reliable. The same number of steps is also performed by the work agency they usually adopt.

Although CB never used the services offered by headhunting companies, the possibility of using assistance provided by such firms is becoming a reality. CB had to replace one of his IT specialists because it was not skilled enough for the position. The poor quality of this employee reflects the firm belief in the not-satisfactory outcomes of the work agency.

4.3.2.2 Extensive training.

CB historically performed its training activity sporadically. The number of workers stayed the same for an extended period, the production system was the mass production, and the employees were doing relatively simple jobs that do not require any particular training effort. In such a scenario, the main focus of the training was to provide all the technical skills to the employees, along with the training about the security of the workplace, as prescribed by the Italian law. The approach to training started to change after 2015, with the company transitioning toward Industry 4.0. Industry 4.0 supported the implementation of an HR System that could also assess the capabilities level of the employees. This choice of adopting an HR system without having an HR department comes from the increased necessity of performing training in a fast and effective way. This need is related to the growth of the company in the last years.

> *" We do not have time to waste in general and unfocused training, so we are trying to implement some assessment of the capabilities so that we could do training only on those activities that are not well developed by the employees. […] We aim to hit that 50% of processes' inefficiencies."*
>
> Sales manager

The implementation of the HR system is also linked to the new technological innovations that occurred in CB. This allows the collection of a different set of data that enable the firm to take care of employees' well-being.

> *"We are taking care of our employees; this is why we have asked one university to research our employee well-being and to check whether or not, this industry 4.0 is affecting them."*
>
> Managing Director

4.3.2.3 Self-managed teams and decentralisation of decision making as the basic principles of organisational design.

Traditionally, the decision making inside CB was all made by the Founder of the company. His decisions were never questioned by anyone, only on rare occasions, the founder asked the opinions of a few (including the SM). The use of the mass production reinforced this top-down approach and employees were only asked to do their work in line as better as possible not worrying about anything else. Two events changed the firm's perspective about the employees. The first one is the implementation of the Industry 4.0, while the second one is the new management style adopted by the new Managing Director.

> *"We are relying on teams for doing some particular task at the line level, while at the staff level usually, everybody works on his or her own, but we are trying to raise the level of autonomy of every employee, giving them the needed skills for working on their own"*
>
> Managing Director

CB is actively working on the training of its employees for improving the technical skills of the employees but also for increasing the self-managed teams and reducing the centralisation of the decision making. In order to achieve such a goal, the training is divided into two phases. The first phase is a result of factors that are impacting on CB, in other words: the vast number of employees hired, along with the increased number of orders received, pushed the company to train new employees with "*basic*" skills for doing

a "*regular*" job (emphasis on the words because the SM used them). The first phase is supported by specialised and focused training that spread from the identification of the skill gaps that employees have. Once this phase is over, the second phase starts. This phase focuses more on the management side, allowing employees to grab the idea of what the company is doing and, particular attention to the why. Once the employees possess a good understanding of the organisation's life, the training focuses more on the soft skills. In this way, the MD and the SM hope to allow employees to increase the ability of autonomous decision making. For the MD this skill is essential, it is a direct consequence of the Industry 4.0 implementation. The change in the kind of work performed by employees shifts the task from working jointly with the machines to the supervision and predictive maintenance of these machines. According to the SM, the training activities of the second phase will be conducted internally by CB, because the available courses offered by consultancy firms do not address in the desired way the phenomena.

4.3.2.4 Comparatively high compensation contingent on organizational performance.

The compensation contingent on performance did not find room under the lead of the Founder of the firm. Although a formal performance management system was not adopted at that time, the performances of the employees were still collected. The development of this process comes along with the development of new machines and the possibility offered of tracking the activities of the employees. Thanks to this, since the mid-1990 CB was able to collect the information about the performance of the employees in line, to check whether they were meeting the deadline. This way of managing the performance of the employees fits perfectly with a mass production model, as intended and prescribed by the Motion Study (Barnes, 1940). In support of the performance management comes the technological innovation again.

> *" The system we developed can also collect information about employees such as the clocking in/out, the amount of the overtime, and so on. Soon we will also implement the performance evaluation of our employees since our system allows us to do so. We are just trying to understand how to set the right objectives. We are carefully planning this*

activity because we are also trying to motivate our employees and we do not want to end up with the opposite: demotivating them. We need to understand what brings to the best outcomes."

Sales Manager

The ERP the company is implementing, allows to gather and process much information, including the ones related to employees. The collection of the process of the data is now a lot easier than it was in the past, but the way for using this information is still unclear. For this reason, CB did not start formal performance management, but it is still discussing on which key performance indicator should be included in the evaluation of the employees' performance. This problem is discussed in a dedicated meeting that takes place every month in the last year. Despite the effort, CB appears reluctant in implementing performance management because several times emerges a priority the protection of the employee wellbeing. The performance management activity appears to be, to some extent, harmful to this condition.

4.3.2.5 Employment security.

The type of work contract preferred inside CB is the permanent one. Staff, Administrative and Line Workers, all are employed with this permanent contract with no difference, except in the mansion and pay related to the position. This contract was chosen because of the high number of employees that were hired recently. In particular, CB avoids the use of the apprenticeship contract; such a work contract obliges the company to provide between 140 and 400 hours per years of training to each worker employed with that contract. The exact numbers of hours depends on the form of apprenticeship chosen. Despite choosing the permanent contract seems more the result of a necessity, CB also decided to provide its employee with this contract in order to increase the employee well-being level. The underlying assumption is that a permanent contract leads to a better/improved level of employee well-being.

> *"We try to avoid apprenticeship contract because this kind of contract requires to do a certain number of hours of training. Since our workforce grew by 40% in 2 years, we would have ended up by stopping the production and only doing training."*
>
> Managing Director

Moreover, the impossibility of opting for the apprenticeship left CB with only two options: temporary or permanent contract. A skills shortage in both the internal labour market and in the external labour market is another reason favouring the adoption of permanent contracts over the temporary ones. This cause CB to invest much effort in training. One of the concerns the managers showed is precisely the fear of training an employee that will leave the firm right after the conclusion of its formation period. For this reason, in the thinking of CB's management, the choice of a permanent contract seems to better offer security to both sides by reducing the chance of the workers of free riding. Another attempt at minimising the possibilities of employees leaving the firm is the salary level. CB claims its employees usually earn the 10% more of the average employees in the region and the 20% more when compared to the national average for the position. This monetary incentive is the only lever used to achieve and offer employment security, other possibilities (i.e. insurances, fringe benefit) are not yet followed, but the management stays alert.

4.3.2.6 Reduced status distinctions and barriers, including dress, language, office arrangements, and wage differences across levels.

CB admit having some issues with individual employees; in particular, the SM said they have some employees "*whose behaviour is not compatible with some others*". In order to solve this issue, the shift schedule is a "*careful*" activity performed by the SM. The goal is to avoid these employees to work too much together in order to lower the risks of any conflict. Despite this case, the company claims their employees are usually respectful of each other, and they also spend some time together after work. CB's organisational climate is positive and regularly assessed to check for changes.

Nevertheless, CB also started to pay attention to the employee wellbeing, by also working with a department of psychology of a university.

Despite this, CB stopped the social events they had until the start of the industry 4.0 implementation. After the foundation of the company, there were usually two dinners per year offered by CB to all his employees and relatives.

> *"With the growth of our company we stopped any social event for the moment. It would be tough now to manage that. Once we approach the end of the industry 4.0 implementation, we will see what we can do about it."*
>
> Managing Director

The goal of this social events was to foster the bond between the employees and the management, while also sharing part of the financial gain of the founder. This tradition of dinners stopped after the begin of the industry 4.0 implementation. The MD does not find this activity helpful in reaching the firm's goals, and since they grew in number and managerial complexity, the time required for doing such an activity would be tremendous. Moreover, CB acknowledges the importance of these events and look to a future post Industry 4.0 implementation in which these social events can become part of the organisation's life again.

4.3.2.7 Extensive sharing of financial and performance information throughout the organisation

CB did not share any financial information with employees. This choice comes from the belief of the founder and the actual MD, that sharing financial information will lead to a pay raise request. This request could be ignited by the employees understanding how much money the company is making. The MD saw this coming when there was an attempt by some of the employees of forming a union. The attempt sunk, and CB still does not have a union inside the company.

Regarding the sharing of the performance information about the employees, the performance was shared to improve efficiency. CB is working at the implementation of effective performance management that would not harm the employee wellbeing.

> *"We do not share any financial information with our employees. I even think that many of them would not understand this information. So, I prefer not to create any misunderstandings. Besides this, the general information of our revenues can be accessed publicly by asking the chamber of commerce access to our company report."*
>
> Managing Director

CB approached the Information Sharing after the implementation of Lean Management. The Information Sharing is a common practice inside CB; in particular, the management tries as often as possible to include every worker's opinion into account. According to MD, including employees in strategic decisions is not always possible. Many times workers do not have a clear picture of the viable options. However, the information sharing occurs by speaking to them and publishing news on the company's intranet. Many employees were worried that Industry 4.0 would have terminated their jobs, but the management re-assured them that the technological innovation would have saved much time and boring piece of the work, while also improving production and productivity. The investment CB is carrying out in the second phase of the training (the one focused on the development of the soft skills) should support the ability of decision making and information sharing activities, because employees will become more conscious about their organisation and more confident in their abilities to take the right decision.

4.3.3 Industry 4.0 in Company B

Industry 4.0 implementation in Company B officially started in 2015 according to the management of the firm. Although the year mentioned above had the MD formalising the firm's strategy for the next years, the achievement of higher efficiency standard started right after the birth of the firm. Hereafter a small summary of all the major

implementations that marked the life of the organisation before the industry 4.0 implementation that occurred in 2015.

> *"For [omissis], digitalisation in the production process is already a reality. We collaborate with universities and research centres to realise a motivated and satisfying workplace where machines and human potential interact in a digital environment functional to production. This is Industry 4.0."*
>
> Corporate Communication of Company B

As mentioned in the case description, the company was initially founded in 1972. Until 1985 the production was completely manual and thus relied entirely on workers performing many activities. It is only in 1986 that the first CNC machine was bought. CNC machines are machines that work together with software, receiving from this one the order of how to manufacture a product. The software specifies to the machines how to cut or operate, by giving information about the movement the machines must do in the x and y-axes. By implementing a CNC machine, CB was able to reduce a lot of the inefficiencies that were caused by the workers, who were conducting all the steps of the production process manually.

After the successful implementation of the first CNC machine, the company bought others, and then in 1991 networked all of them, by connecting the machines to the computer through an ethernet network that was created for this purpose. This network allowed CB to increase the speed of the operations related to the communication between the computer and the machines, and yet it resulted in improved firm efficiency.

In 2000 CB decided to improve the programming part of the production, by implementing new software: 3d CAD-CAM. 3D CAD is also called 3-Dimensional Computer-Aided Design. It is used by a multitude of users (i.e. engineers, architect) due to its better precision in the visualisation of the parts designed. It is often used for the design phase, production and the manual drafting. This technology allowed CB to reduce the production time by up to 50% to produce specific components.

In 2009, because of the innovations already implemented inside the firm, CB offered two new services: third-party assembly line, technical design department. According to the MD the third part assembly line is related to the automation that freed some of the time of unspecialized workers, and then created new opportunities for CB of how to use

these workers. The second innovation, technical design department, is a direct consequence of all the new employees employed in the design phase.

Another major implementation occurred in 2010. In this year, the never-ending quest for efficiency brought CB to implement their first five-axis CNC machine. This variation of the traditional CNC machine allows performing operations of the product on five axes simultaneously. By operating in such a way, the five-axis CNC machine allows to significantly reduce the lead time of the products and thus, it results in improved efficiency. In the case of CB, the benefits gained are: a reduced number of operations required, reduced load time and reduced cycle time. In the case of the number of operations, this number dropped by more than 60%, while the set-up time reduction oscillates between the 20% and 30%. As for the reducing the time of the cycle time up to 40%, for specific processes.

In 2014, CB top management realised that the company spend much time improving the efficiency of the process, but only on the machines side. For this reason, the MD started an analysis of the firm process in order to become a Lean Company. As a result of this, the company now adopted some of the principles of the lean manufacturing (i.e. visual display, continuous improvement). According to the MD, the effort of the lean implementation "*as prescribed by the manuals*" is a never ended activity. For this reason, the top management believes their implementation of the lean is successful even if it is not completed. Thus, effort in pushing this implementation further is still ongoing, and this activity is now side by side with industry 4.0 implementation, although the latter one has the core of the attention, Figure 43 depicts the Industry 4.0 application platform inside CB. In the same year, CB proved to meet the newest standards of quality by obtaining the i9001:2015 iso certification.

The interest in Industry 4.0 raised after completing the implementation of Lean Management. The MD, who has an engineering background, decided to push automation further, in line with the historical tradition of the company of striving for excellence in manufacturing. The goal, once again, was to increase the efficiency of the firm. For the first time, the focus of the firm shifted to the only achievement of better performance, to also increase the level of well-being of its employees.

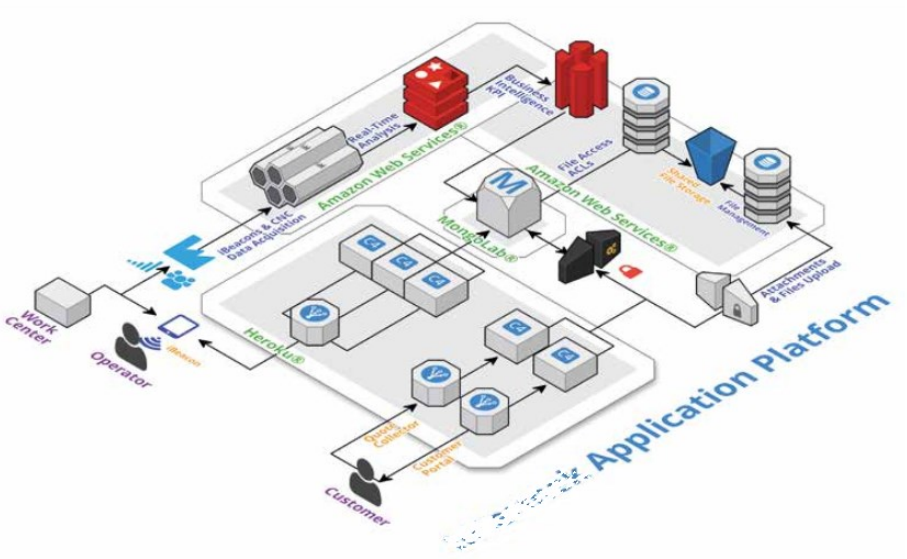


Figure 43- Industry 4.0 application platform of Company B

Due to all the technological innovations already implemented inside the firm in its 42 years of life, CB constitutes a fertile ground for Industry 4.0. The strategic industry 4.0 implementation plan elaborated by the management drew three main actions: connecting machines, implementing ERP, "connecting" employees. The first part of the plan focused on the connected machines, for this reason, a three-step way of proceeding was formalised to address new and old machines. The increased number of orders received required CB to buy new machines. To meet the industry 4.0, only the ones that possess networking abilities were bought. In this way, it was possible to connect all these machines to the network of the company, in a wireless manner (the networking provided in 1995 was with ethernet cables).

Moreover, it was possible for CB to access the data about the production and the machines. For the machines already existent, which did not have such wireless access, the company undertook an updating program through the installation of the component that allows the connectivity. By doing so, CB was able to have all the machines connected to the company's network. Currently, more than 25 CNC machines are used inside the plants of CB, 14 of these are new and possess native Industry 4.0 capabilities. The third part of the plan regarding the machines is the replacement of the already existing machines with a new one offering the same industry 4.0 capabilities above-mentioned. Despite this could seem opposite or alternative to the second step, which prompts for updating the already existing machines, the MD and the Operations Manager (OM) of

CB claimed that the cost for providing such connectivity to the machines was a paltry sum, and for this reason, the upgrading plan was a must.

> *"Replacing still functioning machines all in one was out of the picture. It would have costed much more* [than upgrading], *and it would have also required us to do more training of employees on the new machines, which was something we had to avoid since we already significantly increased our workforce, and thus the need for conducting training."*
>
> Operations Manager

Currently, the firm decided to replace three of these machines during this year due to the benefit provided by the Italian government to those companies that implement new machines with industry 4.0 capabilities. If the benefits remain the same, CB will replace three other machines the subsequent year. This will bring the total number of native machines up to 20, leaving the firm with only five machines that do not possess these native capabilities. The five machines will then be substituted shortly due to the reaching of the end of their expected life.

The second plan is denominated "implementing an Enterprise Resource Planning software", and it is focused on the identification (and satisfaction) of the step needed for implementing an ERP. This second plan is divided into three subparts: "*clouditization*" (emphasis because it was a word used by the IT specialist of CB), ERP identification, ERP implementation.

The first step is the one called "*clouditization*" by the company. The goal of this step was ensuring that every information was digitalised and thus collectable, and even more important, easily accessible. For this reason, the company relied on four technologies: Ibeacon, Heroku, Mongolab and the Amazon Web Services.

-Ibeacon is a feature developed by Apple since IOS 7. It relies on the Bluetooth Smart introduced with the 4.0 version of the Bluetooth protocol. This new functionality allows transferring elaborated data, based on the GPS position, by optimising the energy consumption of the mobile devices (i.e. smartphone and tablet). For the successful transfer of the information, it requires an iBeacon-ready device or application.

Inside CB, the Ibeacon functionality is used by employees for communicating with the CNC machines. Moreover, also allow workers in line to check the stats and status of

the machine near its location without selecting one (since the GPS positioning give meaningful information to the user).

-Heroku is a platform created in 2007 whose aim is to support the development of new applications. It is nowadays one of the biggest "platforms as a service". By using Heroku, it is possible to create web-based applications, in this way the programmers will work only on the interface and the functions while Heroku offers the infrastructure. The application of Heroku inside CB is the same as just described, development of an application web based for accessing various information, along with the data about the production.

-Mongolab is a company founded in 2007 who offers database-as-a-service. It allows Cloud Automatization, Back-up and Recovery, Monitoring and analytics tools, advanced security and easy to use data browser (graphics interfaces for building/editing documents). In the case of CB, the Mongolab is the database of choice, and it works along together with the Amazon Web Services who provides the datacentre.

-Amazon Web Services are a secure cloud services platform that delivers processing power, database storage, content delivery, and other capabilities to support the sizing and growth of business operations. It was used inside CB as the backbone supporting the IT infrastructure of the company and generally the cloud services and data centres. Figure 5 shows the connected platform implemented inside CB

The second step (ERP identification) and the third step (ERP implementation) are closely connected to each other. The ERP identification phase aimed at the identification of the benefit and cost CB would expect from the implementation of the available ERP software.

> *"I did not find a company that told me they were supporting us during the implementation, or that they were available to customise their product to meet our necessities. All these huge corporations do not have on their radar SMEs like ours, so it was almost mandatory developing by ourselves the ERP software."*
>
> Managing Director

According to the words of the MD, the analysis of the available software lasted a few months. During these months CB consulted several companies asking for prices, for

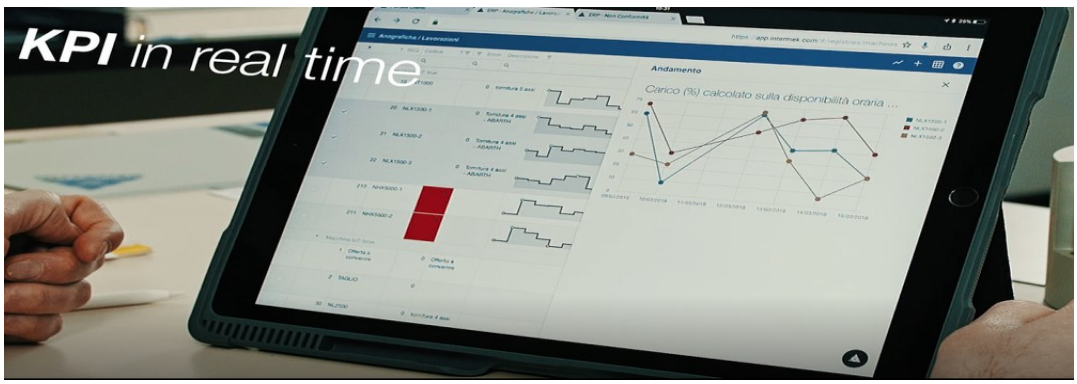
customised solutions, and for support during the implementation. All the firms offering ERP software did not meet one or more of these requirements. As a consequence, CB asked a consultancy firm which rejected the job.

The phase name "ERP implementation" spread from here, from the difficulties CB had in finding a reliable partner for providing and assisting during the implementation of the ERP software. For this reason, CB decided to create and implement its ERP.

> *"After deciding we were not going to adopt any ERP software already made by other companies, I decided to acquire a small software house that assisted us during the implementation of Heroku, Mondolab and IBeacon. In this way, I could use the expertise of the two people working there for creating a tailor-made ERP that suits us perfectly. When compared to ERP offered by multinationals companies, ours do not provide all the functionalities. However, it has the ones we need and that we care about.*
>
> Managing Director

The development of the "*tailor-made ERP*" (Figure 44) lasted more than one year while the implementation is still ongoing in order to fix any bug. The developed ERP allow CB to collect data about several indicators, about machines and employees. In order to collect information about employees, any of them is wearing a card that transmits data to the machine and the system. In this case, the realisation of a Cyber-Physical System is close because this card allows the system to know the position of the workers and to adapt to this situation or interacting with it. Further details about this tracking system were not provided to the researcher. The IT specialist and the MD claim this is possible due to the card having a Bluetooth transmitter, but they did not want to explain more since this is a hard topic, because it involves the privacy of the employees.

