A Study on the Impact of the Fourth Industrial Revolution and Big Data on Human Resources in Italian Companies

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Abstract The Fourth Industrial Revolution poses new challenges and increasing market competition for human resources required with new skills. This chapter examines the impact of Big Data on Human Resources in 38 companies and 3 universities in the Emilia-Romagna region. Companies were divided into two main groups: leading companies in the region that use or produce Big Data and Analytics and Information and Communications Technology (ICT) companies that offer services related to Big Data. Through interviews and questionnaires, it was possible to identify certain challenges faced by companies and territorial strategies required to improve the skills and retain their human resources. This includes the need to channel and adequately blend tacit knowledge with the new codified knowledge born out of the enabling technologies, to increase employee loyalty and membership towards the company to minimize attrition to competition.

Keywords Fourth Industrial Revolution · Big Data · Human resources · Competences · Skills · Training · Tacit knowledge · Codified knowledge · Loyalty · Membership · Corporate Academy · Emilia-Romagna · Italy

1 Introduction

Today, the tug of war between man and machine is undoubtedly a risk to the employment of low-skilled human resources. Since ancient times, the relationship between technology and work has been conflicting. While the discovery of inanimate sources of energy solved the issue of human and animal fatigue, the invention of simple or articulated machines has placed people's occupations at risk. Technological unemployment has ancient roots. Around year 1000 in Italy, watermills were introduced

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in the process of fulling cloth, which was earlier performed by workers. One mill replaced more than 40 hands. A few centuries later, in France, this led to popular uprisings of workers against the construction of mills. However, this opposition proved futile and the mills not only spread rapidly but to other fields such as, iron production, sawmills, and paper production (Cipolla, 1995).

The biggest side effect of "modern" unemployment technology is its structural effect, which has gradually grown over time. When water mills was introduced, the workers who used to full cloth were able to find a new occupation. However, peasants lost their jobs in the fields because of the introduction of machines. This reminds us of the most important change highlighted in the third edition of the Principles of Political Economy and Taxation by David Ricardo (1817, 2015), as Sraffa (1951) recalls, which is Ricardo's change in opinion concerning the introduction of machines. While in the first edition the introduction of machines was considered beneficial for all social classes, in the third edition he believes that the use of machines is often detrimental to the interest of the working class. However, the large-scale introduction of machines will require a new workforce to manufacture the machines themselves. Since peasants removed from the fields due to machines could not easily become engineers, blacksmiths or carpenters, this job loss created imbalances in the labour market. If machines lead to unemployment in the agricultural sector, the supply chain of machine manufacturing grapples with a labour problem to cope with the massive increase in demand. As John Maynard Keynes stated in the Economic Possibilities for Our Grandchildren (1930), we are being afflicted with a technological unemployment. This means that unemployment due to the discovery of means of economizing the use of labour, is outpacing our ability to find new uses for labour.

As technology becomes more extensive, the labour market unsettlement or substitution effect is vast, and workers with varied capabilities are likely to become rapidly obsolete.

The new term, Industry 4.0, stresses that the Fourth Industrial Revolution is underway. This is not a simple technological change, but a more far-reaching process that involves the technological, economic, social and organizational spheres: a "disruptive innovation" that modifies the rules of the game and competition between companies and nations. No radical technological innovation can grow and spread without adequate organizational innovation which, if lacking, can be one of the main obstacles to the innovative process. Given the extent of the ongoing transformation, organizational innovation is not confined within the company, but involves the supply chain and the territory in which the company operates.

At the heart of the Fourth Industrial Revolution lies the Cyber Physical System (CPS) which finds its complete realization in the Internet of Things (IoT) or in an articulated sensor system that allows machinery and their components not only to interact with each other but also with people (Human-Machine relationship). These sensors lead to the collection of an immense amount of data (Big Data) which together with data collected outside the company must be stored and processed. In larger companies, which are facing the challenges of the Fourth Industrial Revolution, this has led to the creation of Data Analytics Units. The Fourth Industrial

Revolution poses new challenges for companies from the human resources standpoint. This includes channelling and adequately blending tacit knowledge with the new codified knowledge introduced by the enabling technologies, along with the need to increase employee loyalty and membership towards the company to minimize attrition to competition.

The question that is probed in this research is, what is the impact of Big Data in the most advanced companies in the Emilia-Romagna region? In addition, does Big Data only provide opportunities for STEM[1] graduates? From a quantitative point of view in this research, the answer is yes. However, an important consideration is that Big Data, in the Italian reality, is at its nascent beginning, especially of its cost-effective use. Interviews show that only 23% of the companies interviewed have ongoing Big Data projects.

This research aims to evaluate the impact of the Fourth Industrial Revolution and Big Data in "advanced" companies in the Emilia-Romagna region, with particular interest in human resources. Through direct interviews it was possible to identify certain strategies that companies need to execute to improve the skills and retain their human resources.

2 Methodology

This study is based on a research carried out by the Research Centre for Economic Studies, Nomisma, in 2018. This research included 38 large companies and three universities. The methodology followed six steps.

The first step involved extensive desk analysis and examination of the main contributions of academic literature on the Fourth Industrial Revolution and Big Data. The second step included interviews with people with knowledge and experience on the research subject as well as on the large companies that participated in Big Data conferences, seminars and projects in the region. This was paramount to collect useful information and to identify the companies to be investigated. Step three comprised the sampling of businesses, which were divided into two main groups: leading companies in the region that use or produce Big Data and Analytics and Information and Communications Technology (ICT) companies that offer services related to Big Data. The fourth step involved business interviews. The companies were contacted and were also required to complete a lengthy questionnaire. The fifth step included interviews with supervisors of computer engineering courses, in three out of the four universities in the region. This was a significant step that involved a more in-depth study on human resources with the training and market supply of these resources emerging as one of the strategic issues high in both intensity and recurrence. The final step focused on the elaboration of the results of the interviews and questionnaires.

[1] Science, Technology, Engineering and Mathematics.

The questionnaire was designed on the basis of a long networking experience of the Nomisma research centre and the first author of this study holds role of the scientific supervisor. There were no statistical tests carried out. The questionnaire is mainly qualitative and partly quantitative. The statistical credibility of the questionnaire was based on the extensive desk work and the aid of the previously established connections of the Nomisma research centre. The Nomisma research centre has a 30-year continuous relationship with all the major Italian and regional companies. With this aid, the authors had access to all the companies on the demand and supply side of Big Data and Data Analytics and those that participated in Big Data conferences, seminars and projects in the Emilia-Romagna region.

The questionnaire was considered valid because each individual question addressed specific and relevant aspects of Big Data and human resources. Application of construct validity was effectively facilitated using a panel of experts who were familiar with the measure and the phenomenon.

In addition, the companies interviewed represent the largest share that deal with these issues in the region, in terms of turnover and number of employees. It is important to reiterate that in the last 5 years, the Emilia-Romagna region leads in terms of GDP growth and export rates, in Italy. The region is also home to four main universities and the Big Data supercomputer, the most powerful in Europe.

3 Literature Review

Since its origins at Hannover Fair in 2011, the term "Fourth Industrial Revolution" has been used as a synonym for CPS in the production sector (B-Heuser and Hess, 2016). Over time, the term expanded to include many enabling technologies such as IoT, cloud manufacturing (cloud computing), smart manufacturing; and additive manufacturing technologies (3D). Many definitions of the Fourth Industrial Revolution have been articulated based on various standpoints and research areas. The Fourth Industrial Revolution can be defined as a new level of organization and management of the value chain in the product life cycle, or as a term that combines technologies with concepts of the value chain, within the modular structure of the intelligent factory (Smart Factory), the CPS monitors the physical process by creating a virtual copy of the physical world (Hermann et al., 2016), and cloud manufacturing for the Fourth Industrial Revolution (Thamesa & Schaeferb, 2016).

It's also the usage of available data, where production technologies can be enhanced and converted by the CPS which enables all the physical processes and information flows to be available when and where they are required across holistic manufacturing supply chains, multiple industries, small and medium-sized enterprises (SMEs), and large companies (Zhong et al., 2017). The CPS not only represents the meeting between the physical and the digital world, establishing global networks that include machinery, storage systems and production facilities (Shafiq et al., 2015), but also "systems of collaborating computational entities" in connection with the physical world (Monostori et al., 2016). The ability of two systems to comprehend one another using the same functionality I called interoperability, (Chen et al., 2008). The architecture of the enterprise has evolved from one that was mainly internal during the 1980s into a vibrant and innovative front for interactions and interoperability, closely connected with the whole surrounding milieu. The enterprise architecture comprises of three subsystems that cooperate with each other: i) physical subsystem, including human and technical agents; ii) decision subsystem, where planning, decision and monitoring actions are carried out; iii) information subsystem, where information flows as well as process, storage and retrieval of data (Romero & Vernadat, 2016). Each of these subsystems can itself be viewed as a complex system, so enterprise architecture can be seen as a System of System (Ackoff, 1971; DiMario, 2010). The new technologies allow a close interaction between these three subsystems, not only within the enterprise but also with the subsystems of the value chain. Today, the most advanced version of Enterprise Resource Planning (ERP) manages IT systems that support intra-organizational collaboration between logistics, procurements, sales, marketing, human resources and finance. (Callaway, 2000; Møller, 2004). In the new millennium, the use of ERP has gone beyond the walls of the enterprise to extend to supply chains, including customers and the sales side of the marketplace through Supply Chain Management (SCM).