Figure 44 - ERP software developed by Company B



The ERP also allow to perform several tasks that support the employees' daily activities, such as: taking notes (Figure 45 - online note on a project inside ERP software) or giving feedback on documents (mainly used by the quality department) which is enabled by the cloud since the documents are hosted in the cloud.

Figure 45 - online note on a project inside ERP software

Another possibility offered by the implemented ERP is the use of augmented reality (Figure 46). By using this functionality, the worker in charge of the quality check could also assess the conformity of the product with the supposed version. The software can provide the supposed shape of the product by only enabling the camera and framing the desired product.

Figure 46 - Augmented Reality

The ERP further assist the quality department by providing real-time data acquisition. As shown in Figure 47 it is possible to check the conformity of the object; the system will

collect the information from a Bluetooth calibre and will show the difference between the measured and desired value.

Figure 47 - Data Acquisition in Real Time

The ERP system also allows interrogating the system about the packages that are about to being delivered. Every package is equipped with a QR code, by only framing the code with the camera, the systems will give general information about the content of the package. The same kind of information is also possible for the components. A page containing all the information could be loaded by the system when prompted to do so. All these capabilities have the name of "digital ecosystem" (Figure 48).

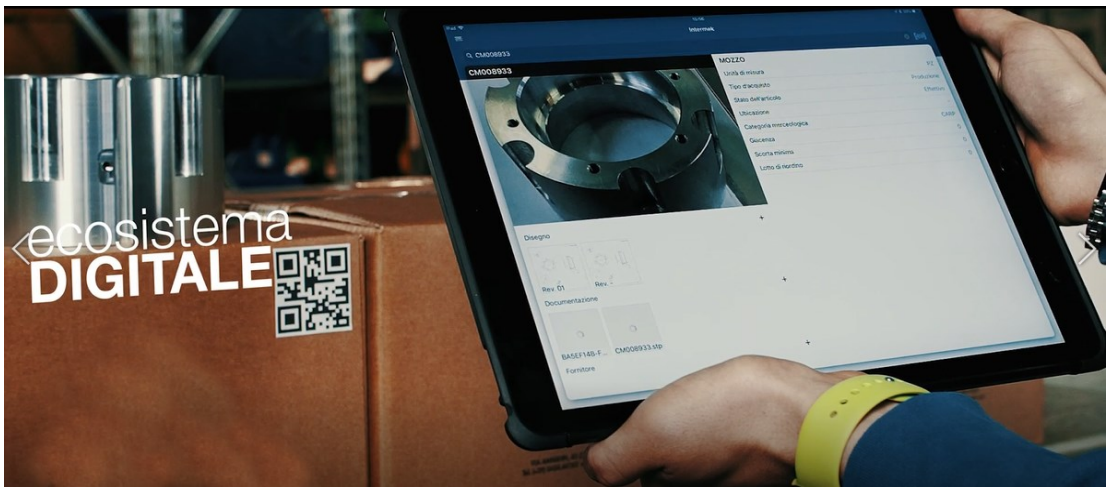


Figure 48 - Digital Ecosystem in the implemented ERP by Company B

4.3.4 Main Evidence

Industry 4.0 implementation is affecting CB's way of managing employees on different levels. For what concern the HRM function, this function is not formalised and neither it is present in the organigram of the firm. The tasks related to this function were carried out by the founder; nowadays they are carried out by both the Sales Manager and by the CEO of the company. It is important to note that the firm did not create a dedicated HR position within its structure. The Sales Manager carries out the duties and the planning of the activities associated with HR. Therefore, the Sales Manager is in charge of both the Sales and the HR department. The company showed an interest in the development of employee well-being, has emerged from the partnership with one university. The person in charge of fostering the employee well-being is the Sales Manager, which support the sentence above about the salience of this person inside Company B.

By looking at the HR practices, the firm changed the way it selects the employees. The first and more basic evidence of such a change is the number of steps that the company needs before coming to a final decision about whom to hire. Moreover, the company decided also to outsource the process to some work agency.

As appeared with company A, also company B do not think the outcome of its selection process is quite good and looked at another way for escaping the swamp. Industry 4.0 main consequences appear to be, once again, the skill shortage, which combined with an increase in the production volume of the SMEs, urge them to hire new employees. For this reason, fearing that employees could need much time before working efficiently, Company A review its training system. The first step was creating a way for assessing the skill levels of the employees. The identification of the gaps of the employees allows the firm to focus on training. In such a way, the employees receive training only in the lacking areas, in order to overcome the skills shortage.

The firm is also trying to set the performance management of its employees. This process is quite long and encounters resistance in the management who do not want to harm the employee well-being of the employees.

In conclusion, Industry 4.0 implementation affected company B, the most visible is the fact that the company grew in its size dramatically in just a couple of years. Such a rapid expansion, pushed the firm to become more structured, mainly related to its HR practices. The formalisation of such HR practices did not come through the creation in

the organigram of an HR Manager, but the task carried out by the Sales Manager does look like he is in charge of the HR function.

The most impacted HR practices are training and selective hiring of the employees, which, again, are a consequence of the skills shortage created by the firm.

4.4 Company C

This section summarises the main important information about the firm, Table 17 shows such information. Company C (CC) is an Italian family firm located in the Veneto Region, North-East part of Italy. It was founded in 1961 by an aeronautical engineer and operates in the manufacturing sector. The company is owned and managed by the same family since its birth; it is the founder's son who now runs the business. The actual CEO entered the company in a minor role in 1972 after his studies in mechanical engineering.

CC grew over the year and become a leading firm in the field of precision engineering. It is now specialised in the production of parts and machines for mills and pellet production. At the moment, the firm has 90 employees, more than 60 employed at the shop floor level. It has a turnover of 13 million euro. CC consolidated over the years the after-sale service and the technical assistance: the company's engineers are always available to solve any problems or give directions and advice.

All the major implementation about technological innovations took part under the actual CEO leadership, who is an early adopter of technologies, He was among the first buyer of the "Apple 2" and introduced this computer inside the firm, revolutionising the sales department.

The interest of CC in Industry 4.0 directly spread from the passion mentioned above of its CEO for the technological innovations. For this reason, CC is in the middle of its Industry 4.0 implementation plan. According to CEO, the company is pushing for Industry 4.0 because that is the future that must be pursued. Moreover, it is vital for CC to stay competitive by reducing the inefficiencies. Despite this attention to the machines side, the CEO also foster the satisfaction of his employees, because they are "*a family that allowed us to grow and to become what we are now*".

Table 17 – Company C Major indicators

Country	Location	Turnover	Employees	Sector	Generation	Production model
IT	Veneto Region	13 million	90	Mechanical	2nd	Not Lean

4.4.1 Company's Evolution

This section provides significant information about Company C major event, as well as technological innovation.

The Company C was founded in 1961 by an aeronautical engineer who wanted to start his own business after working 15 years in the most prestigious firm in the area.

> *" The company produces technologically advanced machines, is a leader in the field of animal feed generation, wood and plastic pellets, inorganic and organic-mineral fertilisers, and biomass processing."*
>
> Corporate Communication

The leadership role the company now possess is a result of the evolution and the strategic choices made through the years.

The first 20 years of the life of CC were relatively a calm period. The activities performed by the employees in the production were completely manual, the automation was not in the picture. During this year the founder improved both the production processes and the market expansion. The former was achieved by introducing in the factory two machines that assisted the workers in line in the production. These machines were semi-automated, their introduction freed workers' time, resulting in a reallocation to new tasks.

In 1971 the son of the founder (SoF), who later become the next CEO, entered the company as a sales representative for CC. The first computer entered the company in 1978, and it was the SoF who brought it. With this implementation in the sales department, the time needed for realising the quotation was drastically reduced.

> *"I remember when I showed how fast I was in writing a quotation or a bill. My employees told me: in a few years you will not need us anymore".*
>
> CEO

A polish manager coming from CC's main competitor allowed the market expansion.

The expansion led to an increase in the production, and this required a bigger warehouse and a bigger space allocated to the production, neither of these was possible in the existent facility. For this reason, in 1980 CC moved the production and the

headquarters in an area of approximately 10km squared. Almost 40 years later, the company is still located in the same area.

During the eighties, CC focused on the improvement of the production process. In the '90 the founder left the company in the hand of its two sons, the SoF previously mentioned became the CEO, while the second son became the CFO. The joint leadership lasted until 2008, the year in which the CFO left the company due to disagreement in the way the CEO was managing the company. Despite this fight, the son of the CFO, who studied business administration, is working in the sales department. This person is the designed successor of the CEO and should succeed him in the next few years.

4.4.2 HRM in Company C

> *"Inside our company, there are people, each of them with their story, not numbers."*
>
> Mission statement from an official document of the firm

Company C traditionally values its employees and honestly believe in the engagement of its employees as a lever that could lead to superior firm performance. The quotation above shows this positive approach to the employees. Despite this care, only recently the CEO hired an HR manager for delivering some HRM processes. Before this date, every process regarding the employees was carried out by the entrepreneur. The choice of hiring an HR manager is related to the increasing complexity the firm faced, after the introduction of the industry 4.0. Especially for those employees that were already working inside the factory and that are working there since the '90s.

4.4.2.1 Selective hiring of new personnel.

> *"We have a huge problem in finding the right employees for the right position. Traditionally we laid out this process by asking a work agency to find the people, but the outcome is usually not satisfactory. For this reason, I decided to hire in our company an HR Manager that manage almost every task related to the human resource management."*
>
> CEO

Company C find the hiring process of the employees as one of the most crucial activities of the entire organisation. Therefore, an HR manager was hired to conduct and supervise this delicate process. During the early stages in the development of the company the Entrepreneur conducted the recruitment, he oversaw who was supposed to be hired. Only on rare occasion, this activity was allocated to the market. With the growth of the company the hiring became more time consuming, therefore the decision of CC for using the services offered by work agencies. The use of the work agencies is a recent choice that followed the direction pointed by the CEO. The work agencies were used for some years, and they are still used despite the non-satisfactory results. Currently, is the HR manager who usually carries out the recruitment. The activity is outsourced to a work agency only when the HR manager or the CEO is busy. However, the final decision regarding the employment is always up to the CEO.

CC struggles in finding employees with the proper technical skills among young people. The problems that arise from the hiring are:

1) Not enough people with an essential level of technical skill;
2) The poor education system at high school and university level;
3) A long time before people can work autonomously.

One of the problem CC faces is the lack of technical skills, according to the CEO, this problem spread from a distance between what is taught in the high schools and universities compared to what is needed in the companies. The labour shortage pushed CC to address this issue. The action of the company resulted in a general recruitment policy that contains two way of proceedings.

-The first one is the creation of a partnership with high school students. In this way CC can reach the students easily, cutting the expenses for the recruitment. The students could spend their mandatory internship period inside CC and get to know the company.

-The second general policy is to prefer the possession of good soft skills over the technical skills. Management believes that employees who possess only the technical skills can perform worse than employees who have soft skills. According to CC, this labour shortage is an opportunity for focusing more on the "right employee" but requires time in order to train the employees adequately.

4.4.2.2 Employment security.

> *" We usually ask new employees for entering with an internship, a temporary contract and then the permanent one."*
>
> HR Manager

CC regularly use internship, temporary contract and permanent contract for employing the workers. The CEO wants every employee to have a permanent contract, but before giving such a contract, the employee should prove its ability to work and behaving well. For this reason, the approach of the company towards the employment security remained the same over the years. The contract of the employees usually starts with the internship for both staff/administrative personnel and workers in line. The internship is particularly inviting for every company because it allows firms to avoid the payment of a full salary to the employees and the related taxes as well. In the case of CC, the choice of the internship is saw by the management as preliminary insurance that allows the firm to know eligible candidates. By doing, so CC can cut the personnel cost while understanding if the employee fits the company. While this applies to workers in line, in the case of staff employees, the internship phase could be skipped.

> *"We are severely damaged by the new Italian labour law called "Decreto Dignità". This law poses restrictions in the use of temporary contract, for this reason, we will reduce the number of people that we planned to hire, decreasing from 7 to 2."*
>
> CEO

Following the internship there is usually a temporary contract. The temporary contract is seen as the insurance. This phase could take up to 1 year before shifting employees to the permanent one. During this stage CC evaluate the development of both the hard skills and soft skills of the employees and conclude their suitability. This step is so important that after the introduction of a new Italian labour law called "Decreto Dignità". The CEO is thinking of reducing the new employees hired. This decision comes as a direct consequence of the rigidity of the labour market especially for what concerns the use of the temporary contract. The new law introduces restrictions of using such a contract, limiting its use only in a situation of the peak of workload.

4.4.2.3 Self-managed teams and decentralisation of decision making as the basic principles of organisational design.

> *"We are now talking about a change in our organisational design. For several reasons, with one of this being pressures from the market, we would like to become a lean company. We are in contact with a consultancy firm for this change."*
>
> HR Manager

The team working inside CC is still at a low level. One of the reasons behind such short adoption of the team working is the kind of work performed by the employees. Another reason is the routine established that affect such a way of working. Moreover, most of the employees learned to work more than 30 years ago. The HR Manager and the CEO conducted an internal analysis of the topic. The main conclusions are two and are related to the willingness of the decision making: that many of the "old" employees do not want to take part in the decision making, neither they want to change anything related to the way they work. The pressures posed by the market, pushed for flexibility and dynamism, for this reason, CC hired a consultancy firm. The aim of this is to allow CC to become a company that embraces lean management. The team working inside CC will benefit from the shift in the production system. Another lever the firm will use is the hiring of people with the soft skills necessary to work in a such a new environment. The 40% of employees that will leave the company by 2025 represents a tremendous opportunity for CC for succeeding in the teamworking implementation.

Despite the apparent efforts in implementing the teamworking above-mentioned, there is some resistance that unconsciously comes from the top. The HR Manager is the person in charge of the recruitment; she is the one conducting the interviews and the one that assesses the candidates. However, after making a short list of suitable candidates, is the CEO who pick the "right employee". This kind of behaviour is typical of an SME in the manufacturing area. Nonetheless, such a centralisation of power gives back a picture of an organisation with some issues and a lot to improve for enabling the sharing of the decision making.

4.4.2.4 Comparatively high compensation contingent on organizational performance.

Company C strongly believe in communicating how vital its employees are, also relying on attractive retribution. From line workers to engineers, on an average, the salary is higher than the one offered by competitors by more than 10%.

The compensation contingent on performance did not apply in CC; the firms do not reward employees for their performance, because this could cause some imbalance and deteriorate the relations between the employees who performed poorly and the ones who performed well. According to the CEO, CC push for the motivation of its employees through the engagement. The engagement of the employees is the results of a pleasant work climate that spread from employees' perception of the workplace as a family.

> *"We usually pay more than our competitors. We think that pay should not be the most important driver to stay in a company. We look at our employees as a family."*
>
> CEO

The vision of the lousy repercussion that could spread from the performance management of the employees is changing. The change is part of the work that the new HR manager is conducting inside the firm. According to the CEO, the firm collected information about employees' performance since the 90s but did not used this information for evaluating the employees, neither for giving some salary contingent on the employees' performance.

> *"We do not have structured performance management; we plan to do so shortly, this is part of the duty the HR manager will carry on. The performance management will always be related to increasing not only our performance but employee well-being as well."*
>
> CEO

The HR manager is actively working on the implementation of an HR system. For this system to become fruitful, the HR manager is working in changing the organisational culture, particularly the one related to the performance evaluation. The family nature of the firms put the CEO in a position where the employees follow his belief with the

utmost rigour, and the organisational culture of CC spread from there. The historical tradition of the firm for not doing performance management, and the personal belief of the CEO of this practice to harm the employees, pushed the HR manager in directing her actions towards not only employees but even to the CEO and the top management.

> *"I believe the implementation of an Information Systems of Human Resources will allow us to do many more things with the information available."*
>
> HR Manager

The Industry 4.0 is allowing the firm to collect much information; this opportunity translated in the implementation of an information system for the human resource management (HRIS) of the employees. Before this moment, the firm did not have any HRIS.

4.4.2.5 Extensive training.

The training is one of the most critical HRM practice according to the CEO of the firm. The salience of the topic generates from the context in which the company operates and, in particular, to the skills shortage. The desired skill levels of the employees do not meet the expectation, and for this reason, the CC created an Academy for helping employees in forging their skills. The academy is prevalently focused on the hard skills formation to its employees, but the services are also provided to other companies who wish to acquire the expertise of CC.

> *"There are problems on several levels: the workers fresh of school possess only half of the required competencies we need to fill this gap. Workers need at least one year to be in complete control of their tasks. For this reason, we created an "Academy" in which we gave classes to our employees."*
>
> CEO

The Academy allows employees to enrol in courses that allow the employees to increase their skills competency, but they also have the possibility of choosing courses that are not related to the work area, but to the personal area. In this way, the HR manager hopes to facilitate the development of a positive attitude of the employees

towards the company. This attachment creation lay on the underlying concept that CC cares about its employees, and that want them to avoid any personal and professional stall, which the industrial setting partly causes it.

> *"In the past, the training was only occasionally performed, nowadays the training is of vital importance, and I also think that the training help in the development of the employee as a human being not only as a worker in a plant. Therefore, we want to stimulate our employees by pushing them to follow training courses even for themselves."*
>
> HR Manager

One of the causes CC pay attention to the training, is that many employees will retire from the firm in the next few years. The retirement poses an enormous problem that is sharpened by the labour skill shortage.

> *"We have a serious problem of generational change, 40% of our workforce will retire by 2025. Therefore we need to do something about it and to plan the recruiting and training activity carefully."*
>
> CEO

For this reason, the company is thinking about how to enhance employees training.

4.4.2.6 Reduced status distinctions and barriers, including dress, language, office arrangements, and wage differences across levels.

For CC the reduction of status distinctions is one of the priorities related to the engagement of the employees and in the creation of a harmonious workplace. The firm believes that the industrial setting in which operates it is not sufficient in stimulating by itself the employees' development. For this reason, the firm organised and still organises various events inside plants to allow the employees to enjoy the workplace. This social moment also allows the family of the employees to visit the factory and to see where they work.

"For us, it is imperative to involve our employees in the daily life, for this reason, we organise events inside our plants. We already did several cinema nights, and also musical concerts."

CEO

The events inside the factory increased the engagement of the employees, especially the cinema nights. The musical concerts organised attracted the attention of the media, but they impacted less on employees.

"We have a canteen at the disposal of every employee, despite the aim was to involve everyone, the workers in line prefer to go home to their wives, while the administrative and staff employees do use the canteen."

CEO

The success of the social events organised by the company, convinced the management of the firm in establishing a canteen for the employees, in order to engage the employees during the lunch. According to the CEO, this attempt did not bring the desired results. The employees have the routine of going back to their houses and sharing their times with the family during lunch. Therefore they avoid the canteen. On the opposite, designer, engineers, marketing employees, they all enjoy the lunch at the canteen. The HR manager believes this is a problem that the company should tackle. However, the vast amount of people that will retire by 2025 will naturally contribute to the reduction of this issue. The HR manager wants to increase the number of employees that go to the canteen, working again on the organisational culture.

From the financial point of view, the CEO and the HR manager works closely in identifying employees' needs. Benefit or monetary compensation if the employees are worth of it. Since this could cause some problem or jealousy toward other employees, an objective system is currently on the go.

4.4.2.7 Extensive sharing of financial and performance information throughout the organisation

The sharing of the financial information, according to the culture of the Veneto Region, is something that rarely is done by the entrepreneurs. Consistently with this culture, CC does not disclose any information about the financial performance to its employees. The firm believes this information could potentially lead to adverse consequences, such as employees asking for a higher salary. According to the CEO and the HR manager, the company look for the engagement of the employee but do not want to use the salary compensation as the only lever that allows doing so. For this reason, along with a salary that is greater than the one offered by the competitors, all the actions of the HR manager and the CEO point on the engagement of the employees.

> *"We do not share any financial information with our employees. For what concern the performance information yes, it is since the mid '90 that we collect information about the time of the employees, but we did not find yet a way for not creating a fight, and so we collect and share this kind of information parsimoniously."*
>
> CEO

The information about the performance of the employees is one activity internally performed by the firm, but that only rarely reached the employees. Whether or not disclose more this kind of information is one of the topics discussed currently inside CC. In particular, the HRIS should allow the company to keep track of this information quickly and to share with the employees.

4.4.3 Industry 4.0 in Company C

Industry 4.0 implementation inside CC officially started in 2013, but from its birth, the firm strived for excellence and efficiency. The CEO believes Industry 4.0 could create a tremendous opportunity for the business and will allow the company to survive and to

meet customers' expectations. Industry 4.0 implementation is a result of the pressure posed by customers who became more demanding, especially in asking for products with the same high-quality level, but with a shorter time for the delivery.