The CPS, acts in close collaboration with the diffusion of IoT which is the most widespread technology among the manufacturing companies of the Fourth Industrial Revolution. By relating humans with machines, IoT integrates knowledge between organizations (Lu, 2017), which, increases efficiency and effectiveness in company and value chain management. In 1999, Kevin Ashton first used the term Internet of Things (Ashton, 2009). The term illustrated the power of connecting radiofrequency identification in the field of supply chain management (Lee et al., 2017). Since then the term has received more attention in industry and academia, placing IoT between the revolution of the internet and the metamorphosis of objects (Sundmaeker et al., 2010). Today there are several definitions of IoT: (1) intelligent objects; (2) an extension of the Internet; (3) a global network infrastructure; (4) the interaction of information (Lee et al., 2017). IoT grasps different fields of knowledge, such as telecommunications, informatics, electronics, and social science for it to develop (Atzori et al., 2010). In this revolution, the role of the government is of unprecedented strategic significance, both in the supply and use of data and in guaranteeing human resources with suitable training to deal with the change.

Both CPS and IoT require the processing of an extraordinary amount of data. Therefore, today Big Data is at the heart of many manufacturing and service companies' action plans. The volume and level of detail of data captured by enterprises using IoT produced a vast flow of data that can be processed to create new products and services and more articulated competitive contexts. Expanding the definition, Boyd and Crawford (2012), describe Big Data as a cultural, technological and academic phenomenon that results from the interaction of three elements: technology, analysis, and mythology. Massive data sets offer a higher form of intelligence and knowledge that can generate insights, which were previously impossible. Big data is usually defined by four Vs: volume, variety, velocity and value (Zikopoulos et al., 2012; Berman, 2013; Gantz & Reinsel, 2011) to which the fifth V (5Vs model) of "veracity" was in recently added (Bello-Orgaz et al., 2016). The diverse flows of information offer enterprises an enormous amount of data, which is growing exponentially every year (Kaisler et al., 2013), that are too complex to be processed with the standard software available to organizations and enterprises (Mayer-Schonberger & Cukier, 2013). It is linked with codified knowledge (Bandyopadhyay & Sen, 2011), which is then processed by complex algorithms, which can be pushed up to artificial intelligence (Duan et al., 2019; Xing et al., 2016). The data can be handled through a company's own Business Intelligence (BI) division or by using infrastructure as a Service (IaaS) delivered over the Internet and remote data centres, used mostly by small and medium-sized enterprises that lack the resources to create their own BI (Armbrust et al., 2010). It is considered a powerful technology to carry out complex and large-scale computing operations without the need to maintain costly computing hardware, dedicated space, and software (Hashem et al., 2015), and for this reason, it has extensively spread among organizations (Huan, 2013). However, three problems delay its application: (1) a fear linked to security in terms of data management for cybersecurity (Hipgrave, 2013; Lee, 2019); (2) the desire to not outsource information and strategic knowledge; (3) the customization of some of the processes necessary for a company.

The use of artificial intelligence would appear to crush human resources in a small corner, as noninterfering observers of automatic systems, which, in addition to producing, it replaces human resources in the decision-making processes (Onik et al., 2018; Forrester Research, 2018). The Fourth Industrial Revolution and Big Data require codified knowledge in order for them to operate, whereas in companies, there is a widespread of tacit knowledge. Generally our actions depend on a pool of knowledge, some of which we are conscious of, and some of which we are not, when not fully conscious, tacit knowledge is formed (Polanyi, 1958). Therefore, knowledge can be separated into two categories: codified knowledge and tacit knowledge. The first is transmitted through languages, IT systems, and theoretical and technical manuals. The second is usually passed from teacher to pupil through observation and learning by trial and error (Arrow, 1971).

Italian industrial districts and production chains produce a great amount of tacit knowledge, which forms the tradition and heritage of businesses. If this transmission method is interrupted, replaced by the new languages of the Fourth Industrial Revolution, this amount of tacit knowledge would be lost. For this reason, some large companies have created corporate academies (Allen, 2007; Prince & Stewart, 2002), with the aim of transferring and maintaining the pool of tacit knowledge present in companies and facilitating organizational change (Prince & Beaver, 2001). Furthermore, this structured training process aimed at creating a shared corporate sense (Allen, 2002), retains human resources within the company.

4 Results

From Table 1 below, it's evident that finding suitable human resources is of major concern for both companies, those who use or produce Big Data for their products and Information and Communications Technology (ICT) companies that offer services related to Big Data. Seventy-seven percent of the companies who use or produce Big Data stated the difficulty of finding the required human resources in the Italian market to develop Big Data and hire more data scientists or increase the size of their Data Analytics unit. However, only 23% of these production and service companies specified lack of human capital training or possession of specific skills as an issue. In other words, universities adequately train individuals with the correct and required skills for the needs of businesses, but they are numerically insufficient to meet the rapid demand of companies that develop Big Data. Similarly, ICT companies who offer Big Data services stated the difficulty in finding the needed resources (75%), and a higher percent specified lack of human capital possession of adequate skills as an issue (37%).

The major gap seems to be in the use and design of artificial intelligence. The competitive edge for companies dealing with Big Data will be based on data possession, immense data warehouses of personal data combined with powerful machines with enormous computing capacity. However, for artificial intelligence, competitive edge is due to the distinctive competences of human resources. The companies interviewed were aware of the strategic importance of ensuring adequate human resources, possibly the best, in the market.

As shown in Fig. 1, the required professional skills for Big Data are mostly data scientists (45%), IT executives (23%), physicists and mathematicians (18%), business analysts (9%) and engineers (5%). Trainings in the region are robust and of high quality, but insufficient for the needs of today's competitive environment.

Although all four regional universities offer a three-year undergraduate program, master-degree programs in computer engineering, and degree courses in mathematics and physics, the number of these graduates is not enough to meet the demands of companies, who face stiff competition to hire such resources as soon as they graduate. All the companies interviewed agreed that the lack of specific skills is one of the biggest obstacles to the development of Big Data in their company.

Table 1 Difficulty finding human resources (ICT companies and production and service companies)

	ICT companies	Production and service companies
Deficiency in needed human resources	75.00%	76.92%
Lack of skills	37.50%	23.08%
No problem in finding adequate human resources	6.25%	23.08%

Source: Personal elaborations based on the interviewed companies, May 2018

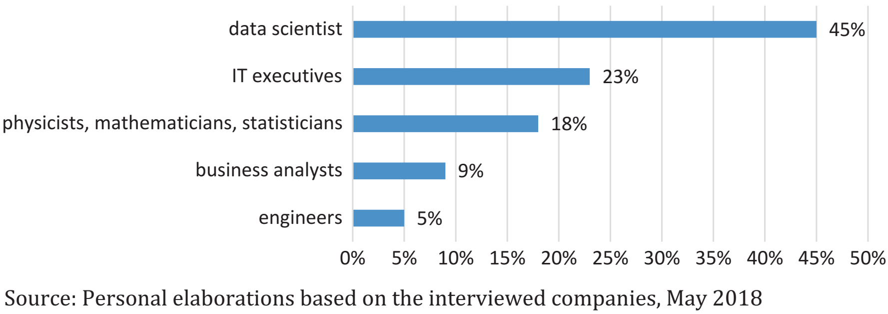


Fig. 1 Professional competences required (production and service companies). Source: Personal elaborations based on the interviewed companies, May 2018

The gap in the demand and supply of skills has a significant negative social impact. A significant part of employment with high added value is lost and the competitiveness of companies is weakened as acquiring adequate human resources is of central strategic value to Big Data. Government policy actions are vital to increase the competitiveness of companies in this rising competitive environment.

Big Data is one of the most interesting occupational scenarios in Italy. Of the sample of companies interviewed, 90% of ICT companies who offer Big Data-related services and 79% of production and service companies that demand Big Data, have forward-looking hiring strategy when it comes to Big Data. The latter is connected to a clear medium-term strategy (Fig. 2).