> *"We are pushed to the industry 4.0 especially by our customers. They now ask for producing a product in 4 weeks, and four weeks is the time that we normally need, that leaves us with no margin of error. This situation is unbearable, for this reason, we need to eliminate the inefficiencies, and transitioning towards Industry 4.0 seems the best thing to do."*
>
> CEO

Here a list of the significant technical implementation before Industry 4.0. The company was founded in 1961, at the moment almost every activity related to the production was performed manually. It is only in 1970 that the founder of the company was able to buy the first dicing and dies machines. The introduction of this kind of machines helped the company in increasing the efficiency of the firm while also reducing some of the time required by certain operations. From the '70 to the '90 the firm kept automating the production by putting more and more machines. The technological improvement and the quest for the efficiency partly stopped during the '90s, since this period was more focused on the market expansion worldwide of the firm. Between the 1990 and 2000, many computers entered the company, especially for the CAD designer and for supporting the production. In 2008 the machines were plugged into the network of the company by an ethernet cable which allows the firm to communicate to the machines.

The Industry 4.0 implementation officially started in 2014, the plan drawn by the management was composed in 4 parts: the first part concern with the implementation of the connectivity of the company, both internal and external. The second part focus on the creation/implementation of software that allows to communicate with machines and to acquire data. The third part is the one related to the training of the employees. The fourth part is the one related to the automation of the company.

The company equipped all its machines with connectivity. The wireless connection was introduced to allow the access from mobile devices to the machines. The wireless connection was juxtaposed to the ethernet cable, that was not replaced in order to have

a backup solution in case of problems to the wireless network. In order to facilitate the workers of the employees, especially the one in line, one of the first implementations occurred was the dissemination of mobile devices and computer besides every machine. This completely changed the operator interaction with the machines, especially for the ordering part, which now consists in pressing a button on a touch screen on the tablet. Before this implementation, a code was scanned with a pistol scanner, and before this, the code was entered manually in the system. By implementing the tablet, the company was able to cut almost every sheet of paper in the production.

CC rely on the software and services provided by Google. For this reason, every employee receives an email address that is backed up by Google infrastructure and this also allow to access the cloud of Google, which facilitate the information sharing. This first part of the plan concludes with the company that signed a contract with a telco operator for putting the fibre connection to the company, which consisted in bringing the fibre not only in activating the services. The choice of the fibre connection allowed the company to boost its speed in the activity related to the download and upload of documents, and in communicating between peers.

For every employee was also created an ID related to their google mail, and this mail is used for the clock in / clock out of the employees. When entering the plant/offices, there is a touchscreen monitor in which every employee must click on his picture for the clock in / out operations.

This high use of software comes from the company investment in the digitalisation. The company hired permanently 3 IT specialists and had a fourth person working in the IT department which is an external consultant. The Consultant oversees the customisation of the ERP software implemented by the company. The name of the software was not disclosed. The CEO claims he invested 400.000 thousand of Euro in the digitalisation of the firm processes. Such amount includes software licences, the IT specialist salaries, training for the employees and the laying of the optical fibre.

After all this new technology implementation, the CEO expressed a desire to the Industry 4.0 implementation, which should have proceeded with the automation part. The reason behind the stop in the industry 4.0 implementation, is because this implementation was faster than the employees in adapting to the new scenario, which caused some problems. According to the CEO, this is partly caused by the habit, and

routine employees have acquired working in the company for several years, in a different manner, therefore the need of training employees to work in a such a diverse way.

4.4.4 Main Evidence

Company C is characterised by having a long history since it was founded almost 60 years ago. In its history, the presence of a clear and structured HR function is something related only to the late life of the organisation. The organisation hired an HR manager only recently, and as a direct consequence of Industry 4.0, therefore Industry 4.0 implementation impacted on Company C in different ways. The main "fault" ascribable to the Industry 4.0 implementation is, once again, the skills shortage. Company C was already experiencing some difficulties in the management of its employees, difficulties related to the ageing of the workforce and to the need of hiring new employees that will take over the retiring ones. The replacement process appeared to be most difficult than what was initially thought by the CEO. This brought the company to think about how the HR practices were delivered and if they were successful. The Industry 4.0 did not create the problem by itself; it put much pressure upon the management, who was fearing of having a connected and smart company, without employees that are able of working there successfully. For this reason, the Industry 4.0 implementation pushed the firm to change its recruitment process. The skills shortage is so high that the firm had to sign an agreement with some region of the central part of Italy, asking workers of moving to Veneto working at Company C.

The firm also decided to improve its training system. On this topic, the influence of the Industry 4.0 is always related to the skill shortage, and to the time that the company require before an employee can work by himself. For this reason, Company C created an "Academy" that it is open even to customers who wish to learn more about the company way of working. Moreover, the "Academy" is a way in which the management try to foster employee well-being. The "Academy" offers different courses; the most important are the ones related to the hard skills needed at work. However, employees could also choose to be trained on things they wish to know, boosting personal development.

For Company C the topic of employee well-being is essential even when designing the salary contingent on performance or the possibility of working in teams. However, the interest of the firm in fostering employee well-being did not seem directly related to

the Industry 4.0 implementation. In this case, the Industry 4.0 seems to have created such a disruption that allows the firm to act in the way it wishes it could do, representing a sort of *tabula rasa* for the management.

4.5 Company D

This paragraph provides a summary of Company D so to give a clear view of the essential information before analysing in depth the information about Industry 4.0 implementation and HR practices. This information is summarised in Table 18 below.

Company D (CD) is an Italian company located in the Veneto Region, North-East part of Italy. CD is a family firm that was founded in 1971 as a foundry by a Mechanical Engineer. The same family still owns the firm; it is managed by the second generation: the son of the founder it is currently the Managing Director. The company business concerns the production and design of mechanical components. The success history of the firm allowed CD to be ranked among the top 500 companies inside the Veneto Region. Currently, the company has a turnover of 14 million euro. Inside the factory found work 96 employees, with more than the 80% working in production.

In the last years, under the leadership of the Managing Director, the firm underwent a serious of improvement that pushed its production model to the lean management. Moreover, the firm also took part in a research project called Foundry 4.0. This project was focused on the interconnection and communication inside the company between the different machines and computer. Along with the Foundry 4.0 project, the company undertook the path of the Industry 4.0 implementation since it represents the natural one expressed by the continuous innovation undertaken by the firm.

Table 18 - Company D Major Indicators

Country	Location	Turnover	Employees	Sector	Generation	Production model
IT	Veneto Region	14 million	96	Mechanical	2nd	Lean

4.5.1 Company's Evolution

Company D was founded in 1971. Since its foundation, the management believed in the importance of innovating the firm, especially in the production side, for increasing the efficiency of the processes. This lead in 1978 to the first CNC (numerical control

machines) to enter the plant. In 1983 were introduced the CAM programming while in 1986 was the time of the introduction of the CAD software (which was integrated with the CAM). In 1990 the company undertook a project that leads to the measuring machine for measuring reports from the trimming tools.

Another major implementation occurred in 1996 with the adoption of the Magma software, which allowed the company to perform simulation about the diecasting process.

In 2005 were introduced in the foundry the first 5-axis CNC machine which leads to the reduction in the production time of many products.

Nowadays the company believe in delivering its value from seven critical success factors: product development, design diecasting, design trimming, sampling, measuring reports and research and innovation.

-Product development

The Company D can conduct a feasibility study and development of the design necessary to the production of the needed part through diecasting. All the aspects of the process are analysed: casting, trimming and machining. The analysis of the part brings to the definition of parting lines, tolerances and material allowances to maximise the lifetime of the tools and the final quality of the cast and machined part.

-Design and manufacturing diecasting tool

The Company D can design the die casting tool bases itself on the customer's requirements about volumes, cycle time and resources available for the project. This is allowed by the filling and solidification simulation that enables the optimization of the feeding of the part, the position and number of the venting elements, the areas to thermoregulate and/or cool down even with the use of jet cooling pins, the areas where the volumetric shrinkage needs to be compensated with squeezing pins. The company also build die casting tools for HPDC presses with closing strength up to 1200 ton.

-Design and manufacturing trimming tool

The design of the trimming tool, carried out simultaneously to that of the die casting tool, has the aim to deliver a cast part which is ready for surface treatments or machining without any further handling. The introduction of working units, when possible, reduces the incidence of mechanical machining.

-Sampling

The sampling enables to check the perfect mechanical and diecasting performance of the die casting tool, the correspondence of the parts to the initial requirements and the supply to the founder of those parameters from where to start the series production.

-Measuring reports

The dimensional check of the first samples brings to a real-time evaluation of the sampling results and the immediate correction of any possible out-of-tolerance dimension. The diecasting tool will be delivered to the customer only when entirely corresponding to the dimensional requirements of the product.

-Preseries

Company D can respond to customer request of small series or raw cast parts. This is allowed by using series diecasting tools or test tools which are built in a short time.

-Research and innovation

Company D has long experience in research projects in the European environment. It also worked with the universities and research centres in the industrial and metallurgic field.

4.5.2 HRM in Company D

An HR Manager is currently employed inside Company D. The HRM manager was hired ten years ago after the expansion occurred to the firm in those years. Before the HR Manager, all the HR practices were performed by the company's founder, and by the CEO (his son) once he succeeded him. The duty of the HR Manager contains almost every practice related to the HR while the focus is to support the CEO and the company's need. According to the HR manager, one area that is suffering is the training. This emergency, as described by the CEO, spread from the lean implementation and the industry 4.0. Both this implementation changed many aspects of the life of the organisation, and especially the older employees faced some resistance to change.

4.5.2.1 Employment security.

The Company D use every possibility of contracts offered by the Italian labour law. The kind of work contract chosen for formalising the employment of the workers is highly dependent on the open position. The permanent contract was not used by

Company D as a lever for attracting and retaining the employees. The company did not show to have a strategy related to the employment security of its employees. The interviewed managers did not provide evidence about the importance of employees' engagement.

> *"Every employee is treated fairly, and we give a work contract that meets the seniority level of the employee."*
>
> CEO

The process of employment is straightforward and do not relate to the kind of job position: workers in line and staff/administrative employees are treated in the same way.

The employment contract inside CD depends more on the seniority of the candidate/future employee. If a candidate is a fresh graduate will pass through an internship plus a temporary contract. Only later the employee will receive a permanent contract.

In the case of a senior profile, the HR manager, who is involved in the recruitment process as well as the employment part, offer the employee a temporary or permanent contract. Usually, this depends on the employee and whether he/she is employed in another company with a permanent contract, which would not motivate the employee to sign a worse work contract. Despite this possibility, Company D did not experience many of these cases, only a few employed in technical positions.

4.5.2.2 Selective hiring of new personnel.

Recruiting the right people is a topic that raised in the last years inside Company D. The HR Manager and the CEO focuses more on the selective hiring due to the lean implementation occurred between 2012 and 2016 and the Industry 4.0 implementation that it is still ongoing. The firm found that the candidates that are entering the market do not possess the technical skills required. Only a few high school students are found to possess the right skills, for this reason, the company is in contact with the professional high school and host the students for their mandatory internship period. The same belief

surrounds university student or graduates. The firm tried to recruit these students by offering to conduct bachelor and master thesis

> *"We believe that it is more important to find the right people. We are not bothered by training them; we developed a good training system over the years."*
>
> CEO

An old policy explicitly acknowledged by the CEO during the interviews, push the management not looking for hard skills but looking for good people. This leads the company in an increased number of steps in the selection process. The firm found itself satisfied with this way of proceeding and do not mention any changing for this process.

For what concerns the carrying out of the recruitment and selection, the HR Manager deliver almost every step of this process. Only the final interview with the candidates is conducted with the line manager and with the CEO. The CEO has the final say about which candidate to hire. The lean implementation and the industry 4.0 despite changing the way many employees work, did not reflect in a change in the way the recruitment process is carried out inside the firm.

4.5.2.3 Self-managed teams and decentralisation of decision making as the basic principles of organisational design.

Company D use of teamwork is low. According to the CEO, the cause for such a low level of teamwork lays in the way a foundry production system works. Despite this, the company wishes to increase its use of teamworking. Such a preference spread from the lean implementation, and the industry 4.0 implementation, which allows allocating employees differently since part of the manual activities are now automated.

> *"There is little room in a foundry like ours for working in teams. We increased the use of teamwork after reviewing and optimising the processes, especially for the Industry 4.0. However, it is still possible for only certain kind of works."*
>
> CEO

The decentralisation of the decision making did not consciously permeate the top management. From the strategic point of view, the organisation hierarchy it is not questioned. Despite this, the growth of the company pushed the CEO to give away part of his tasks to other people, which goes in the direction of the decentralise the decision making. However, while in literature it is desired for a decentralisation of the decision making that flatten the hierarchy, Company D distribution of decision making is a result of the increased number of things that needed to be managed. The same hiring of the HR manager was a response to a need.

> *"Our organigram stayed the same over the years. We have many changes, especially on the technological side, since we strive for innovation, but our organigram stayed the same. Of course, it grew in numbers, but the hierarchy structure is the same"*
>
> CEO

4.5.2.4 Comparatively high compensation contingent on organizational performance.

The compensation is one of the topics that is affected by the Industry 4.0 implementation. The company D as a long history rooted in his organisational culture, of compensating the employees only according to their seniority level, which was also reflected in the employment contract given to the employees. Despite the management view of the employment security did not change, the compensation contingent on the organisational and individual performance is one of the goals that the HR Manager wish to achieve within the next year. The reason for this renewed interest in the compensation comes from the ability to collect information about the employees. The industry 4.0 implementation allowed to install the sensor on every machine, which leads to the collection of such information, even information related to the employees' performance. Another factor influencing such belief is the implementation of a Human Resource Management Information System (HRIS). Before the Industry 4.0 implementation, all the information about the employees were handled manually by the founder, the CEO and the HR Manager. The Industry 4.0 implementation also pushed the management to update their installed software. The traditional way of managing the employees was

abandoned in favour of a new HRIS. The last factor which enabled the new view about the compensation is the processing mapping that was done. This allowed company D to have complete control over the process. As mentioned earlier, the goal of the Company D is to implement compensation contingent on performance and performance management as well. According to the HR Manager and CEO resistance of the employees and the labour law are significant barriers to the implementation of contingent salary.

4.5.2.5 Extensive training.

The training activity inside Company D takes place in two phases. The first phase is concerned with the assessment of the employees' competencies level while the second phase focuses on the training. The assessment phase is a consequence of the rush perceived by the management of training the employees. The CEO claims that employees in production require from 3 months to 12 months of training, with the 90% of these employees that are ready to be fully operational within six months.

> *"We do not have a problem with training; we have a problem with the time that it requires."*
>
> CEO

Technical employees (such as mechanical engineers or CAD designer) need almost two years of training since the job is more complicated than workers in line. The industry 4.0 implementation along with the expansion of the company broadened this problem. In particular, the company found graduate students not to possess the right technical skills. CEO claims the training time is not a problem by itself but that since there is a time between the hiring time and the working time, which can last several months, everything must be carefully planned. The rationale of the assessment is to identify the areas of improvement of the employees, by doing so, the company can directly focus on the employees' weakness and to shorten the training time.

The second phase is the one in which the training is delivered. Company D still use frontal lessons. This method appeared outdated to the CEO and the HR Manager, who both claim to be open to introduce e-learning if the situation about the skill shortage, and

the expansion of the firm, would not end soon. The E-learning implementation is enabled by the new HRIS system adopted by the firm.

4.5.2.6 Reduced status distinctions and barriers, including dress, language, office arrangements, and wage differences across levels.

According to the CEO and the HR Manager of the Company D, the firm communicate to its employees who are the rules for reaching a higher salary. The lever for this is the possession of the seniority. In the management view, this transparency and accountability enable a favourable organisational climate that also leads to the diffusion of an equity feeling among the employees.

The company treats employees equally and with equity, do not prefer one employee over the other based on prejudice or preconception. This also reflects in the recruitment policy; the CEO affirmed not to prefer any employees, the Industry 4.0 implementation did not affect this preference. According to the CEO a 50 years old employee or a 20 years old employee, they both possess the ability to work in the firm.

The firm push for decreasing the status differences also by organising a visit to other vital companies. Everybody is invited to visit these companies. The CEO claimed that even when the performance management will be implemented, and operative, the participation in such an event would not depend on the performance level of the employees. The HR Manager assesses the satisfaction of the employees who took part in these events and found an increase in the identification with the company.

Furthermore, Company D regularly organise social dinner and open days. The social dinner happens 2-3 times per year; every employee is invited. Usually, the schedule of such dinner is related to some positive event of the company.

The open days are usually organised on Sunday, these days the firm welcomes everyone, including the relatives of the employees.

4.5.2.7 Extensive sharing of financial and performance information throughout the organisation

The company D do not collect information about the performance of the employees. The performance is controlled by checking the process timing and the production advancement assigned to every employee. When something wrong appears on the chart, the management identifies the problem and solve it. Despite this, the CEO and the HR Manager expressed their interest in the development of performance management.

The performance management is enabled by the HRIS system that is about to be implemented.

The information related to the final information of the company is not shared with the employees. The CEO did not find any valid reason to share such delicate information is with the employees. Furthermore, the CEO claimed he never really thought about sharing the information since this is a thing rooted in the organisational culture and that he learned from the management style of his father.

4.5.3 Industry 4.0 in Company D

The industry 4.0 implementation inside company D started in 2015, right after the conclusion of the lean implementation. Company D it is historically looking for continuous improvement, according to the CEO, the industry 4.0 is a new name that was given to a trend that spread in manufacturing in the last ten years. The CEO positively welcome this branding and also believe in the consequences cause by industry 4.0 automation: a super increase in the efficiency of the production and a change in the way employees work.

"We firmly believe innovation wins over stagnation."
CEO

Moreover, the CEO find attractive the financial incentives provided by the Italian government. Such benefits allow CD to invest in the industry 4.0 implementation. Due

to the continuous improvement philosophy of the company, many innovations on the technical side happened in the last years. For this reason, the firm did not benefit from the fiscal incentive related to the acquisition of new machinery. On the opposite side, the benefit related to the software side were welcomed, and this is one of the reasons for the implementation of an ERP and the HRIS.

> *"The [Italian] fiscal incentives for Industry 4.0 are positive to activate an investment. Give a name to a change that is not of today, but in the last ten years it is also positive."*
>
> CEO

The industry 4.0 implementation inside Company D happened in two phases. In the first phase, the company worked along with a university, for enabling the acquisition of data from the machines. Every machine was given sensors to make this transmission of data possible. The second phase concerned the connectivity of the machines, ensuring everything was connected. The first phase gave the possibility of communicating, while the second focused more on establishing the connection. The machines were already in possession of an ethernet connection that allowed the computers to connect with the machines. This connectivity check showed the areas that required attention. All the machines were connected by wireless to the local network area of the firm. The third phase is the establishment of software for collecting and analysing the collected information. The company decided to develop software on its own. To achieve such a goal an IT programmer was hired, and the person is still working on the development of this software.

According to the CEO the Industry 4.0 allowed to increase the volumes of production, this increased managerial complexity. This shifted his attention from the management of the production to the management of the entire company, to be sure that everything was implemented right.

> *"Increased production volumes increase the complexity to be managed, are more focused on management than on production. Increased production capacity and not management, so when a customer asks where we are, I do not have to put pressure on anyone."*
>
> CEO

The substantial expansion and the increased managerial complexity of the company urged the firm to track all the operations. According to the CEO, this is one of the main reasons why Company D pursued the Industry 4.0 implementation: become leaner. The rationale behind the third phase of the industry 4.0 implementation, is the ability for every manager to access reliable and essential information, without bothering anyone and with no delay. This resulted in Company D being able to access every information on time. Before the industry 4.0 implementation this information was provided inefficiently, and often they become old and unusable.

According to the HR Manager, one consequence of the industry 4.0 implementation was the resistance to change. Despite the HR Manager and the CEO were not surprised by the resistance to change, which already happened other times in the life of the firm, they were more surprised by who resisted. While administrative employees, staff employees, and workers in line opposed little resistance, the line managers showed the highest resistance. The CEO had to persuade them about the utility of the new way of work to win this resistance.

4.5.4 Main Evidence

Company D is one of the companies where the Industry 4.0 implementation did not show many visible changes. The lack of tangible differences seems to be related mainly to the low level of maturity of the firm, about the Industry 4.0 implementation and by a slow growth over time, which hindered many of the changes other firms occurred. About the implementation of Industry 4.0, this was favoured by the previous effort posed by the firm in the lean implementation. The decision to become a lean organisation is linked to CEO's vision, which fosters "*innovation over stagnation*". On this basis was implemented the Foundry 4.0 project, the main goals of the project were the interconnection and intercommunication between the machines and the IT infrastructure of the firm.

From an HR point of view, the practices are carried out by an HR Manager who entered the firm in the last ten years. The presence of an HR Manager is not reflected by the management style, with the HR supporting the firm but in a reactive way, which do not fit the HRM theory about the strategic nature of this position. Where the action of

the HR manager is worthy of notice, is the preference for preferring soft skills over hard skills. This kind of preference found legit support in the literature since it is one of the main points of a good selection outcome. Selecting the "right people" required the company to change its recruitment process, which become more structured and it now embraces several steps before coming to the final decision about whom to hire. Despite this way of selecting the personnel is acknowledged in literature, the Industry 4.0 implementation seems not to have affected such a process. It appears that the company grew steadily in the last ten years, and the workforce increased slowly over time. Along with the presence of an HR Manager, this seems to be the reason why, differently from other firms implementing Industry 4.0, the recruitment process was not affected.

Industry 4.0 put the basis for the adoption of self-managed teams, even though the adoption is still at a low level, the reason behind this problem lay in the fact that firm is mainly a foundry and many of the jobs related where not yet automated, which created little room for teamworking.

The impact of Industry 4.0 is evident in training. Even though the firm has a "*good training system*" there is a problem related to the time needed before employees can work on their own. This time shortage is addressed by increasing the efficiency of training. As happened in other firms, the serendipity of Industry 4.0, seems to be related to the implementation inside companies of a Human Resource Information System, which is enabled by the new ability of the firms of gathering information.

In conclusion, Industry 4.0 impacted minimally on Company D. Looking at the reason why this could be for several reasons: one of this could be related to the lean management implementation. Such implementation could have overshadowed some aspects related to the Industry 4.0. Another reason could be the size of the firm, the number of employees of Company D is higher, this suggests the idea that the growth of the firm, which usually equally results in growth of the complexity, mitigated the effect of the industry 4.0, since the management structure of the firm was more defined than the other firms.

Lastly, industry 4.0 seems to have had an indirect impact on the adoption of an HRIS, while direct effect, in this case, are not recognisable.

4.6 Company E

This paragraph provides a summary of Company E so to give a clear view of the main important information before analysing in depth the information about Industry 4.0 implementation and HR practices. This information is summarised in Table 19 – Company E major indicators.

Company E is a Dutch Company located in the South part of the Netherlands. It was founded in 1981 and operates within the metal sector. The firm's core business is the metal elaboration of tubes, pipes or metal sheets. Company E provides different solutions to customers for pipes, tubes and metal sheets, such as cutting, sawing deburring, or tapping. In the past 35 years, Company E has grown into an essential and reliable partner for the entire Dutch metal processing industry. Currently, the firm has 55 employees and a turnover of approximately 12 million euro. The firm owns a 6000 square meters plant and has gone through serious investment in the implementation of the industry 4.0. On this topic, the firm took part in the field lab called "flexible manufacturing". Due to the effort in the Industry 4.0 implementation, in 2017 Company E has been named among the top three firms in the field of smart manufacturing within the 13,000 members of the Metal Union, and for this reason, received an award.

According to the official documentation on the firm, Company E delivers its value through six levers: 24/7 operativity, which means the company production never stops, with some orders handled autonomously by the machines during night and holidays, every day of the year. Order tracking, which allows customers to check the progress of their order by logging in in the corporate website of Company E. The possession of Quality certifications and the ability to produce small batches are two other levers used to deliver value. A broad portfolio and a reliable partner with 35 years of expertise complete the offer.

Table 19 – Company E major indicators

Country	Location	Turnover	Employees	Sector	Generation	Production model
NL	Oisterwijk Region	12 million	50	Mechanical	Management buyout	Lean

4.6.1 Company's Evolution

Company E was founded in 1982, since its foundation the company went through several changes, with the most important one being the shifting of its business model. During the early years in the life of the organisation, the company was a hardware shop still operating in the metal sector. In 1992, the company shifted its focus to the production on the components they were already selling. In the same year, another significant change happened: one of the current Directors of the company entered the firm as a manager and bought the 49% of the company's shares. In 2001 the current Director, along with another manager, bought the remaining shares of the firm from the founder. The duo now owns the totality of the shares, and they are both the Directors of the company. For this reason, the first director will be called "Director F" and the second one "Director S". The two directors believe in the opportunity technology and automation could deliver to the business.

> *"I would rather prefer to spend money on a robot instead of a vacation in Hawaii."*
>
> Director F

Since the buy-out of the company in 2001, the Director's strategy followed two main lines: increase efficiency and reduce lead time. Efficiency gain was seen as a lever for enabling lower prices, and for this reason, potentially attract new customers. The lead time reduction strategy boosted the firm ability to operates rapidly and to deliver the products faster than the competitors. The strategy outlined for achieving the before mentioned goals was the investment in technology. Between 2004 and 2010 the firm invested in buying new machines, which were faster and more reliable compared to the previous one owned. The acquisition of new machinery was also related to a dramatic

increase in the production volume, with the already existent machines that were not able to keep the production pace.

In 2012 the company underwent a program for fostering the flexible manufacturing, for which it also took part in the field lab called "flexible manufacturing". By working with research centres, Company E was able to shorten its delivery times. Currently, the company can saw or cut the products in less than 24 hours.

Since 2015 the firm is implementing Industry 4.0 (Smart Industry in the Netherlands).

4.6.2 HRM in Company E

> *"First improve the role of man, only then possibly purchase new equipment and ICT. To fully exploit new technology, a culture of improvement is indeed necessary."*
>
> Director S

The activities related to the human resource management inside Company E are carried out by the two directors. The two decided to keep handling the HR tasks even after the expansion of the firm, which brought an increase of the 25% of the workforce in the last few years. The company believes that employees have a crucial role in ensuring the successful implementation of any new technology. In particular, the firm fosters a culture of innovation: according to the directors, it is not possible to innovate and to sustain these innovations without a proper company's culture. For this reason, the two directors put much emphasis on ensuring the employees were adapting to the new working scenario.

> *"What disappears is repetitive work, which is quite boring. Instead, get jobs more challenging. Moreover, most people do see that we will be much more competitive."*
>
> Director F

The company did not encounter resistance to change in the employees, according to the directors, this was possible due to the employees understanding the positive nature of the technological improvement, which would have also led to an increase in the working conditions of the same employees. The possibility of working a less routinised

job with a decrease in the fatigue associated with such works convinced employees in welcoming the industry 4.0 implementation.

> *"The function of man in the factory shifts to control of product to control of the process. Our employees only check, do not make anything. As long as robots do not have artificial intelligence, they are still best suited for monotonous work. Tasks that require more creativity yet remain human domain."*
>
> Director S

4.6.2.1 Employment security.

Company E follows a common hiring path for all his employees regardless of their job position, for both workers in line and staff or administrative employees. The firm uses the principle called "3-10-10", which stands for 3months-10months-10months, these are the duration of the first three temporary contracts.

The 3-10-10 principle is rooted in the organisational culture of the firm, and this way of proceeding stayed the same for the last twenty years, despite all the significant changes occurred to the firm.

When asked about the importance the employment security could have for attracting new employees, as well as retaining them by offering a permanent contract. The two directors claimed their way is standard in the Dutch culture, so it is pretty accepted not offering in the first instance a permanent contract. Moreover, the two directors claimed the ability to attract talented employees depend on their experience more on the attractiveness of the firm. Consequently, Company E has a good reputation, and it is attractive for the employees. Furthermore, the two directors find the possibility of employees leaving the firm as something that would not want to happen, but also as an opportunity for new good employees for entering the company.

4.6.2.2 Selective hiring of new personnel.

> *"We continue to need people because everything we make is custom-made. We also have no problems in recruiting the right employees, you need to be attractive to them, and we do have a good reputation."*
>
> Director F

The recruitment and selection of new personnel are one of the HR practices that mostly got the attention of the management inside Company E, primarily due to the industry 4.0 implementation. This practice was initially carried out by the founder of the company. After the buy-out, the responsibility shifted to Director F who always consulted Director S in deciding which figure was worthy of hiring.

The firm does not have any preference for attributes desired employees should have; it is company believe that they can train the employees easily. Moreover, the new working scenario is more accessible than before, with employees that shift from manual working to the supervision of the machines.

> *"We are growing our production volume without increasing the employees proportionally; this minimises our labour cost."*
>
> Director S

Nowadays the company outsourced the recruitment process for most of the openings. The reason behind this choice lays in the time this activity requires, and to the difficulty in finding employees due to the skills shortage. The directors claimed they quickly found someone to employ, but only because they use polish workforce. Finding Dutch employees is more difficult, this pushes the firm to hire recruitment agency who can easily access a list of polish employees. According to the directors, Dutch employees seem to prefer working in the service sectors, while the job in the manufacturing is deprecated.

4.6.2.3 Self-managed teams and decentralisation of decision making as the basic principles of organisational design.

> *"We would make everyone work in a team if we could, we saw some benefits for people that work in such a way. However, we cannot do it for everyone, especially now that we are a focus on the industry 4.0 implementation we struggle in identifying areas of improvement outside this"*
>
> Director S

Company E way of working changed radically from the foundation of the firm. In the first period, the way of producing resembled the mass production. In that scenario, every employee paid attention only to himself. After 1992, with the management buyout, and the newly established firm belief in the benefit of technological implementation, the attention towards the teamwork increased. This interest is part of the management belief in the improvement of employees' condition after the adoption of some new technology or a general change in the organisational asset of the firm. Despite the interest the management have in boosting teamwork, according to the two directors, the application in the plant met many difficulties that constitute a significant barrier to its full adoption. One of the reasons behind these difficulties is related to the production model. Only with the just in time production, the management was able to organise teamwork, always respecting the limitations imposed by the production model.

Since the industry 4.0 implementation inside Company E is not finished yet, the management is still focusing on that topic. After this implementation is over, the two directors will dedicate their time in improving the well-being of their employees. According to them, an increase in the use of teamwork will be tried. The managers claimed they are thinking even now about this topic since some of the changes occurred affected the relocation of the employees. It was the case of the fork-lift driver, whom all become obsolete after the implementation of the automated warehouse. This forced the company to decide what to do with the employees; they were all offered a new job-position inside the firm or a money-benefit for leaving the company.

4.6.2.4 Comparatively high compensation contingent on organizational performance.

> *"We do not think employees will be motivated by setting a goal and linking this goal to some fringe benefit or monetary compensation."*
>
> Director F

Inside company E, the discussion about employees' salary was radically reviewed after the management buyout in 1992. Before that date, every employee was receiving a fixed amount of salary, not contingent on any performance, both organisational or individual. After the two directors took over the firm, they fostered compensation contingent on the

organisational performance, especially related to the profit. According to Director S, the fixed amount of the salary account for more than the 90%, with only 10% related to the organisational performance. The company motto about the compensation topic is *"know, control, improve".* With this saying, the firm focus its attention on being able to monitor the performance of the company. Despite this motto, Director F claims not to have an effective performance management system for the organisation, and neither have one for the employees' performance.

For this reason, the two directors are about to implement a performance management system. This will allow management to check (control) the performance of the employees and allow to improve their performance. However, the lever for increasing the performance level of the employees is not linking a variable part of the salary to the performance. According to the directors, despite the industry 4.0 implementation allowed to acquire such data very quickly, the country culture would not play in the company's favour. The employees would not accept such a way of compensation, for this reason, the possibility of having performance contingent on the individual performance does not find room in the company and should neither find it shortly.

4.6.2.5 Extensive training.

> *"Training is a necessity; we also invest heavily in mentoring. However, nowadays the employees realise that we are living in a fast-changing world, and they ask to be trained in order to stay attractive and not becoming obsolete."*
>
> Director S

Company E believes in the importance of giving to every employee adequate training and mentoring. The high investment in training pushed the company to establish an "Academy". The rationale behind the Academy is to become more efficient even with the training of the employees. Before the just in time production, and before the industry 4.0 implementation, the focus and importance of training were still at a high level, but it changed the way of its delivery. Before these two significant shifts in the organisation's life, the training was a full-frontal activity that was performed to every employee, in order to minimise the cost of the activity. Such a way of handling the training, resulted in the

company to almost shut down its production: only a few employees were kept in the production for keeping the plant working. With the mass production this was not a severe problem, but with the new customers' needs about the customised solution in small batches, the old way of training become rapidly obsolete. The firm adapted to the new situation changing the training scheme and introducing the figure of the mentoring. The mentors are associated with a new employee who should guide and support, for every job-related difficulty that could raise. Another change is also the possibility of e-learning, which detaches the firm from having fix days in which the training is possible: in such a way, a moment in which the production is low is used to maximise the training of every employee. Actually, according to the Director S, one of the reasons for the firm focusing on training is the interest showed by their employees for remaining up-to-date and valuable for the labour market. Some training still requires an expert in the field who deliver face to face classes. To minimising such cost of training and for improving the relations with customers, company E founded an Academy. Lectures in this area are open to the customers, in such a way the can see the investment the firm is putting in their employees and increasing the knowledge of what happens, and how, in Company E.

4.6.2.6 Reduced status distinctions and barriers, including dress, language, office arrangements, and wage differences across levels.

> *"We know every employee; we know their story. We called them by their name and the same to them; they know they can count on us."*
>
> Director F

The reduction of status differences inside Company E is pursued in different ways. One of the first ways was to embrace the diversity. According to the two directors, this is also possible due to the Culture who foster melting pot between people with different stories and background. Moreover, the company really push for hiring Polish workers, the two directors found them to have high motivation to work, for this reason, they try to provide extra support for these employees.

"Our way of working is enormously automated and therefore unique in the world. I sometimes come here at the weekend, when there are no people in the factory, while all robots and machines work. That is a powerful sight."

Director F

The firm also removed any dress code; employees are free to dress in any way; the only exception is for the workers in line who have to wear on top of their clothes protective elements that are mandatory by the labour law about safetyThe distance between the operators in line and the management is almost set to zero. The two directors foster the informality, everyone calls the other by name, resulting in the neutralization of the difference in the organisation's hierarchy.

"Historically, the metal world is a man's world, but women get the same opportunities from us as men and are therefore also active here."

Director F

When prompted about the impact of industry 4.0 implementation on the topic of status reduction, the management finds some meaningful impact. First one is the increasing need for specialised workers that lead, once again, into the hiring of polish employees.

However, the significant impact of the industry 4.0, is on the shift between working in line and supervising the machines in line. Such a significant shift allowed women to enter the "*men's world of metal*", since being a heavy lifter is no more a requirement for workers in line.

4.6.2.7 Extensive sharing of financial and performance information throughout the organisation

"As management, we are now less hands-on and more concerned with the policy. We dare to entrust the company to our MT, which we coach and guide in the factory. The management and MT have also been working for years with an external coach so that their vision, objectives and culture remain clear."

Director F

Company E discloses information about the performance of the organisation in different ways, according to the job position and to the necessity of accessing that information. To workers in line the firm only disclose their performance information and the financial one. Of interest for the employees is this last one since some part of the compensation is related to the profit gains of the firm. Despite there are no consequences for performing under the average, the two directors claimed employees to be interested in keeping up a good performance.

The people who know most of the information are the marketing and sales department. People employed there to get to know all the information about the selling or the marginality for every product.

The industry 4.0 supported data collection about the production and the employees efficiently. Such a possibility is one of the reasons why the company is thinking of implementing a performance management system, that could enhance the information sharing of the firm, resulting in the increased involvement of the employees.

4.6.3 Industry 4.0 in Company E

Company E started its investment in Industry 4.0 since 2015 when it agreed to be a partner at the "flexible manufacturing" field lab of the Netherlands south region. The company firmly believe in the importance of the technological innovation as a lever to become a leader in their market.

> *"You always have to look ahead for several years and keep on investing, only then you can lead the way. Anything that can more efficiently with software and automation, we pick up".*
>
> Director F

Despite 2015 being the official date in which the management started focusing on the industry 4.0 implementation (smart manufacturing according to Dutch terminology used to refer to the phenomena). The steady evolution from just-in-time (JIT) implementation to smart manufacturing was quite linear and smooth. The smart manufacturing took benefit of many improvements that were realised during the JIT transition. The decision

of adopting Industry 4.0 was an opportunity to increase the overall performance of the company and thus gaining market share. The two directors draw a strategic plan for the industry 4.0 implementation, which is still undergoing. The strategic plan above mentioned, was composed of different phases. The plan was created starting from the desired ending point of this project: a fully automated process, from the order of the customers to the delivery of the process. The two directors decided that everything should end with the website of the company being able to acquire the customers' orders and also allow to check the progress. Nowadays Company E succeeded in reaching this goal when customers place an order on the company's website they instantly get a quotation. After concluding the order, the firm links the required material directly to the right/proper machine. Robots bring the plates fully automated to the machines. There the plates are automatically processed into the parts customers have ordered (Figure 49, Figure 50). This process repeats itself seven days a week and 24 hours a day.

Figure 49 - Automatically sorting plates of steel inside Company E

The transition towards this industry 4.0 implementation encountered some bottlenecks. The biggest bottleneck according to the two directors, was the coupling of the IT-systems to each other, with the most delicate being the ERP system and process automation. The ICT requires heavy maintenance to ensure the successful communication and information exchange of data without flaws, and thus requires

employees working on it. The company increased the cost related to the IT department by hiring an ICT specialist with a permanent contract. Moreover, is expanding the department with two other programmers, due to the high number of errors that the firm encounters. The rise in the costs associated with the IT department did not affect the overall performance and efficiency of the firm, which was able to double its production volumes, after the industry 4.0 implementation.

Figure 50 - Automated warehouse

Although the industry 4.0 the maturity level of the company is quite high, the firm identified some areas that are still lacking and demand further investment. The identified areas are augmented reality, AGV, and full automation. The augmented reality it is not used inside the company in any way. The firm is intentioned in the concept of the predictive maintenance and wants to enhance employees working on the maintenance of the machines, by providing them with VR or other devices capable of providing the augmented reality.

> *"Next step for us is going towards a man-less work. From man-arms to man-less is a learning process."*
>
> Director S

The second mentioned area of improvement is the one related to the Augmented Guided Vehicles. The firm currently has 1 AGV inside plants, the AGV use is elemental,

and it is not smart enough to interact with the surrounding machines. Company E wants to change this AGV, and to includes several others, to help in the reduction of weight transportation for the employees.

The last area is the one related to the automation, although much of the process is already automated, there are three lines in which the production can still improve. As a next step, that will take place between the end of 2018 to mid-2019, Company E will work along with the University of Leuven on a research project that will automate these three lines in the production.

4.6.4 Main Evidence

The topic emerged from the Within-case analysis of Company E are several, namely: country culture, firm growth, new ways of working.

Related to the country culture, Industry 4.0 allowed the company to collect data about employees' performance, but the firm prefers to use this information only for checking if everything is working as expected. Implementing some performance management related to the reward of the employees would not be welcomed by the workers, which seems to be related to the Dutch culture.

The second topic mentioned is the one related to the firm growth. As already it has been showed by the analysis on the other companies, Industry 4.0 is strongly associated with a growth in the firm size, of both the complexity and the employees' number. Company E implementation of Industry 4.0 allowed increasing the production volume, while in other firms this leads to hiring new employees, Company E used this growth for not firing employees whose job-positions were replaced by industrial automation. For example, the automated warehouse made forklift drivers becoming obsolete, the increase in the production volume served as an opportunity for the company to re-allocate these employees to new functions. Not all the employees accepted the new reality, for those who did not want to take part in the factory, the company offered some compensation for leaving the firm.

The third topic emerged from the analysis of Company E, is the one called "new ways of working". This topic is related to the firm's growth enabled by Industry 4.0 implementation. The automation of many processes inside Company E resulted in the elimination of outdated job position, such as the fork lift driver mentioned above.

Another effect of the industry 4.0 implementation is the creation of new jobs in the production, which shifted the focus from employees working to employees monitoring machines. The outcome of this shift is the possibility for women to work in a factory, even of a company that work the steels, which for a generation was a "*men's world*".

Focusing on the Human Resource Management function, it is the two directors of the firm who usually carry out the HR practices.

In conclusion, Industry 4.0 implementation on Company E seems to differ from what noticed on other firms slightly. There are two main reasons behind these differences; one is trackable in the culture of both the firm and the country. The second has to deal with the level of implementation with the Industry 4.0: other companies in this study focused on the software implementation (using overarching ERP including MES functionalities) and the digitalisation. Company E adopted since the beginning of the industrial automation as the main driver on its Industry 4.0 implementation.

5. Cross-case analysis

5.1 Overview of the chapter

This chapter contains the details of the cross-case analysis which provides evidence emerging after the data collection and the description of single cases, as suggested by Eisenhardt (1989). Following the guidelines set out by Eisenhardt (1989), and Patton (2002), the five cases are compared according to different techniques, to identify patterns among cases and develop the propositions which are presented here. The purpose of the study was to understand how the industry 4.0 implementation impact among human resource management practices carried out in the Small and Medium Enterprises. Therefore, this chapter analyses the information collected provide an answer to the research questions.

This chapter will discuss the main evidence emerging from the cross-case analysis, for practical reason and in order to give a clear and complete picture to the reader, every paragraph has the name of High-Performance Working Practices.

After the discussion about the HPWP, it is showing the maturity of the HR practices as well as the Industry 4.0 maturity. After that, a framework is proposed.

The conclusion of this chapter is the paragraph related to the main evidences emerged during this cross-case analysis, which provide a summary of the content posted and formalise the identified propositions. Table 20 contains general information about the investigated firms.

Table 20 - General information about the firms

	Company A	Company B	Company C	Company D	Company E
Industry	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
Employee	40	42	90	96	50
Turnover	7 million	5 million	18 million	15 million	12 million
Technology	Sensors, Connected Machines, Cloud, ERP,	Sensors, Software ERP, automated	Tablet, Sensors, Software, Cybersecurit	Tablet, sensors, software, augmented	Sensors, Software ERP, automated

	vertical warehouse semi-automated	warehouse, tablet, computers, cybersecurity, cloud-connected machines	y, Connected Machines	reality, 3D printing, cloud, ERP, connected machines	warehouse, tablet, PC, 1 AGV, cybersecurity, cloud, connected machinery
Organization	Lean	Lean	Not Lean	Lean	Lean

5.2 Evolution of the HRM inside industry 4.0 SMEs

5.2.1 Employment Security development.

The Employment security of the employees is one of the practices where the impact of the Industry 4.0 was lower in almost every company. The literature (Pfeffer, 1996) on the topic of High-Performance Working Practices (HPWP), suggest to companies to prefer the use of permanent contract over the temporary one. By doing so, the possibility of employees fearing, and even boycotting, radical innovations, will be minimised because employees will feel like a member of the organisation forever. Moreover, the job-security helps in building employees' commitment.