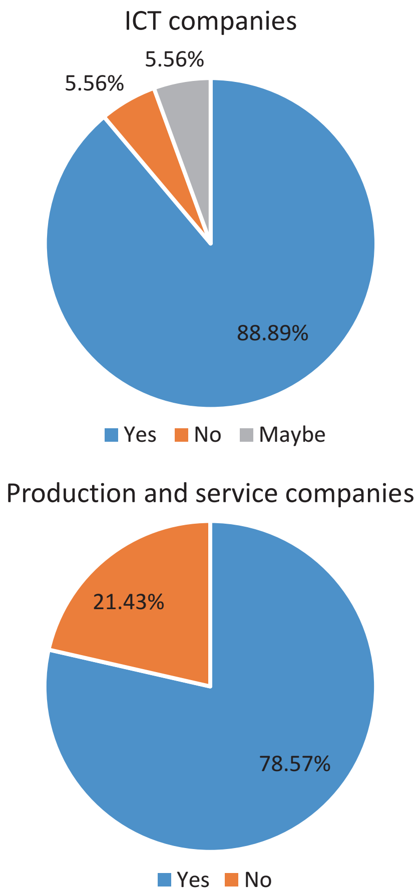
When it came to the preferred channels for finding and selecting these qualified human resources, both ICT and production and service companies preferred universities. New recruitment channels such as social platforms and specialized websites were also being considered (Figs. 3 and 4).

While, 54% of production companies are already thinking about Big Data and have started testing, the remaining 23% have not conceptualized any Big Data projects yet (Fig. 5).

That the Fourth Industrial Revolution, including Big Data, is a distant future reality for most companies. A recent interview with generic manufacturing drug companies showed that despite the large use of automated machines, the enabling technologies of the Fourth Industrial Revolution (including Big Data) are unknown to the large majority (59%) and only 30% of them believe that Big Data can significantly impact the competitiveness of their businesses over the next 5 years.

Similarly, companies in the Emilia-Romagna region who have implemented Big Data projects have also estimated a 5-year duration to profit from the use of Big Data in their company.

This means that the introduction of Big Data in the business sector, or at least in the production and retail sectors is not immediate. While the intent that companies should embrace Big Data is strong, the application of the same in a company is fraught with uncertainty in the short-term. Hence, here there is a need for professionals with “humanistic” study backgrounds who can read this phenomenon from



Source: Personal elaborations based on the interviewed companies, May 2018

Fig. 2 Responses for the question—Do you have a forward-looking strategy when it comes to hiring for Big Data skill sets (ICT companies and production and service companies). Source: Personal elaborations based on the interviewed companies, May 2018

a different perspective and assess its new business applications. Big Data, and the processing of a large amount of data, poses the challenge of artificial intelligence.

5 Discussion

While the Fourth Industrial Revolution is driven by an unprecedented technological change (CPS, IoT, Big Data and Artificial Intelligence), it is precisely because of its characteristics that it places human resources at the centre of the production and creative process. Data is the new black gold, but human resources with talent, skills

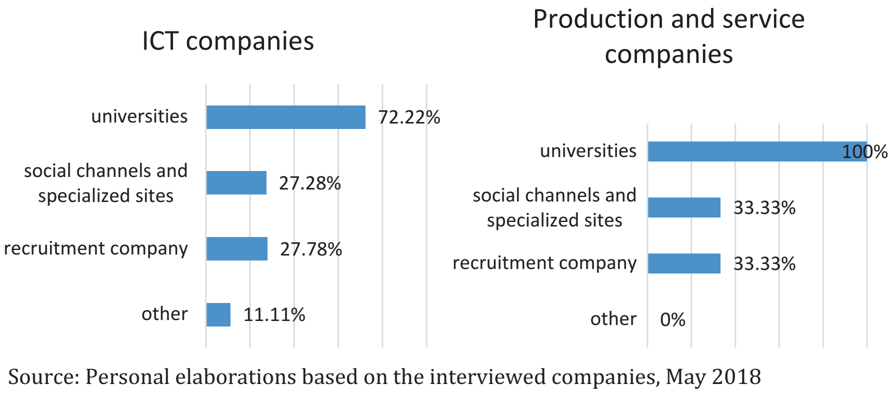


Fig. 3 Preferred recruitment channels (ICT companies and production and service companies). Source: Personal elaborations based on the interviewed companies, May 2018