On the firm side, the use of permanent contract should also impact on the hiring process and allowing the constitution of a leaner company (Pfeffer, 1996). However, only Company B claimed to have changed its attitude towards the work contracts. Table 21 contains information about the cross case analysis regarding the employment security.

Table 21 - Employment security cross analysis

Company	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
Employment security	Apprenticeship + permanent	Permanent	Stage apprenticeship temporary permanent	Stage apprenticeship temporary permanent	"3-10-10" rule
Who perform	CEO	CEO + Sales	HR Manager	HR Manager	Directors
Industry 4.0 Impact	None	Yes	None	None	None
Differences between LW	None	None	None	None	None

Almost every interviewee asserted to encounter difficulties in finding employees with proper technical skills, but the respondents did not see the possibility of offering a permanent contract as a lever that could enhance the attractiveness of the firm. The explanation for such belief also lays in the fact that many of these firms are investing many of their resources into establishing a good training process. For this reason, even if not explicitly acknowledged by the companies, the industry 4.0 impact upon the employment security seems to be rooted in an unconscious strategy and attitude towards the Industry 4.0 implementation that tends to prefer the investment in training over the employment security.

5.2.2 Selective hiring of new personnel

The hiring of new employees is one of the HR practices that interested companies the most. In particular, the Industry 4.0 created skills shortage, which emerged clearly during the implementation and which resulted in a mutation of the way firms deliver the recruitment process. Before Industry 4.0, the companies showed a pretty basic knowledge and use of the hiring/recruitment techniques. This practice was seen as a necessity and carried out trying to minimise the associated cost; this is one of the reasons why almost every firm put the "word of mouth" referral, as the first method used for the selection. The employee who was usually in charge of the process was the Owner/CEO of the firm. The Industry 4.0 created problems especially in finding employees with an

adequate amount of technical skills. Table 22 contains information about the cross case analysis regarding the selective hiring of new personnel.

Table 22 - Selective Hiring cross analysis

Company	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
Selective Hiring	Steps	Steps	Steps	Steps	steps
Who performs	Managing Director	Sales manager	Hr manager	Hr Manager	Directors
Industry 4.0 Effect	What, how, who	What, how, who	What, how, who	What, how, who	What, how, who
Differences between	yes	yes	yes	yes	yes

The skills shortage pushed firms in abandoning the "word of mouth" technique, focusing on more structured ones, delivered by line managers or other professional like recruitment agency or headhunters. Due to the high cost associated with the billing of head-hunters, the services of these firms are used only for hiring managers, while for the other employees the companies tend to prefer recruitment agencies. Despite having specialised firms providing the employees, many firms did not find the quality of the provided employees to be the desired one. For this reason, many companies are signing an agreement with high school for hosting students who can become suitable for the hiring shortly.

To some extent, the companies acknowledge the importance of hiring the right employees, and for this reason, having a large pool of candidates as it was by using recruiting agencies for finding candidates, was a good way for ensuring good hiring. Despite the literature (Pfeffer, 1998) suggest hiring employees that fit and meet the company culture and value, almost all the companies implementing the industry 4.0 accused to looking for technical skills over soft skills because Industry 4.0 dramatically increased the production volume and the needs for new employees. This increased the

complexity, and the employee number grew by 20% to 40% in some of these companies. Such a growth put much pressure into the training sustainability, and thus the needs for finding employees who have the most technical skills ready at hand.

5.2.2 Self-managed teams and decentralisation of decision making

The literature about self-managed team's adoption suggests the adoption of such a way of working, which could enhance intrinsic motivation and job satisfaction of the employees, turning in superior performance. Inside Industry 4.0 Small and Medium-sized companies, the self-managed team's adoption is partially blocked by the needs of the production in the factory. Despite these strict limitations, all the companies expressed interest in the topic, while 2 of them (CA, CB) declared to have already implemented the self-managed team for certain employees. In these two cases, the decision of using teams was more related to the vision of the managers about the way they would like the company running, rather than an innovation enabled (or forced) by Industry 4.0. Table 23 contains information about the cross case analysis regarding the self-managed teams.

Table 23 - Self Managed Teams cross analysis

Company	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
SMT	Yes	Yes	No	No	No
Industry 4.0 Effect	Change in employee work	Change in employee work	No	No	Change in employee work
Differences between LW	More related to Prod model	More related to Prod model	No	No	More related to Prod model

In this case, the Industry 4.0 is impacting upon self-management teams by changing the kind of work performed: CA, CB, CE, who are the companies with the highest level of industry 4.0 maturity, implemented work in teams after removing employees from the line, or changing their routines.

5.2.3 Comparatively high compensation contingent on organizational performance.

The compensation contingent on organisational performance appeared has one of the hot topics. In literature, this topic suggests compensating employees giving them a salary that is higher than the average, and that is contingent on the performance. The way of this contingency to be can vary according to the firm structure, and to the firm's strategy, the most known are profit sharing, team incentives, pay for skill, gain sharing, stock ownership and individual incentives (Pfeffer, 1998). Furthermore, the compensation contingent on the performance could lower the conflict between the capital and the labour, especially if the variable compensation takes the form of stock sharing, with employees gaining some part of the property of the companies. Table 24 contains information about the cross case analysis regarding the compensation contingent on performance.

Table 24 - Compensation Contingent on performance Cross Case

Company	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
Compensation contingent	Under implementation	No, but is under discussion	No, but it will after HRIS	No, but it will after HRIS	Yes but not individual no PM
Industry 4.0 Effect	Facilitate data collection	Facilitate data collection	Facilitate data collection	Facilitate data collection	Facilitate data collection
Differences between	No	No	No	No	No

Almost every companies claimed to pay their employees higher than competitors, the rationale behind such behaviour lays in the firms believing an increased salary will increment the firm attractiveness and lower the turnover of the employees. Industry 4.0 impact on this topic is twofold: on one side Industry 4.0 creation of skills shortage require firms to become more attractive for the employees. On the other side, Industry 4.0

facilitate the acquisition of the data about the employees' performance. Of all the companies only two (CA, CE) already activated performance management, while the others express their interest in its implementation. The interest spread from the acknowledgement of possessing much information that could be elaborated and use, this ultimately led on many occasions to the adoption of integrated HRM information Systems (HRIS), which will lead to the performance management.

Despite this benefit and the new ability to quickly collect such performance information, companies fear the implementation of the performance management, and even more, they fear the link between the performance and the employee level, fearing this could harm employee well-being (CB, CC).

5.2.4 Extensive training.

The extensive training of the employee is one of the HR practices that was majorly affected by the industry 4.0 implementation. In particular, the Industry 4.0 created a skills shortage phenomenon and a re-skilling necessity in those firms who suppressed some job position as a consequence of technological innovation. The skills shortage resulted in the need for firms of training the employees quickly and effectively. According to MacDuffie (1995) "having a workforce that is multiskilled, adaptable to rapidly changing circumstances, and with broad conceptual knowledge about the production system is critical to the operation of a flexible production system". This belief also emerged in the words of the interviewee, every company handled the training-problem in their way, but everyone acknowledges training to be important for changing the way firms operate. Training also allows seeing "different views of people held by the different firms and their corresponding production systems" (Pfeffer, 1998). Table 25 contains information about the cross case analysis regarding the training activities inside the organizations.

Table 25 Extensive training cross analysis

Company	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
Extensive training	Training and coaching	Frontal assessment	Frontal E-learning Academy	Frontal E-learning in future	Frontal E-learning Academy
Industry 4.0 Effect	yes	yes	yes	yes	yes
Differences between	no	no	no	no	no

Furthermore, the Industry 4.0 implementation enabled the adoption of HRIS in almost every firm. Because of the skills shortage, the firms saw the possibility of gaining many advantages by implementing an HRIS, and it was usually sawed as a nexus that could decrease the cost associated with the training process, as a way of speeding up the process and to dynamically perform the activity. Some of these companies also established the so-called "academy" which usually are Business school born within the organisations. The aim is to share knowledge and business values. This academy usually targets employees of each department and is also open to train clients.

A project to grow the company from within, starting from the human assets and intellectual resources of the company while strengthening group work and collaboration between colleagues.is a school created is a platform where people can take classes, or even given the opportunity to receive training not only to the employees but even to customers.

5.2.5 Reduced status distinctions and barriers, including dress, language, office arrangements, and wage differences across levels.

The reduction of status differences did not find widespread adoption. The companies showed a lack of interest on this issue, and for this reason, this topic is perceived by the firms as a minor one. Only one company (CC) tried to stimulate their employees and reducing the status differences by the introduction of social events like cinema nights or concert in the factory. The industry 4.0 impact upon this practice was acknowledged only by Company E, who was able to employ more women in the production. The other companies lamented a reduction in the time available by the management in organising a social event.

Moreover, almost every company grew as a consequence of the industry 4.0, but the management stayed the same in its numbers, which resulted in having the same numbers of people managing a bigger company. Thus, the time allocated to the planning of the event or draw policy for the status reduction was ultimately cut. The general lack of attention to this topic showed by the companies, help in showing the priorities of the firms as well as their orientation and management style.

Furthermore, the companies who naturally did better on this topic seems to have done this more for a cultural reason instead of analytical or strategical thinking. Similarly, many companies found resistance in the organisations of their events that are culturally related. Table 26 contains information about the cross case analysis regarding the reduction of status differences.

Table 26 Reduction of status difference

Company	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
Reduction Status difference	Social Event	Nothing	Social Event	Transparency and accountability as the main lever	Informal No dress code Diversity

Industry 4.0 Effect	no	no	no	no	yes
Differences between	no	no	no	no	no

The organisation of social events did not find any application in company E because in the Dutch culture employees do not want to spend extra time at work, while in Company C the attempt of establishing a canteen for the employees, resulted in only the management and some administrative staff going there.

5.2.6 Extensive sharing of financial and performance information throughout the organisation.

The extensive sharing of financial information among companies found some resistance from the management. The difficulties are usually related to the country culture or the firm culture: all the Italian companies carefully protect this information, and limit the information sharing only to significant indicators, like the turnover of the company before closing the fiscal year. On this topic, Industry 4.0 seems not to have had any impact.

Regarding the organisational performance, and more specifically the individual performance of the employees, the matter is treated differently. In particular, the Italian companies were interested in deploying a performance management system for the evaluation of the employees. The industry 4.0 contribution on this topic, is related to the ability to collect data and for the implementation of an HRIS. Despite the companies being very interested in the performance management, the sharing of these data is feared by the companies. Companies think that sharing this information could potentially harm employee wellbeing, job satisfaction and organisational climate. For this reason, all the companies will wait to see what is best for their business, if sharing or not sharing this information.

Companies did not welcome the link between performance management and the compensation contingent on the performance level. Companies fear to compensate according to the performance achieved, could harm the employee well-being. Table 27

contains information about the cross case analysis regarding the sharing of financial and individual performance information.

Table 27 - Sharing of information

Company	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
Sharing financial info	Limited	Limited	None	None	Limited
Industry 4.0 Effect	On PM	On Pm	On Pm	On Pm	On Pm
Differences between	No	NO	NO	No	No

5.3 Development of the proposed framework

In this paragraph, the maturity level of all the firms was assessed. The assessment is performed for both the HR maturity practices and the Industry 4.0 maturity. This paragraph shows the dimension used for conducting the assessment and then shows for each company the radar related to the maturity. Lastly, the paragraph shows the proposed framework.

5.3.1 Industry 4.0 Maturity

In literature, there are several scales available for assessing the maturity of the Industry 4.0 implementation, but only a few scales are developed and validated at the scientific level. Despite this concern, the aim of this thesis is not the definition or creation of a scale to assess the impact of Industry 4.0 on manufacturing SMEs but to study the Industry 4.0 phenomenon and its impact on the organisations, and in particular on the HRM function. For this reason, one of the maturity scales already available was adopted for assessing the implementation level of Industry 4.0. The main maturity scale adopted by companies and consulting firms that are present in the literature are shown in Table 28 – Main Maturity

scale available in literature. These maturity scales are designed for addressing the maturity of bigger companies, and for this reason, none of this was chosen as the one upon which to address the maturity level.

Table 28 – Main Maturity scale available in literature

Scale Name	Fonte	Assessment Approach
IMPULS – Industrie 4.0 Readiness (2015)	VDMA, RWTH Aachen, IW Consult 16	Assessment in 6 dimensions including 18 items to indicate readiness in 5 levels; barriers for progressing to the next stage are defined as well as advice on how to overcome them.
Empowered and Implementation Strategy for Industry 4.0 (2016)	Lanza et al.	Assessment of Industry 4.0 maturity as a quick check and part of a process model for realisation; gap-analyses and toolbox for overcoming maturity-barriers are intended; no details about items and development process offered
Industry 4.0 / Digital Operations Self Assessment (2016)	PwC	Online-self assessment in 6 dimensions; focus on digital maturity in 4 levels; application as a consulting tool as a fee for assessment is required in 3 of the six dimensions; no details about items and development process offered
The Connected Enterprise Maturity Model (2014)	Rockwell Automation	Maturity model as part of a five-stage approach to realise Industry 4.0; technology focused assessment in 4 dimensions; no details about items and development process offered (white paper)

I 4.0 Reifegradmodell	FH – Oberösterreich (2015)	Assessment of maturity in 3 dimensions including 13 items for maturity indication; maturity is assessed in 10 levels; no details about items and development process offered (development process not finished)
3 stage maturity model	Ganzarain (2016)	3 Macro dimensions: Envision, Enable, Enact. Take in to consideration Energy, Electronics, Digital Business and Advancement in Metal Mechanic
Maturity Model for Industry 4.0	Schumacher (2016)	9 Dimensions: Strategy, Leadership, Customers, Products, Operations, Culture, People, Governance, Technology
Toolbox Industrie 4.0	VDMA (2018)	6 Dimensions: Data Processing in the Production, Machine to Machine Communication, Company Wide Network, Infrastructure of Information and Telecommunication Technologies in Production and Efficiency for Small Batches
Industry 4.0-MM	Gokalp (2016)	Holistic approach consisting of the assessment of process transformation, application management, data governance, asset management, and organisational alignment areas

For the scope of this thesis, the scale developed by the Mechanical Engineering Industry Association (VDMA) was adopted. The scale defined by this association was found to have a good fit with the focus of the thesis since it is targeted to assess the

Industry 4.0 maturity level, especially of Small and Medium Enterprises. The VDMA represents more than 3,200-member companies in the SME-dominated mechanical and systems engineering industry in Germany and Europe. The scale is centred with the analysis of the Industry 4.0 maturity level in the production, for this purpose the scale use five dimensions, namely: Data Processing in the Production, Machine to Machine Communication, Company Wide Network, Infrastructure of Information and Telecommunication Technologies in Production and, lastly, Efficiency for Small Batches. These dimensions are further explained below, for each of them a summary of its content is provided.

1-Data Processing in the Production

The processing of data for various applications is a crucial issue for Industry 4.0 applications in production. Data processing in production can be used for simple documentation as well as for objectives aiming at process monitoring, autonomous process planning and control.

2-Machine to Machine Communication

Interfaces for automated data exchange between machines form the basis for numerous Industry 4.0 applications. Field bus interfaces, as well as industrial Ethernet and web interfaces, are applied in the industrial environment. Web interfaces and applications with autonomous information exchange (web services) offer the advantage of a possible separation of information and location.

3-Company Wide Network

An improvement of the networking between the production and other company levels opens synergies and avoids duplication of work. The networking between production and other departments facilitates unified IT solutions, standardised workflows or consistently used file formats from which the entire company benefits.

4-Human Machine Interface

Considering the increased complexity of the production systems, human-machine interfaces are crucial. In industrial reality, the starting point is often represented by local

display units that do not have user-friendly operating concepts. New operating concepts such as mobile tablets or data glasses that conveniently provide the right information in the right place are potentially promising for simplifying the work of employees and for increasing the production efficiency.

5-Infrastructure of information and telecommunication technologies in production

The infrastructure of information and telecommunication technologies in production determines the possibilities of implementing innovative applications and potential improvements for technical and organisational processes. In addition to the use of central data servers, web-based communication portals may be used. Automated processes for exchanging data with external partners of the value chain or instead value network represent further steps towards an Industry 4.0 vision.

6-Efficiency for small batches

The trend toward individually produced goods and continuously smaller batches leads to a rising complexity of production processes. Reaching higher efficiency with small lot sizes are thus becoming a decisive competitive factor. In this regard, a modular structure of the respective products or the use of flexible production facilities with the appropriate coordination in the respective value chain can open up new potentials

5.3.1.1 Industry 4.0 Maturity levels before implementation

During the interviews, the respondents were asked retrospectively about the level of "Industry 4.0" in their company, before starting an industry 4.0 implementation plan. Despite this could seem a paradox, the rationale behind such a way of proceeding, is the fact that many times in practitioners' mind, Industry 4.0 is seen as the natural evolution of a phenomenon which did not have any definitive or clear label but that was happening. Is thus possible that companies implemented, just for giving examples, sensors in their machines or that they strengthen the ICT structure of the firm before the Industry 4.0 implementation, to face contingencies or to meet a particular strategy. The level of maturity before the Industry 4.0 implementation is shown below in Table 29. As mentioned in the paragraph 5.3.1, such maturity level was assessed using the Toolbox

Industry 4.0 developed by the VDMA; the researcher gave the ratings according to the interviewee reply to the researcher's question. These maturity scales address the maturity of Industry 4.0 in the production, by giving a score 1 to 5 to the six dimensions of interest, were one stand for "not implementing" and 5 for "completely implementing" Industry 4.0.

Table 29 - Industry 4.0 maturity before implementation

	CA	CB	CC	CD	CE
Year	2011	2015	2014	2013	2012
MtM	1	2	2	2	1
CWN	2	2	2	2	2
ICT	2	2	2	1	2
MMI	2	2	1	2	1
DP	1	2	2	1	2
ESB	1	1	1	2	2
Average	1,5	1,83	1,66	1,66	1,66

Legenda:

1= Not Implemented

5= Completely Implemented

MtM = Machine to Machine Communication

CWN = Company Wide Networking

ICT= ICT in production

MMI= Man-Machine Interface

DP= Data Processing

ESB =Efficiency with Small Batches

From the assessment of the maturity level of Industry 4.0 before its implementation as shown in Table 29, several conclusions can be drawn. All the companies started the implementation of Industry 4.0 in the different moment over time. Only Company A acknowledged the label Industry 4.0 since its inception, due to the Managing Director of the firm discovering the term, and the related concept, at the Hannover Conference in 2011, where the concept was first introduced to the world. Such heterogeneity in the

moment of adoption, suggests the fact that the phenomenon did not affect managers since the beginning and thus confirm the absence of a clear understanding or standard adopted definition, about Industry 4.0. This comes with little surprise since the literature about the topic is still debating around the phenomenon, especially whether or not it is an industrial revolution.

Moreover, the firm showed to be influenced by the political factors such as labour law regulations or the financial benefit provided by the government for boosting Industry 4.0 implementation. It is the case of the Italian firms, except for Company A, all the others started the Industry 4.0 adoption because it was less expensive. Table 30 shows the reason for the adoption of Industry 4.0 that emerged during the interviews.

Table 30 - Industry 4.0 Reason for the Adoption

Company	CA	CB	CC	CD	CE
Reason for the adoption	1) Enter the automotive market 2) Gaining Efficiency 3)Meeting customers demand 4) Fiscal incentives	1) Gaining Efficiency 2) Improving Employee well being 3) Growing firm size 4) Fiscal incentives	1) Meet clients' demands 2) Gaining Efficiency 3) Fostering Innovation 4) Improving Employee well being	1) Continuous improvement philosophy 2) Better control of what happens inside the company 3) Gaining Efficiency	1) Become a leader in the market 2) Gaining Efficiency 3) Culture of innovation 4) Improving Employee well being

From the information contained in Table 30, it emerges clearly that one of the main topics that welcomed the Industry 4.0 implementation, is the gain in efficiency expected from such an implementation. The reasons behind these expectations about efficiency gaining are several: the culture of the firm, management style just for citing a few. However, one of the most critical factors is related to the survival of the firm. The globalisation pushed companies to compete globally while the customisation pushed the

company to answer customers' needs quickly and with low prices. In this perspective, Industry 4.0 allowed the company to transform the production and to enable the possibility of the product in small batches while staying efficient. As shown in Table 30, all companies already tried to change their production model from a mass production one to a lean management one. The fact companies operated this transformation, is another point in favour of the importance for the firm, of remaining competitive, with the downturn of this to be the failure of the company.

Table 30 also shows three others essential factors: employee wellbeing, customers need, firm contingencies. Regarding the employee wellbeing, some companies (CB, CC, CE) showed a positive attitude toward the protection of the employees' wellbeing as well as their personal development. Industry 4.0 appeared to provide to companies the right instruments for improving employees' well-being, primarily by changing the tasks that need human assistance, especially one of the workers in line.

The second factors cited is "customers' needs". As partially explained in the paragraph above, many companies were influenced in their decision of adopting Industry 4.0 by the customers' needs. What customers need can both be one of the reasons for the adoption and one of the expected outcomes, while also being closely interrelated to the gaining efficiency topic. Moreover, in the manufacturing industry, and especially in the manufacturing sector, meeting customers' needs seems to be one of the drivers of the Industry 4.0 adoption.

The third factors, "firm contingencies", is more general and abstract and deals with the personal story, evolution and contingencies of the companies. One of the companies wanted to adopt industry 4.0 for entering the Automotive Market, which required the ability to track, and store, all the data about the production of the components provided to the automotive firms. Similarly, one of the companies believes Industry 4.0 could pull the company to become a market leader.

In conclusion, this paragraph showed the Industry 4.0 maturity level before its implementation. Such a situation was assessed with the help of the Toolbox for Production designed especially for SMEs by VDMA. From the analysis of the factors that favoured the implementation of Industry 4.0, four factors were identified: gain in efficiency, employee wellbeing, customers' needs and firm contingencies. A brief explanation of these factors was provided.

5.3.1.2 Industry 4.0 maturity level after implementation

The previous paragraph showed that the companies differed in their level of maturity and that the implementation of Industry 4.0 spread in different years. This suggests the idea that the introduction of the Industry 4.0 concept did not have a ground-breaking effect on companies, and neither or managers. It seems that other factors pushed the company to adopt Industry 4.0, namely: management culture/style/philosophy, fiscal incentives, gaining in efficiency and boost of the employee well-being.

Similarly, of what showed in Table 29, the actual level of implementation of Industry 4.0 was assessed at the moment of the interviews. The aim at this point was to check the real level of implementation of the Industry 4.0 and to compare it with the data collected before to see how much the companies progressed and where they invested more since this could help in drawing some conclusions about the impact Industry 4.0 had on companies. Table 31 shows these maturity levels related to the six dimensions of the Toolbox for Production designed by VDMA.

Table 31 - Industry 4.0 level of maturity

	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
MtM	3	3	3	3	5
CWN	4	4	3	3	3
ICT	4	4	3	2	4
MMI	5	4	4	3	4
D.P.	4	3	3	3	4
ESB	2	2	1	1	4
Average	3,66	3,33	2,83	2,5	4

Comparing the maturity levels showed in Table 29 with the actual one showed in Table 31, some exciting facts emerge. What is worthy of notice are the considerations related to the level where the maturity is the highest, and, on the opposite, the level where the maturity is the lowest. For the highest maturity, it seems Man-Machine Interfaces to be the dimension where companies invested more. This comes with little

surprise since, in the interviews, almost all the companies showed interest in evolving their production and, especially, the work of their employees. Only one company (CC) is still a little behind in the maturity of the Man Machine Interfaces, but this perfectly fit with the overall maturity level of this firm, which is the lowest among the interviewed enterprises. By looking at the reasons why Man Machine Interfaces are so developed inside SMEs, some other considerations could be made, and these are a history of the firm and easiness of adoption. Man-Machine Interface seems to be related with the history of the firms and their propensions to innovate from a technological point of view, the firms themselves. It seems that the older the companies are, the more they push for technological innovation for improving their production and remaining competitive by gaining efficiency. The second consideration, equally important, is related to the easiness of adoption of Man-Machine Interfaces. In particular, these products seem the closest to the tools already in use by companies, since they imply the use of the tablet, computers, smartphones. Man-Machine Interfaces allow the "use of mobile user interfaces" or "the augmented reality", and thus, their implementation is fostered and supported by the familiarity of people who are using these devices.

The second general consideration is the one related to the lowest level of maturity that is shown in Table 31 by almost every company, which is: production in small batches. If the previous dimension generated only limited surprise, the same did not apply to this dimension. The source of the surprise is related to the fact that three out of five companies declared they have a lean production also implemented with the help of specialised consultancy firms. The fourth company could also be included in the lean-production category since it has a Just in Time type of production. Only one firm out of five (CC), still have a mass production system, but it is also looking at the implementation of lean production. It is indeed necessary to look even here at the reason why four companies out of 5, have so poor maturity level related to the Man-Machine Interfaces. First of all, one consideration must be addressed to the black swan who performed well, Company E. As shown in Table 30, the most important reason for the adoption of Industry 4.0 in this firm, is the "becoming market leader" motivation. Despite this could be rhetoric, such a motivation shows two interesting facts: a clear company goal and a customer-focused perspective. The first one is almost a paradox, because specifying here that this firm has a clear goal, suggest the ideas that the others did not have a clear goal.

This is not one hundred per cent accurate, the other companies had a clear goal, but it was almost transparent in the words of the interviewees that Industry 4.0 was seen more as a natural evolution of a technological improvement path, rather than a ground-breaking new concept or innovation. For this reason, these companies did not challenge their view and kept working as usual. On the contrary, Company E started from the analysis of customers need and identified that customers' demands were becoming more different and customised, which urged the firm to adapt its production to be able to work even on small batches.

The lean production implementation did not fully take place in these companies; this suggests the idea that firms could have adopted the general philosophy of the lean management or just some of the pillars such as visual management. This point is essential since in literature there are two opposite view, one that sees Industry 4.0 to be an enabler of Lean Production, and one other that sees Industry 4.0 enabled by Lean Production. The results from this analysis seem to favour the former one since all companies that should have implemented Lean showed a low level of maturity related to the ability to produce in Small Batches. Moreover, the Lean Production did not seem to have had a most profound impact than other significant changes that happened in the life of the organisations.

5.3.1.3 Industry 4.0 Radar of the companies

In order to give a better picture, and a visual representation of the maturity levels of the firm, related to the Industry 4.0 implementation, Figure 51 to Figure 55 depicts the radar of the companies. The radars have the shape of a hexagon; every angle represents one of the six dimensions that were assessed using the Toolbox for Production designed by VDMA, which maturity levels were showed in Table 31. Since the radar does not show the full name of the six dimensions, here they are Data Processing in the Production, Machine to Machine Communication, Company Wide Networking with the Production, ICT Infrastructure in Production, Man-Machine Interfaces, Efficiency with Small Batches. More information about the content of these dimensions is provided in the paragraph 5.3.1.1.

From a visual analysis of the radar, it is evident that there are two companies (CC and CD) where the Industry 4.0 level of implementation are lower than the others, in almost every area. Coincidentally, these are also the oldest firms. Reason for such a low maturity level, do not find support in the justification that this could be the result of few times dedicated to the implementation project or that they just started the adoption of Industry 4.0 recently. Company C started the implementation of Industry 4.0 in 2013 while Company D in 2014. Moreover, Company D motto reported in the within case analysis in chapter 4 was "*innovation win over stagnation*". The possible explanation of this low maturity level could be related to the production model. Previous consideration in paragraph 5.3.1.3 suggested that Industry 4.0 is an enabler of Lean Production, and that is not enabled by Lean Production, with this topic being debated in the literature. Company C has a mass production model, while Company D only recently implemented Lean Production, but, according to the words of its CEO, the full implementation is far from being reached.

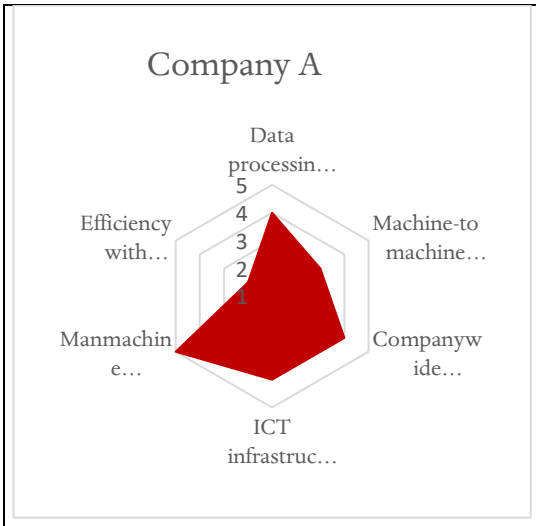


Figure 51 - Industry 4.0 Maturity in Company A

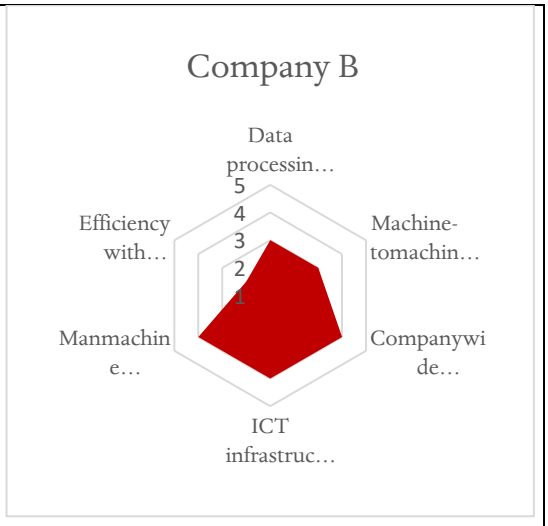


Figure 52 - Industry 4.0 Maturity in Company B

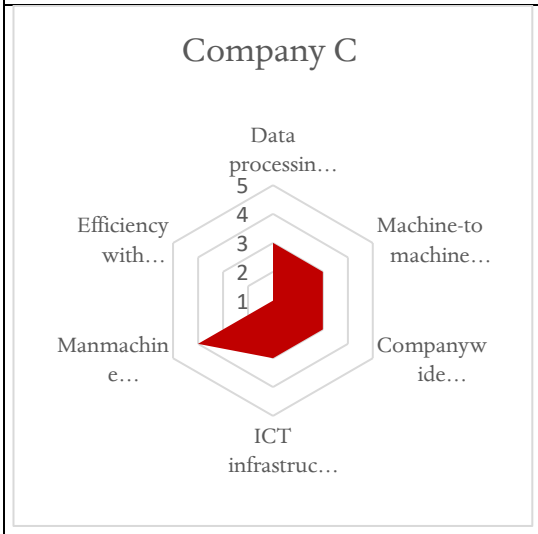


Figure 53 - Industry 4.0 Maturity in Company C

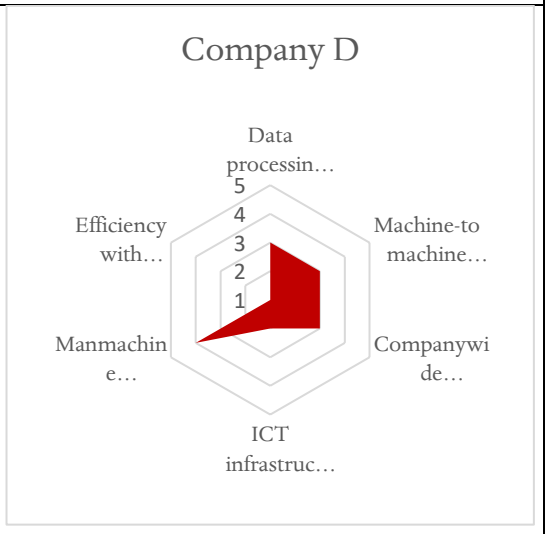


Figure 54 - Industry 4.0 Maturity in Company D

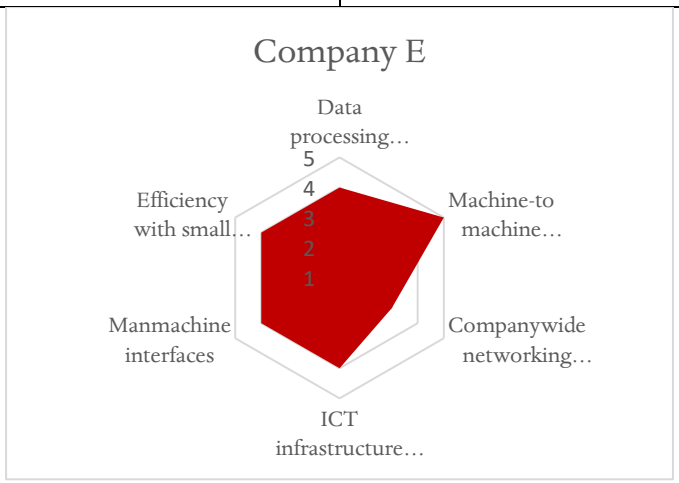


Figure 55 - Industry 4.0 Maturity in Company E

One of the possibilities of such low levels of maturity inside Company C and Company D is that both these two companies produce their components from the raw materials, and for this reason, they have a blast furnace inside their plant. The presence of the furnace could have hardened the implementation of Industry 4.0 in the Production, seems it poses some serious (physical) problem to the way production is carried out.

Therefore, another consideration could be made: Industry 4.0 is not enabled by Lean Production, but companies that have already implemented Lean showed higher levels of Industry 4.0 implementation.

Another consideration could be made about Company E and its high maturity level. The first consideration is that this company is the only Dutch one. The national culture does not seem to play a crucial role in the adoption of Industry 4.0; this seems to be more associated with the firm culture or the management philosophy about innovations. The reason why the nationality it is pointed out lays in the fact that all the Italian firms have access to fiscal incentives to support the Industry 4.0 implementation, which allow them to buy new machines at a "lower price" and also to pay fewer taxes on the "training". The Dutch government do not provide such financial aid but push companies to take part inside Fieldlab, which are composed of other firms (further information about the field lab are provided inside sub-section 2.5.2.2). The exploratory nature of the thesis does not allow to draw some general proposition on this aspect. Therefore further research might shed some lights over the most efficient way of pushing the adoption of Industry 4.0, whether it is the economical way the key to success, or these centres where the knowledge is shared between companies.

Nevertheless, it must not be forgotten that several reasons accounted for the adoption of Industry 4.0. Similarly, many reasons could be responsible for Company E outperforming the others regarding maturity. As already pointed out in the previous paragraph, this could be related to the firm having a clear goal about what to expect from Industry 4.0, and, even more important, its focus on customers perspective allowed Company E to identify the area that needed improvement.

5.3.2 HR Maturity

This paragraph shows the HRM maturity of the companies before Industry 4.0 implementation, and after the implementation, at the moment of the interview. It also provides some considerations that can spread from the analysis of these maturity levels. Before analysing the results of this assessment, some clarification should be provided regarding the method used for addressing the HRM maturity. Opposite to what emerges from the paragraph 5.3.1 review of Industry 4.0 assessment tools, the literature about HRM does not abound in maturity scale. The few scales that exist are also usually focused on the HRM function level, like the one created by Ulrich (1996) which identified four dimensions of HRM: strategic partner, employee champion, change agent and administrative expert. In Ulrich's view, an HRM function do simultaneously all the activities related to the four dimensions, and the purpose of the scale is to understand where goes the majority of the attention of the firm. All this emphasis on the HRM function pushed to reject the use of this scale inside the present dissertation. Many of the companies that were interviewed did not have any formalised HRM function, and in many of these the HR practices were performed as a result of a need.

Furthermore, the size of the companies under investigation is small. Therefore some questions remained unanswered. As partially explained in chapter 2.3, the HRM in manufacturing SMEs lacks many studies that provide evidence about the same effect between MNEs and SMEs. This lack also resulted in a lack of maturity scale that could be successfully used for investigating SMEs. Therefore this criterion also becomes one key point for selecting the proper scale. Moreover, the focus of this thesis was High-Performance Working Practices, and for this reason, a scale that posed too much attention on the HRM function were not ideal for displaying the areas interested by the analysis.

After reviewing other scales related to the HRM, less known than the Ulrich one explained above, the maturity scale proposed by (Kearns, 2012)was found to have a good fit for this research. The scale is composed of nine stages in the maturity of both the HR practices and the HRM function. The first two stages were excluded because they do not apply in today scenario (stage 0 Slavery; stage 1 Sweatshop). The maturity scale is depicted in Figure 56 - HRM Maturity Scale by Kearns (2012), and it shows all the nine

stages. The purpose of this thesis is to answer the research questions, which are concerned with the changes in HRM after the adoption of Industry 4.0. This scale provided by Kearns (2012) matched the research questions by allowing the researcher to have some flexibility in the analysis and not to be bonded to the different labels of the Human Resource Management. Another major point in favour of this scale is the distinction between the reactive perspective and the strategic one.

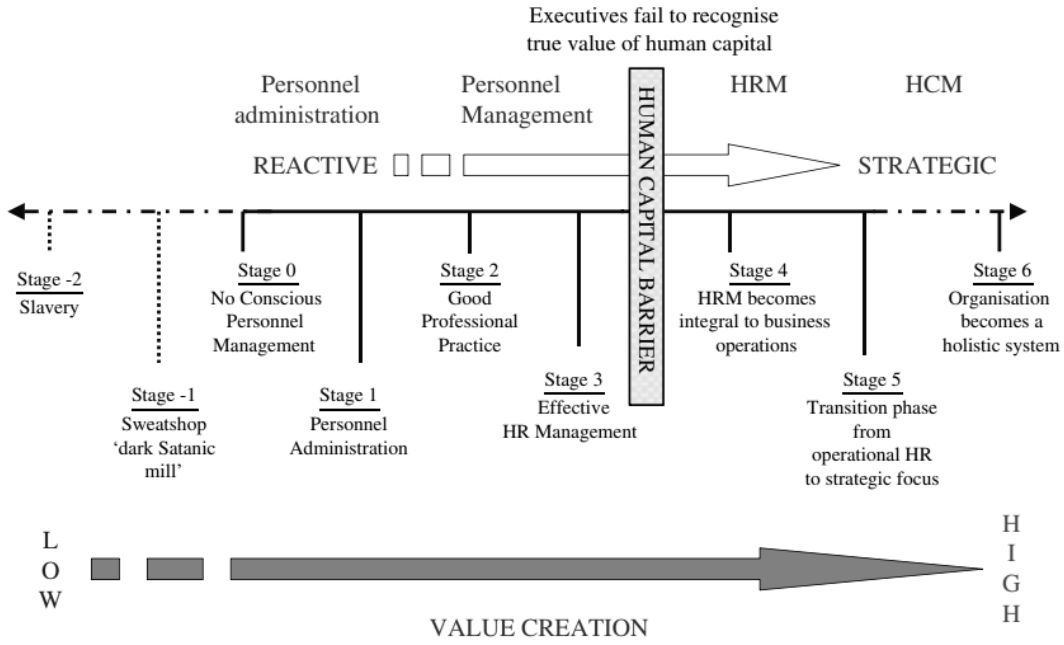


Figure 56 - HRM Maturity Scale by Kearns (2012)

After reviewing and selecting the maturity Scale, it was assessed the maturity of the HRM before the Industry 4.0 and at the moment of the interview. As already explained above, this thesis relied on the HRM side upon the High-Performance Working Practices (HPWP). The HPWP were chosen due to their Universalistic nature and also to allow to conduct an in-depth investigation of companies which do not have and HRM function. The HPWP lack of a standard definition and, more generally, the literature about HRM is divided into supporters of the Universalistic perspective, the Contingent perspective and the Configurational perspective. For this study, as already mentioned, the HPWP were adopted as Pfeffer (1998) formalised them. More than 20 years later, and after many more attempts to define which practices to include in the HPWP, the list provided by Pfeffer is still found to be excellent and parsimonious (Delery, 2017). The seven HWPW identified by Pfeffer are Employment Security, Selective Hiring, Self-Managed Teams,

Compensation Contingent on Performance, Extensive Training, Reduced Status Differences, Extensive Sharing. All of these seven practices were assessed according to the maturity scale designed by Kearns (2012), and for each, a grade between 1 and seven was given. According to the answers provided during the interviews by the respondents, the grade was given by the researcher. By doing so it was possible to avoid any distortion related to companies' bias in self-assessing their maturity. Table 32 contains the maturity levels related to HRM before the Industry 4.0 implementation.

Table 32 - HRM maturity before Industry 4.0 implementation

	CA	CB	CC	CD	CE
Year	2011	2015	2014	2013	2012
E.S.	3	3	3	3	3
S.H.	2	2	2	2	2
SMT	2	2	2	2	2
C.C.	1	1	1	1	1
E.T.	2	2	2	2	2
R.S	2	2	2	2	2
E.Sh	1	1	1	1	1
Average	1,85	1,85	1,85	1,85	1,85

Legenda

E.S. = Employment Security

S.H. = Selective Hiring

SMT= Self-Managed Teams

C.C.= Compensation contingent on performance

E.T.= Extensive training

R.S. =Reduce status differences

E.Sh. = Extensive Sharing

Several considerations can be made from this data. The first of all is related to the HRM function. Out of five companies, only one had an "HR manager", in all the other four companies the HR practices were carried out by the CEO of the firm or the Founder, where this was still running the company. In the case of second-generation firms, this

way of handling the HR practices remain the same in continuity with the habits of the firm. The absence of a dedicated professional in this area could be one of the factors that explain such a generally low level of HRM maturity. About the absence of a dedicated HR manager, it should be pointed out that this is usually the general way of SMEs of conducting business. These firms usually leave all the management tasks in the hand of the CEO/Owner of the company. Therefore the management style in such companies follows the "command and control" (Kaplan, 2005) one. Usually, the creation of the HRM function in these firms is the results of the action of different factors such as the firm's expansion; unsurprisingly, the only firm that has an HR Manager before the Industry 4.0 implementation, is Company D, which is the biggest among the five firms. Despite Company D having an HR Manager, it is not the one showing the highest level of maturity; this suggests the fact that, as pointed out by (Kaufman, 2010), many people working in the employees' management, branded themselves as HR Manager when the HRM label become the most important. Despite this new label, there was no noticeable improvement in the HR effectiveness or the task associated with the HR manager, and neither it was possible to identify differences with the Personnel Manager.