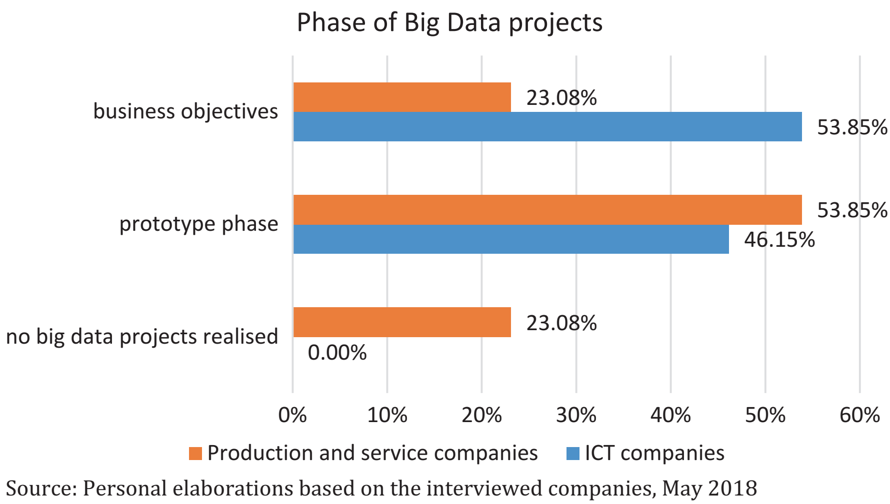
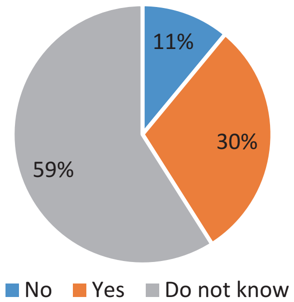


Fig. 4 Phase of Big Data projects in place (ICT companies and production and services companies). Source: Personal elaborations based on the interviewed companies, May 2018

and the ability to manage the new transformation, are as well. However, human resources can pose a constraint on accelerating change in three ways: First, specialized resources (in Science, Technology, Engineering and Mathematics (STEMs)) may be insufficient in number compared to the demand. Second, these resources must then adapt and conform their general IT skills to the requirement of the individual company. Third, it is necessary to redefine the skills of the human resources already operating in the company in the light of the new vocabulary of the Fourth Industrial Revolution. Therefore, it's necessary to plan and implement territorial and entrepreneurial strategies to deal with these three constraints.



Source: Personal elaborations based on the interviewed companies, May 2018

Fig. 5 Responses from companies on their belief of the impact of Big Data on their business in the next 5 years. Response for the question—Do you believe that Big Data will have an impact on your business in the next 5 years. Source: Personal elaborations based on the interviewed companies, May 2018

In Big Data, the job offers have grown rapidly driven by the *expansion effect* and the *enlargement effect* (Poma et al., 2020). The first constraint is attributable to the growth in the job offers (companies requiring labour), from companies which already use such skills (computer engineers, physical electronics etc.). This demand is driven by the potential of Big Data potential and the companies' decision to upgrade their analysis unit and research team. The *enlargement effect* is a new phenomenon. It is because of companies in sectors that historically have never used such skills, such as insurance, logistics or finance, which now need specialized skills to manage the massive amount of data they own, especially in the processing phase. Human resources that were previously required only by companies in the adjacent sectors are necessary for companies of any economic, productive, and service sector.

From a geographical point of view, the strategy is to help structure the degree courses provided by universities and the training courses provided by scientific institutes to make up for the missing skillsets required by businesses today, as well as making the geographical area more attractive so as to acquire resources from outside. For example, an important Italian pharmaceutical company has recently become a benefit corporation to attract the best American talent in the field of research. The younger generation prefers to work for a benefit corporation. Another example is of companies that have built data analytics units to create an interactive and challenging environment for their talented resources.

To overcome the second and third constraints (adapting general IT skills and redefining existing skills), the strategies of the companies have been geared towards increasing economic resources, training hours, and improving their existing structure. The more dynamic and larger companies have already begun knowledge transfer and internal trainings, which in more structured cases have led to the creation of corporate academies. The greater the company invests in human resources, the greater must be the loyalty of the latter towards the company. Therefore, along with the training courses, companies also implement loyalty strategies. The companies that have invested the most in training and knowledge, have also used other strategies to increase the loyalty of their employees such as providing a medical plan for their family members, the possibility of ordering a full meal to take home to their family members, a more accentuated dynamism for the individual career, as well as awards for goals achieved by teams.

Many are of the view that the greatest competition for human resources in today's world, are machines. This stems from the fear that artificial intelligence will evolve to become more intelligent than human beings. Our view is that these human resources and machines should co-exist and work with each other. A correct interpretation of the Fourth Industrial Revolution places people at the centre of the production process. There's currently a technological revolution or a human capital revolution underway. While technologies are becoming more sophisticated, there's a need for new complementary human skills for these technologies to work. Therefore, the possession of quality human capital is vital for success. There would be no machines without human intelligence. A machine is an artificial intelligence device consisting of different parts and is used for performing different functions.