Other considerations could be made from the analysis of the HR practices maturity level. Table 32 shows a generally low level in the maturity of all the HR practices delivered by the companies. The source of such low levels of maturity is related to the reduced interest firms showed about the HRM topics. This issue regularly emerged through all the Within Case Analysis in chapter 4, and in the Cross-Case Analysis performed in section 5.2. Among the generally low level of maturity of the HR practices, some practices showed higher grades: selective hiring and training. These two practices were the most performed due to their salience and visible impact on the firm's life. The other practices such as self-managed teams or employment security did not sparkle the interest of management. Therefore they were performed poorly or not even performed at all.

5.3.2.2 HRM maturity level after implementation

Similarly, to what happened in the previous paragraph with Industry 4.0 assessment, the HR Maturity was also assessed in two moments, the first one retrospectively looked at the maturity level before the Industry 4.0 implementation (Table 32), and it was just discussed above. The assessment of the HR maturity was then performed asking interviewers about how they perform the High-Performance Working Practices today. According to the respondents' answers, it was possible to give grades to all the practices, grades which are depicted in Table 33.

Table 33 - HRM maturity after industry 4.0 implementation

	CA	CB	CC	CD	CE
Year	2018	2018	2018	2018	2018
E.S.	5	4	5	4	5
S.H.	5	5	2	4	5
SMT	3	4	3	3	4
C.C	3	4	2	1	3
E.T.	5	5	4	4	4
R.S	3	2	5	4	3
E.Sh	3	3	1	3	4
Average	3,86	3,86	3,14	3,28	4

The maturity levels of the firm help in defining which were the practices that were more interested in Industry 4.0 implementation, the results are consistent with what was already highlighted in the paragraph about the individual HPWP (5.2.1 – 5.2.6), and they are explained below.

The first conclusion that spread from the analysis is the one related to the general growth of the Maturity level of the HR practices. Once again, it is interesting understanding how and why this happened. One first difference is the one related to the understanding of the importance of the HR practices, while the other is related to the presence of the HR Manager. Regarding the renovate interest in HR, this seems to be related to companies' acknowledgement about the Industry 4.0 effect on employees and

on their way of working, along with some change in the management style/philosophy, which now seems to consider more the employee well-being.

The second factor pointed out, is the presence of an HR Manager. It was already cited many times in this dissertation that SMEs usually do not have such a job position inside the company, and that the related tasks are carried out by the Entrepreneur/CEO of the company. In this case, Industry 4.0 seemed to have pushed the adoption of HR Manager since the attention and time of the CEO were all taken by Industry 4.0 implementation. Moreover, it was not only the lack of time the reason behind the adoption decision, but also the need for keep (or starting) performing high-quality practices. In the previous analysis of the maturity level before Industry 4.0 implementation, it emerged that only one firm (Company D) had an HR Manager. Currently, there is also one other firm that has an HR Manager (Company C) and another one that had associated all the task of the HR Manager to the Sales Manager (Company B). Company A is open to hiring an HR Manager and think this will happen very soon. The only company that does not seems to transition towards the adoption of an HR Manager is Company E. However, this company has a particular governance structure, it has two Directors that run the firm. This diarchy is thus the reason why the pressure of hiring an HR manager is less potent than what the other firms experienced although the implementation of Industry 4.0 is higher than the other companies.

Furthermore, the presence of an HR manager does not directly translate in the delivery of better HR practices: by looking at the maturity level of the firms, it is clear that the two firms showing the lousy level of maturity are precisely the two who have an HR manager. Looking at the reasons of such poor grades, one is related to the just recent adoption of the HR Manager in Company C. On the opposite, as mentioned before, Company D has an HR manager established in their organisational structure since 2008. Despite ten years' time and the Industry 4.0 implementation, these firms do not show significant improvement in the maturity.

Looking at the HR practices, it is possible to identify practices that are more developed than others, as well as the less developed ones. For what concern the most developed, it appears again that Selective Hiring and Training are the central focus of firms' action. One of the reasons for companies' being interested in these two practices, lays out in the effect Industry 4.0 had on the labour market: skills shortage. The firms were able to

increase their production volume, this resulted in a need for new specialised workers to hire, but the skills mentioned above shortage pushed companies in dealing with this problem. As a result, developing more sophisticated HR practices regarding selection/recruiting and training, become of the utmost importance.

The practices that still lack attention from the management are the extensive sharing of financial information and the Reduced in Status Differences, which is consistent with firms not understanding yet the value of these practices, which is reinforced by the absence of an HR manager. However, claiming that the practices under looked are the results of not having an HR manager, it would be too easy and far from the truth. Several other factors enter the game, such as the firm culture, which was already shown in the previous paragraph playing a crucial role in supporting the implementation. The firm culture also accounted for the resistance of the management in retaining information about the financial performance of the firm and the individual performance of the employees. Regarding the Reduced in Status Differences is interesting to note the drawback of Company B, which was the direct result of the time allocated by the management in enforcing the Industry 4.0 implementation, which pushed the management to stop this activity which was felt unnecessary.

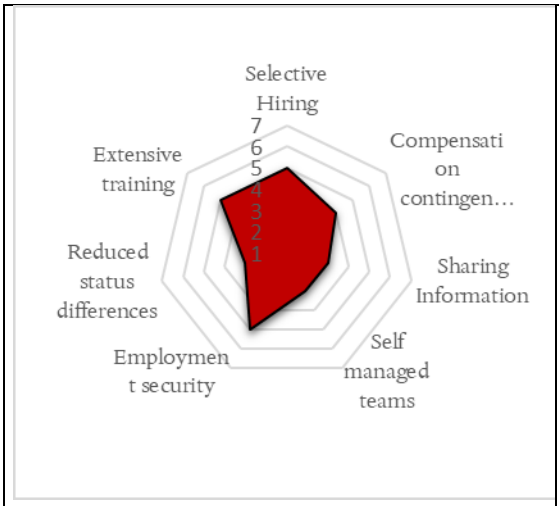


Figure 57 - Company A HR practices maturity

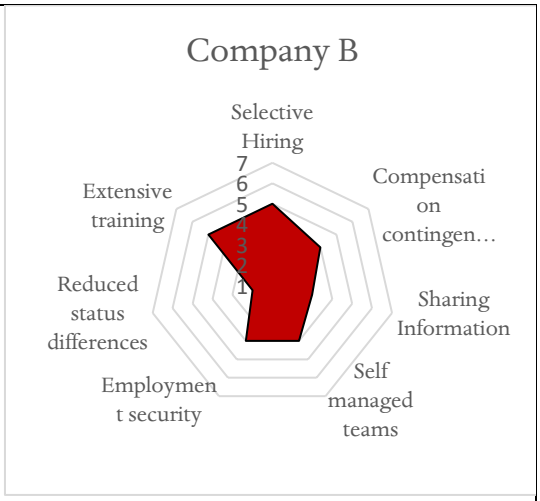


Figure 58 - Company B HR practices maturity

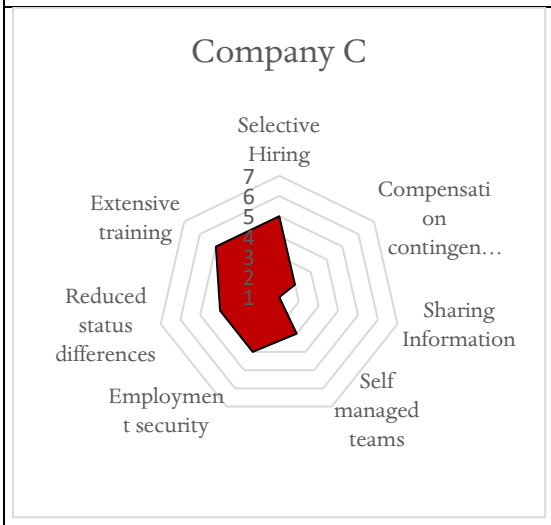


Figure 59 - Company C HR practices maturity

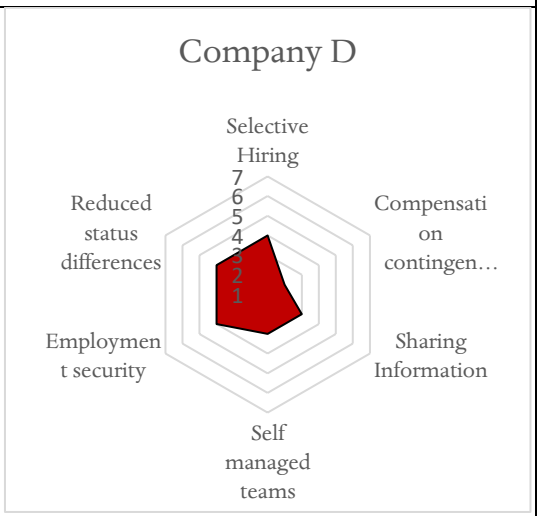


Figure 60 - Company D HR practices maturity

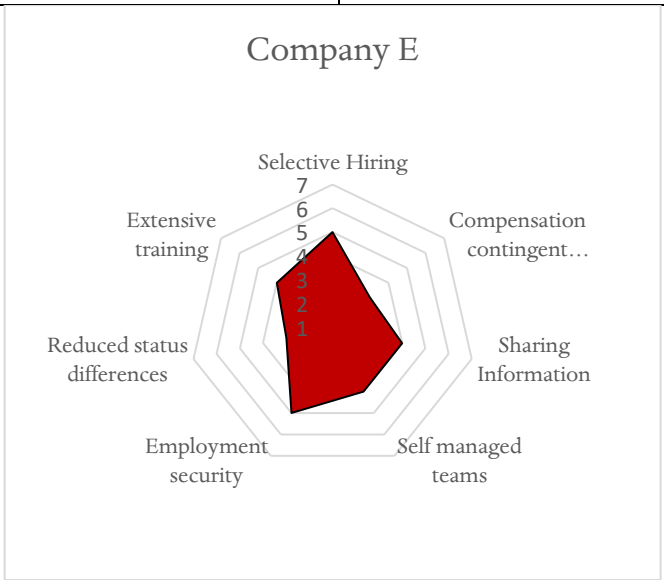


Figure 61 - Company E HR practices Maturity

5.3.1.3 Industry 4.0 Radar of the companies

In order to give a better picture, and a visual representation of the maturity levels of the firm, related to the Human Resource Management (HRM), Figure 57 to Figure 61 depicts the radar of the companies. The radars have the shape of a heptagon; every angle represents one of the seven High-Performance Working Practices, that were assessed using the HR Maturity scale designed by Kearns (2012); the stages that composed this scale were shown in Figure 56 - HRM Maturity Scale by Kearns (2012). Since the radar does not show the full name of the six dimensions, here it follows the name of the HPWP: Employment Security, Selective Hiring, Self-Managed Teams, Compensation Contingent on Performance, Extensive Training, Reduced Status Differences, Extensive Sharing.

The radars showed in the previous page support the considerations given until now about the impact of Industry 4.0 upon the HRM, and thus allowing the identification of the most used and influenced HR practices. From a visual point of view, it becomes even more clear that when it comes to HR practices in manufacturing SMEs, firms still have a long way to go. The reason for the low score was already pointed out in the previous paragraph and is generally related to several factors, such as the lack of an HR Manager. Considerations about Company C and Company D, the only two firms with a formalized HR Manager, were already provided in the previous paragraph. Figure 59 and Figure 60 show a low level of implementation of the HR practices inside these two companies, which is the lowest among the five companies studied in this dissertation. The three other firms are not in a completely different situation, and their situation fit the motto "*if Athene cries, Sparta does not laugh*". Their practices are indeed more mature than the other two, but the differences are not so significant. Employment Security, Selective Hiring and Extensive Training are the ones that are generally more mature. These three companies also have better grades in the remaining HR practices namely: compensation contingent on performance, sharing information, self-managed teams and reduce status differences. The superior performance in these areas does not find legitimacy in the strategic decision of the management, which almost in every firm keep holding back the development of these practices. Management usually does not find these practices attractive or capable of adding value to the companies. In case of the Reduce Status Differences, this topic was usually perceived as one issue that interest bigger corporation

instead of Small and Medium Enterprises. In such a perspective, the decision of company B of stopping the social events aimed at boosting the inclusion of their employees comes with little surprise.

Another consideration should be made about the topic that generally interests the SMEs. Industry 4.0 seems to be one of the factors determining growth in the maturity of the HRM, or at least one of the factors that speed up this process. Besides this, the topics discussed, the general resistance in the adoption of certain HR practices, are not so significantly different from regular SMEs. In other words, SMEs that are growing and do not come prepared for the growth, not having a structured HRM function.

5.3.3 Framework

This chapter provided considerations about the Industry 4.0 in manufacturing SMEs, and in particular, highlighting the effect this implementation had on HRM. Related to HRM, in this chapter all the seven practices belonging to the High-performance working practices (as formalised by Pfeffer, 1998) were illustrated and, results were provided in the previous paragraphs. Furthermore, this chapter contains table related to the maturity levels of implementation of both the Industry 4.0 and the HRM. The assessment was conducted before and after the industry 4.0 implementation; due to time limitations related to the Ph.D. linked to the writing of this thesis, the assessment related to the situation prior to the Industry 4.0 implementation, was conducted retrospectively, more information about this choice was provided in chapter 3.1.3, which accurately focused on retrospective longitudinal case study. The data collected allowed to assess the maturity and to display these levels in four tables (Table 29, Table 30, Table 32, Table 33).

Moreover, these levels were used for supporting the considerations emerged previously about the change in the HRM after Industry 4.0 implementation. In a further attempt to strengthen the findings emerging from the Cross-Case analysis, this chapter also displays the radar with the maturity of the companies. It was provided for each firm two radar, one focusing on the Industry 4.0 and another one with the HRM maturity. The radar, once again, supported the findings, especially in visualising in a friendly manner the way in which Industry 4.0 impacted. It was also easier to identify the HR practices that were more influenced.

The current paragraph provides a framework that was created from the analysis already conducted and from the assessment performed. The Framework is depicted in Figure 62, its aim, once again, is to facilitate the identification of the impact Industry 4.0 had on the manufacturing SMEs. On the Horizontal axis, the framework shows the maturity of the HRM practices, which range from left to right, from low to high. On the vertical axis is displayed the maturity of the firm related to their implementation of Industry 4.0. The lower on the vertical axis a company is positioned, the lower is its maturity; similar to the horizontal axis; this one also ranges from low maturity to high maturity. The calculation of the two dimensions was obtained from the grades resulted from the maturity assessment. In the case of the horizontal axis, the one related to HRM, the axis was dived in 7 parts; each firm was positioned in the axis according to the average grade firms had in the assessment. The vertical axis was divided into five parts, and companies were collocated here according to the average of their grades related to the Industry 4.0 implementation. In conclusion, each company position inside the framework depends on two variables: the average of the HRM practices maturity, and the average of the Industry 4.0 implementation. Since the assessment about the maturity also included the situation before the adoption of Industry 4.0, the framework also depicts the firms' maturity before the implementation.

The created framework (Figure 62), shows the situation of the companies before the industry 4.0 implementation and at the moment of the interview, in 2018. The framework supports the identification of a shift that resulted in the implementation of Industry 4.0 and HR maturity. Despite a growth in the maturity of these two dimensions, the maturity of the Industry 4.0, in proportion, grew more than then HR maturity. Such a difference could be related to the firms focusing on the topic of Industry 4.0 adoption, and therefore it gives back the idea that managers were less worried about HRM issues, which is consistent with what emerged during the Within Case analysis and the Cross-Case analysis, about the main concerns of CEOs.

Moreover, inside the framework no firm moves along the horizontal axis so much that can reach the right quadrant, meaning a more robust maturity of HRM.

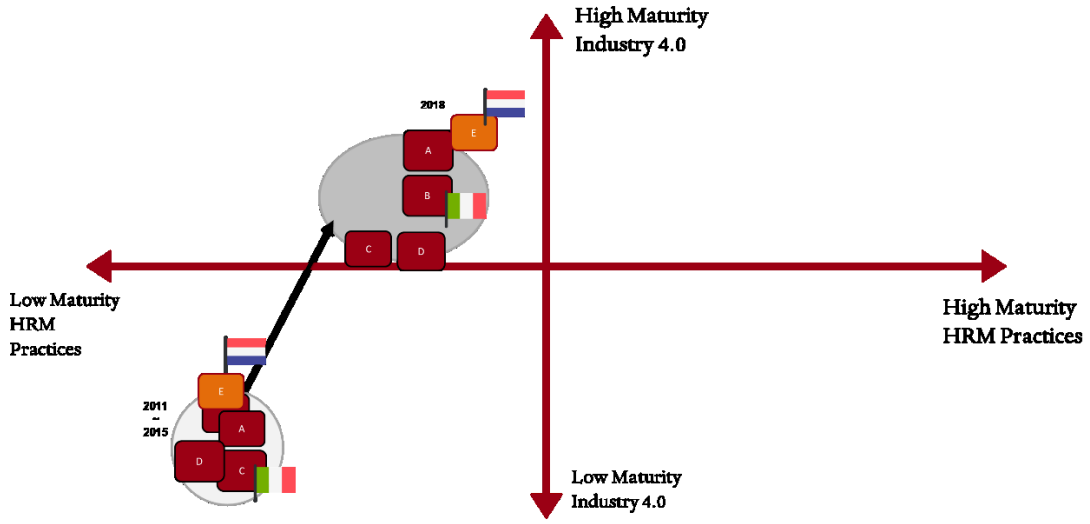


Figure 62 - Framework

All the companies remain on the left side, labels provided by Kearns suggest practices that are performed on this site are conducted in a "reactive" way. The fact that some companies performed some HR practices strategically give the idea that it is still not enough and therefore much more effort should be put by companies in improving their HR function. It should also be underlined that the moment of analysis (2018) does not coincide with the ending of the Industry 4.0 implementation for these companies. The framework clearly shows that firms improved their maturity, but even here the company have still a lot to do.

For this reason, further researches are needed to explore fully 4.0 companies and to check if this further developed the maturity on the HRM side. During the Cross-Case analysis, it emerged more than once that companies were looking at Human Resource Management Information System, as a vital tool for improving their management of employees. Therefore, further study could investigate if the company that introduced such a system, also improved other areas.

5.4 Main evidences

Small and medium-sized enterprise are usually characterised for not having an HR department/function, with all the duties belonging to the HR function carried on by the entrepreneur/CEO/founder of the company. In literature, this situation is quite

reasonable, and usually, HRM function develops over time, as a response to the increasing size of the firm (Pittino, Visintin, Lenger, & Sternad, 2016). The manufacturing nature of the companies and the constant focus on the production's efficiency highlight the fact that employees are necessary, but the management style is still far from viewing employees as a source of competitive advantage, which is one of the philosophical pillars of the Human Resource Management. Despite changes in the view and management inside Industry 4.0 companies, Personnel Management is the primary approach, as it emerges from the companies' disposition inside the created framework. Moreover, it was identified by the analysis of the maturity level that firms shifted from Personnel Administration to Personnel Management. Therefore, this brings to the first proposition identified

PP1: Personnel management is the favourite approach in managing employees in Industry 4.0 SMEs manufacturing companies.

Industry 4.0 created challenges and opportunities for all the firms and usually resulted in improved performance of the firms and growth in the production volume. The most evident effect is a direct consequence of its implementation: Industry 4.0 requires, among all, sensors, connectivity and software. This result in an increased ability of the companies for collecting data, which is an enabler for the implementation of Human Resource Management Information Systems (HRIS). Many companies showed that they were thinking of implementing or already implementing, an HRIS integrated with the various other software, that could allow management to use such information gathered. In particular, the HRIS implementation seems to be the nexus that allows companies to deliver better and more efficient HR practices. Thus, this leads to the identification of a second proposition:

PP2: The collection of huge amounts of data is pushing companies to adopt integrated information systems. These systems create a favourable context to the implementation of the electronic human resource management tool.

Furthermore, Industry 4.0 implementation created a *domino-effect* that impacted on the HR function, creating in some occasions the need for having dedicated HR Manager in the company. One of the main reasons for this necessity lays in the amount of time and focus needed by the industry 4.0 implementation. Such massive demand in SMEs, lead to a drastic reduction of CEOs and managers time for delivering HR practices by themselves. Thus, this leads to the identification of a third proposition:

PP3: The use of industry 4.0 technologies favours the switching from an informal and unstructured HRM department to a more formalised one.

The skills shortage in the labour market pushed companies in re-thinking the way in which they were performing HR practices. Companies changed their behaviour and attitude switching from performing practices in a reactive way to a more strategic one; this leads to the identification of the fourth propositions:

PP4: The use of industry 4.0 technologies favours the switching from HRM practices performed reactively, to a new stage in which those practices are performed more strategically.