Unlike the old industrial revolutions and the old codified fixed mechanistic machines, artificial intelligence technologies represent a completely different reality and require the capabilities of a skilled workforce. In this new disruptive revolution, humans are the ones shaping the technology. Artificial intelligence learns from human habits. Robot manufacturing is now done with an intent to interact with humans, not to replace them. They extend human capabilities, and are able to operate in tiny contexts, for example, functioning as "mechanical" limbs that enhance human capabilities. In the production lines of the companies we visited, the employees run along the production line with devices in hand, punctually checking that all quality, reliability, and safety parameters are met, based on the measures required by the countries of destination. The same workers also have access to the "test centre" equipped with sophisticated machinery to test certain components or to check for anomalies in the production line.

Finally, enabling technologies, associated with the Fourth Industrial Revolution, introduce a new way of thinking and designing. From our interview and visit to a large packaging company equipped with a large operating unit of additive manufacturing (3D), we noticed that the company's young design engineers teach their older colleagues (who are often under 40 years of age) to design "from the void" and not from the full, as they were taught a few years ago. The classic technique of designing from the full was used to obtain a semi-finished product, one of the many components that once assembled together formed an automatic machine for packaging. Designing "from the void" does not just mean reproducing existing semi-finished parts in different ways, but rather imagining the production of more complex parts integrated with each other that cannot be realized with previous technologies. Old and new knowledge must be intertwined and recombined to obtain products with unprecedented characteristics that allow the machine to perform new and more complex functions. The 3D printer gives shape to the void resulting in complex work, as opposed to the Middle Ages when threads were weaved by looms and the weaving of threads created cloth. These are not just two different processing techniques, but a completely different design modality. The technique changes in the sense of the techne' as intended by Heidegger (1953, 1962), that is, the knowledge which guides production, as the "idea", that precedes production. Therefore, all the engineers of this large enterprise must learn to "think" beyond the component they have to design, and realize what additive manufacturing can offer. This core reasoning must be extended to the entire production cycle. An example of this in the case of a large poultry company which we interviewed and visited. It has transformed its newly built smart warehouse making it central and the beating heart of their entire production and logistics organization.

It is therefore a new language that flows between machines, people and businesses. For this reason, in recent years, we are witnessing a flurry of acquisitions of strategic companies, who were once their subcontractors, by the heads of the supply chain (or the leading company). This strategy is followed for three reasons: to keep the strategic knowledge inside, to standardize the "language" between companies in the supply chain, and to acquire new tacit skills in terms of human resources.

6 Conclusions

One of the main developments of the Fourth Industrial Revolution is the focus on the new human–machine relationship, specifically, humans and machines working with each other. While the technological push of the Fourth Industrial Revolution will first need STEM-trained workers, the revolutionary push of the revolution will require a workforce with humanistic expertise to be able to "read" and interpret the underlying changes that these technologies bring to the company and its value chain. In this study that covered the Italian context, the Fourth Industrial Revolution poses three challenges for the Italian businesses in the Emilia-Romagna region, from a human resources context. First, the increasing urgency and need to meet the demand for graduates trained in the skills required by Big Data companies. Second, the interpolation of knowledge, being able to adequately mix the tacit knowledge disseminated in the company with the new codified knowledge introduced by the enabling technologies. Third, the need for higher the investment in human resources, to increase the loyalty (Poma, 2003), and membership of the company's staff to minimize the attrition to competition (Poma, 1995).

Appendix 1: Questionnaire Framework Designed for Production and Service Companies

General company information	• Quantity of data production and velocity of data production
• Company name	• First project related to big data
• Business sector	• Channels used to activate initial projects
• Year of commencement of activity	• Internal and external organization for the utilization of big data
• Name and role of interviewee	
Section A—Company positioning and innovation actions	*Section C—Indications on the professional figures specialized in data analytics*
• Company turnover	• Professional figures and required competencies for the development of big Data analytics
• Number of employees	• New recruitment programs
• Percentage of employees by qualification degree	• Difficulties in finding required professional figures
• Turnover trend, investments, occupation, exports	• Planned training activities
• Innovation activities in the last 3 years	*Section D—Other information related to the use of big Data*
• Modality of innovative processes	• Average annual budget for activities related to big data.
• Planning for innovation investments in the next 2 years	• Financing method
Section B—Elements related to the use of big Data	• Connections with other companies related to the use of big data
• Strategic goals the company aims to reach using advanced techniques of data analysis.	• Connections with educational institutions/ universities
• Actual achievement of goals in the last 3 years	• Connections with international institutions/ bodies for conducting educational and developmental activities
• Presence of obstacles in reaching goals	• Policy interventions to strengthen the adoption of technologies and processes related to big data.
• Impact and result of the introduction of data analytic techniques in business processes.	• Needed support from institutions to strengthen innovation activities
• Business function or area that mainly benefited most from big Data analytics	
• Level of adoption and use of big Data technologies	

Appendix 2: Questionnaire Framework Designed for ICT Companies

General company information	• Origin of the people employed
• Company name	• Information about customers concerning big Data projects
• Business sector	
• Year of commencement of activity	
• Name and role of interviewee	
Section A—Company positioning and innovation actions	*Section C—Indications on the professional figures specialized in data analytics*
• Company turnover	• Professional figures and required competencies for the development of big Data analytics
• Number of employees.	• New recruitment programs
• Percentage of employees by qualification degree	• Difficulties in finding required professional figures
• Turnover trend, investments, occupation, exports	• Planned training activities.
• Innovation activities in the last 3 years	*Section D—Other information related to the use of big Data*
• Modality of innovative processes	• Average annual budget for activities related to big data
• Planning for innovation investments in the next 2 years	• Financing method
Section B—Elements related to the use of big Data	• Connections with other companies related to the use of big data
• Type of consultancy/service offered	• Connections with educational institutions/universities
• Customer location	• Connections with international institutions/bodies for conducting educational and developmental activities
• Level of adoption of technologies related to big data	• Policy interventions to strengthen the adoption of technologies and processes related to big data
• Level of use of technologies related to big data	• Needed support from institutions to strengthen innovation activities
• Professional figures/skills used	
• Number of full-time staff	

Appendix 3: Production and Service Companies Included in the Study

Company	Activity	Location
Bonfiglioli engineering	Industrial machines for quality control in packaging	Vigarano Pieve (FE)
BPER services S.C.p.A.	Banking services	Modena
CEFLA	Plant production, furniture, finishes and medical instruments	Imola
Chiesi	Pharmaceutical production	Parma
CIR food	Restaurant services	Reggio nell'Emilia
Coop Italia	Wholesale	Casalecchio di Reno (BO)
Coop Alleanza 3.0	Business	Castenaso
Cooperativa Bilanciai	Weighing systems production	Calderara di Reno (BO)
CRIF	Business information	Bologna
CRIT Sri	Research and analysis of technical-scientific information	Vignola (MO)
Granarolo	Food industry	Granarolo (BO)
IMA	Industrial machines for packaging	Ozzano dell'Emilia (BO)
Laboratorio "L'immagine Ritrovata"	Film restoration	Bologna
SCM group	Production of machinery and components	Rimini
SCS consulting	Consulting	Bologna
UnipolSai	Insurance and banking services	Bologna
Yoox net A porter	E-commerce	Bologna
SACMI	Engineering	Imola

Appendix 4: ICT Companies Included in the Study

Company	Activity	Location	Sector
4 science	Data management	Ravenna	ICT; healthcare; manufacturing
Axyon Al	Technology	Modena	ICT; financial, banking and insurance
BioDec	Project management and integration with business applications	Casalecchio di Reno (BO)	ICT; healthcare

Company	Activity	Location	Sector
CINECA	Information processing	Casalecchio di Reno (BO)	ICT; multisectoral
DataRiver S.r.l.	Data processing	Modena	ICT; healthcare; manufacturing
Dedagroup	Digital business	Bologna	ICT; multisectoral
Dedalus	Healthcare software	Bologna	ICT; healthcare; public Administration
DM Management & Consulting	MES systems for data collection and analysis	Bologna	ICT; manufacturing
Doxee S.p.A.	Customer communication management	Modena	ICT; multisectoral
Energy way	Industrial data management	Modena	ICT; multisectoral
Engineering	Software and IT services	Bologna	ICT; multisectoral
Expert system S.p.A.	Semantic intelligence	Modena	ICT; multisectoral
Fancy pixel S.r.l.	Customized software for industry	Ferrara	ICT; manufacturing
Gruppo Kedos	IT services	Parma	ICT; financial, banking and insurance; manufacturing
Iconsulting	Data warehouse, business intelligence, Performance management and big Data analytics	Casalecchio di Reno (BO)	ICT; multisectoral
Imola Informatica	IT consulting	Imola	ICT; financial, banking and insurance;
I.S.I. S.r.l.	Smart factory systems	Podenzano (PC)	ICT; manufacturing
Lepida	Technology and consulting	Bologna	ICT; pubic administration
Onit group S.r.l.	Computer technology and consulting	Cesena	ICT; healthcare; manufacturing
RTS Sistemi Informativi	Technology and consulting	Forli	ICT; manufacturing

Appendix 5: Universities Included in the Study

University	Location
University of Bologna (UNIBO)	Bologna
University of Modena and Reggio Emilia (UNIMORE)	Modena and Reggio Emilia
University of Ferrara	Ferrara

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