From the within case analysis performed in the previous chapter and the cross-case analysis of this chapter, emerges clearly that companies are not thinking of adopting HR practices as a bundle or mini bundle. Companies are often missing a clear strategy about people which is often caused by the absence of dedicated HR Manager. Their practices' implementation is more the results of a necessity instead of planned activities. Some practices (e.g. Hiring) are needed in order to guarantee the survival of companies, therefore it is performed without any strategic reasoning. The literature about the High-Performance Working Practices acknowledged this possibility since firms did not put much attention to HRM topics in the '90. Pfeffer (1998) strongly suggest companies that these HR practices have more positive effect when they are combined rather than used individually or sequentially. One of the main reasons behind this lack of unitarity vision dwell in the lack of HR Manager or, more broadly, of a real HR Strategy. Thus, this leads to the identification of a fifth proposition:

PP5: High-Performance Working Practices are adopted individually.

Focusing on the HR practices, this chapter extensively showed how Industry 4.0 impacted on some practices more than others. The red alarm for companies comes in the visage of the skills shortage. This topic drew much attention, with companies putting many efforts in reinforcing these practices and try to perform them in the most effective, and efficient way possible. The two most affected HR practices appear to be Extensive Training and Selective Hiring, which are, as pointed above, two practices that are affected by the Industry 4.0 and the skills shortage. Selecting and recruiting employees became more complicated and time-consuming. For ensuring an efficacious selection, this process was often outsourced to recruitment work-agency, but the skills required were almost impossible to find. This pushed companies into being creative and problem solving, with some of the firms signing a partnership agreement with high-schools and universities in order to overcome the skills shortage. Extreme reaction of this *domino-effects*, the recruitment leads to a not satisfying outcome, which put much attention in the training system. Firms looked at a way of improving the effectiveness of the training, especially because many firms grew in their employees' number and production volume, which pose the necessity of providing high quality training while keeping the production on time and efficient. The answer to this problem came in various form, however, the most critical driver to improve such process was the HRIS, with companies being able to assess the competency levels of the employees and to deliver targeted training, while also use e-learning. Some companies specialised so much in the training that decided to open "Academy" even to customers or other figures. This led to the identification of the sixth and final proposition.

PP6: The use of industry 4.0 technologies favour the development of some High-Performance Working Practices. Training and Recruiting of the talent prevail in order to overcome the skills shortage of the investigated SMEs.

6. Discussion and conclusions

6.1 Overview of the chapter

This chapter resumes the insights of this thesis by recalling its aims and clarifying which were the research questions and how they were addressed. It also provides the propositions that were identified for answering the research questions. Moreover, this chapter proposes some comparisons between these findings and previous literature. The contributions of the thesis to the academic literature and managerial implications are also provided. In the end, the value and originality of the study are presented, as well as research limitations and opportunities for future research.

6.2 The thesis objectives and main findings

This thesis investigated the impact Industry 4.0 had on manufacturing Small and Medium Enterprises, mainly referring to the management of employees and their crucial role in the Industry 4.0 context. Among all the different forms of Human Resource Management (HRM), this dissertation relied upon the High-Performance Working Practices (Pfeffer, 1998) for better investigating the topic of Industry 4.0. The HPWP were adopted for two main reasons: their Universalistic nature and the fact they are well established in the literature. More than two hundred publications focus on HPWP. However, as already mentioned in this thesis, only a few studies analysed the HPWP in SMEs, even fewer on manufacturing SMEs. Despite the general lack of study, HRM extensive literature shows how it affects organisations in several ways, such as: improve organisational performance, improve employee well-being or supporting changes in the production (e.g. introduction of environmental management). About the importance of HRM practices to successfully implement some production model, the literature (Jabbour, 2017) identified some HR practices as more important than others. Therefore this reinforced the decision about the adoption of the HPWP, which are: Employment Security, Selective Hiring Comparatively High Compensation Contingent on

Performance, Extensive Training, Reduced Status Differences and Extensive Sharing of Financial and Performance Information.

To study the impact of Industry 4.0 on manufacturing SMEs, and in particular, on the HRM, three literature reviews were conducted. Usually, one literature review is enough for understanding the theme and framing the research. However, in this case, the topic's novelty did not provide analyses addressing the issue of Industry 4.0 and HRM together. Evidence was also lacking about HRM in SMEs generally, and even more in manufacturing SMEs. For this reason, to provide a strong basis for this dissertation, three literature reviews were carried out and the related gaps finding, reported in chapter 2.

Reviewing the literature, it was clear the substantial impact of Industry 4.0 on HRM due to its disruptive nature. Even if the definition of Industry 4.0, as its consequences, do not have unanimous agreement in the literature, there is clear evidence of its impact on the way in which employees work, therefore needing more assistance from the HR function. However, the research available on the topic, especially in manufacturing firms, do not pay much attention to the HR function's role. Usually, the focus is on the HR practices and not on the kind of HRM approach/model adopted by the companies. Furthermore, Industry 4.0 is expected to have a severe impact on the HR function. A natural question is whether this phenomenon produced a shift in the approach adopted by the HR function.

As mentioned earlier, literature in the manufacturing area poses some attention about the HRM practices, for this reason identifying the HR practices carried out in manufacturing SMEs adopting Industry 4.0 become one of the aims of this dissertation.As mentioned earlier, literature in the manufacturing area poses some attention about the HRM practices, for this reason identifying the HR practices carried out in manufacturing SMEs adopting Industry 4.0 also become one of the focus of this dissertation.

The literature review identified essential research gaps and supported the identification of the three main research questions below:

RQ1: What is the approach used for managing employees in manufacturing SMEs that are implementing industry 4.0?

RQ2: What is changing in managing employees after the adoption of Industry 4.0?

RQ3: What are the main practices about managing employees in Industry 4.0 manufacturing SMEs?

The poorness of research on the topic of Industry 4.0, along with the lack of publications investigating together Industry 4.0 and HRM, pushed for conducting a qualitative analysis. For this purpose, the research questions above were examined using multiple case studies.

Several propositions were drawn along this thesis. Themes such as training and sharing of best practices must be encouraged, the research questions and the related propositions are further explained in more details below. Moreover, the first research question spread from Industry 4.0 disruptive nature, which should change the way employees are managed. Therefore, questioning what the primary approach adopted by Industry 4.0 companies is.

RQ1: What is the approach used for managing employees in manufacturing SMEs that are implementing industry 4.0?

In order to answer the first research question, the researcher conducted Multiple Case Studies, that were analysed according to Yin (2009) Within Case Analysis and Cross-Case Analysis. The dissertation established all the tactics intended by Yin (2009) to build and analyse case studies effectively. Further information about the methodology and precautions used are contained in chapter 3. The results of this analysis are showed in chapter 4 for what concerns the Within Case Analysis, and in Chapter 5 for what concern the Cross-Case analysis. The use of these two methods allowed to investigate the single organisation in depth, and also to compare the different impact Industry 4.0 had on companies. Therefore, related to the first research question, it was identified "Personnel Management" as the main approach in managing employees inside Industry 4.0 manufacturing SMEs. The identification was also supported by the maturity scale used

(Kearns, 2012), which allowed to build the framework shown in Figure 62. Therefore, this led to the identification of the first proposition.

PP1: Personnel management is the favourite approach in managing employees in Industry 4.0 SMEs manufacturing companies.

The nature of the study is exploratory, and thus it pushes for understanding the phenomenon of Industry 4.0, which emerged in literature as a disruptive one. For this reason, the second research questions interrogate about the nature of the shift Industry 4.0 produced on manufacturing SMEs, always related to the Human Resource Management.

RQ2: What is changing in managing employees after the adoption of Industry 4.0

From this second research questions, several propositions were identified. The first one spread from a direct consequence of Industry 4.0 implementation: organisations became fully equipped with sensors, connectivity and software. This technological innovation along with the need created by the Industry 4.0 implementation, pushed companies to collect and use information about employees. Implementing a Human Resource Management Information Systems (HRIS) was indeed facilitated by Industry 4.0. However, some companies were already thinking about implementing an HRIS, in order to deliver better practices. Thus, this led to the identification of a second proposition:

PP2: The collection of huge amounts of data is pushing companies to adopt integrated information systems. These systems create a favourable context for the implementation of electronic human resource management tool.

Delivering better practices is also the focus of the third propositions. Industry 4.0 main issue was the creation of a skills shortage in the labour market, both internal and external. This pushed firms to think more about the HR practices. SMEs generally do not have an HR function, and this was also the case with almost every firm analysed. However, some

HR function must be delivered regardless, because they are related to the survival of the firm, for this reason, the person who carried out the HR practices is generally the founder of the firm. Industry 4.0 implementation impacted on who performed these managerial practices, shifting from everything in the hands of the CEO to allocating the delivery to these practices to brand-new HR manager. However, the solution of paying more attention to the HR issues did not translate into hiring an HR Manager: only one firm hired a new HR Manager. Consequently, the third proposition is related to the formalisation of the HR function inside these companies, as a result of the Industry 4.0 implementation.

PP3: The use of industry 4.0 technologies favours the switching from an informal and unstructured HRM department to a more formalised one.

As mentioned above, companies' gained interest in the delivery of good HR practices. However, this did not lead to the employment of an HR manager. The Industry 4.0 impact on this issue seems lower than the impact it had on the HR practices since only one company hired an HR manager after the Industry 4.0 implementation. The reasons behind firm holding back on HR manager is related to the culture of these firms. However, not having an HR manager does not mean not having HR practices. Mainly because the most dramatic impact of Industry 4.0 is the creation of a broad skills shortage that pushed SMEs to shift their vision of how to perform the practices. This is especially true for practices such as training and recruiting. Performing practices as a reaction to necessities, do not allow the firms to pursue the industry 4.0 implementation since many employees do not come with the proper technical skills.

PP4: The use of industry 4.0 technologies favours the switching from HRM practices performed reactively, to a new stage in which those practices are performed more strategically.

The last research questions dealt with the HR practices and sought to identify the central practices adopted by manufacturing SMEs that were implementing Industry 4.0. While having a substantial value as an academic contribution, this research question was

also identified to provide support to practitioners, by showing them the most affected HRM practices and what HR practices adopted Industry 4.0 companies in order to secure the implementation.

RQ3: What are the main practices about managing employees in Industry 4.0 manufacturing SMEs?

For answering this third research questions, the use of multiple case studies and the analysis performed in the Within Case and the Cross case were crucial. It was already pointed out that in order to support the investigation and the subsequent analysis, as well as the maturity assessment, were adopted the High-Performance Working Practices as identified by Pfeffer (1998). The rationale behind this adoption is related to the Universalistic nature of these practices and the fact that they are well established inside the literature. The first conclusion that is possible to draw on this topic is that the HPWP are adopted singularly. The literature about HPWP suggests using these practices as a bundle, in order to create a positive effect on companies. Despite these suggestions, SMEs seems to have still to improve their knowledge about HRM. The singular adoption of the HPWP is related to the poor formalization of the HR function and to the fact that the business is still conducted on sight, dealing with contingencies one at time; however evidence about the effect of Industry 4.0, suggest that this phenomenon is changing this way of managing employees, especially in firm with a higher level of maturity.

PP5: High-Performance Working Practices are adopted individually.

Until now the dissertation as provided strong evidence about the Industry 4.0 impact upon manufacturing SMEs, and how this also resulted in an impact on the HRM function. The HRM function becomes more structured than before the adoption of Industry 4.0. The HR practices performed more strategically. However, the real formalisation of an HR strategy is still far. It also emerged that the HPWP are adopted singularly, which stress the fact that firms do not have a clear vision about the HRM issues and that manage these issues as a result of the Industry 4.0 implementation. Moreover, some companies

paid attention to their employees well-being, and thus some practices such as the compensation contingent on performance were not fostered.

Focusing on the HR practices, chapter 4 and chapter 5 showed for each company how the practices were performed, highlighting the impact of Industry 4.0 on those. In particular, two HR practices emerged as the most affected by Industry 4.0: Extensive Training and Selective Hiring. As already mentioned above, these practices are so important because Industry 4.0 created a skills shortage that pushed companies to think "more strategically" about the HR practices. In other words, hiring only when needed would not allow the firm to have the time for training employees. Moreover, industry 4.0 increased the production volumes of the firm, therefore resulting in company hiring up to 50% of their workforce.

Regarding the Selective Hiring, companies showed changes in the way this practice is carried out. In particular, before the Industry 4.0 implementation, the selection was pretty simple and straightforward. The preferred methods were word of mouth and spontaneous application. After the Industry 4.0 adoption, firms acted in different ways: they relied more on the services offered by recruiting agencies, headhunters and even more critical, signing a partnership agreement with high-schools and universities. The partnership allowed to limit the cost associated with this process and also allowed to overcome the skills shortage.

Extensive Training is another HR practice that experienced some significant impact from Industry 4.0. The issues that pushed firms' attention towards training are the skills shortage and the increase in the production volume. Despite firms improved their ability to select the right people, the skills shortage did not allow to find employees easily. Even the partnership did not have the desired effect. Therefore, companies looked at the training system as a way to solve the problem. Paying more attention would have also supported firms' preference for selecting candidates according to their soft skills over hard skills. However, the increase in the production volume urged companies to be effective in the training for two reasons: increase in the unskilled employees' number, the necessity to meet the production deadline. The introduction of an HRIS and the adoption of competencies assessment tools were adopted in order to deliver better practices. Therefore, this is the last propositions identified by this dissertation:

PP6: The use of industry 4.0 technologies favour the development of some High-Performance Working Practices. Training and Recruiting of the talent prevail in order to overcome the skills shortage of the investigated SMEs.

6.3 Contributions to theory

The overall contribution of this thesis, due to its exploratory nature, is related to expanding the comprehension of the Industry 4.0 phenomenon, providing evidence about the Industry 4.0 impact upon manufacturing SMEs, a topic that is still not well investigated by the literature. The first contribution was shedding light on this phenomenon, and for this reason, three literature reviews were conducted which provided insights on the topic. One of the three literature conducted paid attention to the different labels of Industry 4.0. Moreover, it sought to understand if this phenomenon was a concept labelled in different ways.

This dissertation provides academic and practical contributions, by conducting multiple case studies and by analysing the related findings, the first main academic contributions include the design of a conceptual framework, that was depicted Figure 62, that is now presented below for easily recall the image. The framework allowed the identification of a shift in both the maturity of the HR practices and the Industry 4.0 implementation. Such a shift suggests that firms investing in Industry 4.0 are also improving their HR function. These improvements come in different forms: formalising the HR function, hiring an HR manager, performing the HR practices more strategically and allow professional to deliver these practices (e.g. recruitment agency).

Secondly, the second theoretical contribution is the identification of the increasing role of the human resource management inside manufacturing SMEs that are adopting Industry 4.0. However, despite the dramatic expectations, Industry 4.0 impact was not so disruptive. Supporting this claim is the fact that firms still have low maturity levels related to their HR function.

6.4 Managerial Implications

Along with theoretical contribution, this thesis provides useful managerial implications. The practical applicability of the findings was at the base of all the research, according to a quotation often attributed to Marx *"practice without theory is blind, theory without practice is sterile".* Therefore, the main managerial implications are the definition of which HR practices are most affected by Industry 4.0 implementation and what companies are doing to improve them. The Within-case analysis and the Cross-case analysis allowed the identification of these HR practices. Almost every company put much emphasis on the delivery of the Selective Hiring and the Extensive Training. Manufacturing SMEs who plan to adopt Industry 4.0 can benefit from the findings of this thesis, knowing that the skills shortage produced in the labour market by Industry 4.0 will push them to carry out practices in a more strategic way. Recruiting employees with the proper technical skills will become significantly harder.

For this reason, along with an improved Hiring process, they should pay attention even to training, because the Industry 4.0 implementation leads to increase in the production volume, which leads to the necessity of new workers. Companies addressed these two practices by outsourcing more the recruitment, and by signing a partnership with high school and university. No significant difference between workers in line and staff employees were found to be related to industry 4.0, while the differences and limitations spread more from the production model adopted by the firm and to the need of meeting production deadline. Furthermore, manufacturing SMEs that plan to invest in Industry 4.0 implementation should welcome the adoption of integrated Human Resource Management Information System (HRIS). The introduction of this system is a direct consequence of the work conducted to transform the firms into Industry 4.0 ones, due to all the sensors and software that were installed in companies.

6.5 Limitations of the study

Despite the above-discussed implications for both academics and managers who wish to adopt Industry 4.0 inside manufacturing SMEs, this dissertation also has some limitations. These limitations are discussed below.

The first limitations deal with the lack of literature. This thesis contains three literature reviews. Despite all the efforts in ensuring an outstanding reviews processes, evidence from Industry 4.0 was mostly coming from conference papers, and therefore they were excluded from the analysis in order to keep only reliable results in this dissertation.

The second limitations are related to the number of case studies conducted. In this thesis, data were gathered from five enterprises, four Italian and one Dutch. To carry out a qualitative study the literature suggests different numbers of cases. Yin (2009) strongly suggest conducting multiple case studies. Moreover, he pushes for avoiding as much as possible the use of a single case study, due to the lack of analytical generalizability. Eisenhardt (1989) suggest four case studies to be the minimum for conducting effecting multiple case studies. In general, there could be endless elements of contingency for HR practices. Hence five cases cannot provide full evidence of how industry 4.0 affect HRM and the High-Performance Working Practices, despite different companies and in different countries have been considered.

The third limitations partially spread from the first one already discussed: the generalizability of the findings. The propositions identified as well as the framework need further investigation in order to gain generalizability. The reason why this should be done is related to the small sample size used in this dissertation. For achieving the analytical generalizability, further research could focus on conducting another qualitative study which spread from the propositions identified in this dissertation and identifies rival explanations (Yin, 2009) to test. Considering opportunities for future research, industry 4.0 is an emerging area of research interest and the study about HRM lacks, especially in SMEs. Moreover, the study relies on case studies coming from 5 SMEs, one of the companies investigated is Dutch. Due to the fact this is the only organization from that country that was analysed, it is not possible to derive conclusions from the country difference.

The fourth limitations are related to the approach adopted in this dissertation, which uses the whole firm. Interviews were conducted with several respondents in the management of the firms; despite these interviews with key informants knowing about industry 4.0 implementation and HRM management, not all partners have been interviewed. Interviews with regular employees, intended not in management positions, could have led to different views about the impact of Industry 4.0 in the organisations, and especially understanding how the HRM affect employees.

Although the limitations explained above may worry the readers about the overall weaknesses of the dissertation, these weaknesses are also the strength of this research. The definition of the thesis' structure happened well understanding that the novelty of the topic would not allow gathering reliable information quickly. This pushed to use several limitations in selecting papers and to conduct three literature reviews. Such limitations favoured the inclusion of numerous contributions belonging to different research streams and, consequently, could support the identification of a wide range of themes useful to the development of the framework depicted in Figure 62.

6.6 Opportunities for future research

This dissertation provides findings that represent future research opportunities. According to the primary results spreading from this work, future research may be useful to investigate empirically, the findings of this dissertation. Future researches, as mentioned briefly in the paragraph about the Limitations of the study, the framework depicted in Figure 62, and the identified propositions should be the focus of further case studies that should explore them, test them or even improve them.

The industry 4.0 implementation should require further research due to its complexity, especially its impact on HR practices. It would be interesting and useful to investigate the impact of Industry 4.0 over time. This has been done partially in this dissertation by conducting longitudinal case study retrospectively. However longitudinal case studies would allow gathering in greater details the impact of Industry 4.0 on HRM. Furthermore, a clear definition of the concept of Industry 4.0 also needs to be investigated. The proposed framework representing the industry 4.0 and the HRM maturity of the practices provide the basis for further investigation.

In particular, the framework could be used in order to understand whether other firms also grow in both the HRM maturity and the Industry 4.0 maturity. A more detailed in-depth study of industry 4.0 and its impact on HRM, which combines both qualitative and quantitative methods will support the propositions that were identified in this dissertation. Furthermore, this thesis identified some difference in the implementation of Industry 4.0 according to the country of implementation; further researches should be conducted at an international level, while quantitative study could further test the propositions provided. To achieve statistical generalizability quantitative data should be collected in more than one way. This would result in the reliability increase of the identified framework. This could be replicated across a different time span with different Small and Medium Enterprises, in the same business sector or different ones.

Further investigation is required regarding specific organisational and managerial factors in industry 4.0 implementation, as well as interrelations between them. For example, employee well-being seems to be attracting attention in firms that are implementing Industry 4.0 despite the literature about the implementation of other production model did not show the same interest. Understanding the development of the employee well-being according to the strategic choices, as well as the role played in the different phases of the industry 4.0 implementation could be intriguing and could provide practitioners with a set of practices to use when adopting Industry 4.0 that enhance the well-being of the workers.

The CEO and HR Manager were two relevant actors, this dissertation provided evidence about the increase delegation of the HR task, shifting from the CEO to the HR manager, or directly outsourced in those firms who did not hire an HR Manager. Further investigations could check if this way of proceeding keep even after the industry 4.0 implementation is concluded since one of the main reasons for the shift can be attributed to the CEOs' lack of time, since they were focusing on the implementation project. Moreover, SMEs increased their HR maturity; further research could assess if this development kept going leading to the establishment of a fully operative, and strategic, HR function.

Industry 4.0 has several repercussions on the organization and on the HR function as well. In particular, as highlighted in Proposition 4, Industry 4.0 boost the adoption of the HRIS since to become a fully operating factory requires the collection of several different

data about the machines, and employees as well. Therefore, future research is also needed in the area of Trade Unions regarding data privacy and protection rights.

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"E quindi uscimmo a rivedere le stelle"

Dante Alighieri, Inferno XXXIV, 139

"And thence we came forth to see the stars again."

Dante Alighieri, Inferno XXXIV, 139