DEPARTMENT OF MANAGEMENT

Chair of Competition and High-Tech Markets

Disruptive Technologies and their Impact on the Labor Market

SUPERVISOR

Prof. Andrea Renda

CANDITATE

Giuseppe Menicocci

ID. Number 656011

ASSISTANT SUPERVISOR

Prof. Giuseppe Colangelo

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Introduction

“Any technological advance can be dangerous. Fire was dangerous from the start, and so (even more so) was speech - and both are still dangerous to this day - but human beings would not be human without them.”(Isaac Asimov)

The impact of Technology has been, in the mere definition of the human being, always more present. The focus on research and innovation of technology, as well as the enthusiasm and the worries that it causes, often lead to distract attention from a careful consideration of the entire context as a whole. In the limits of any biological metaphor, it can be argued that between human being and Technology there is a tight relationship of coexistence and mutual advantage. It can be said that there is a sort of “symbiosis”: our species blended with all the new innovation and instruments that creates and produces. It is quite impossible not proving the easiness that technology generates in different realities, such as social’s and professional’s, through, *ex plurimis*, the transfer of activities, competences, and even decisions, which in the past were belonging to humans, to machines and artificial intelligence robots. All of these concepts bring to another consideration: the technology advancement entails a minor material compliant in the form of an increasing dependency of human to technology itself.

If, on one hand, history tells us that the rhythm of technology progress is constantly increasing over time, due to the fact that a set of new discoveries serve as basic ground for others, newer and larger, on the other hand, it is required to notice that the consequences, of the technology evolution itself, cannot be confined to its immediate effects. There are (and there will be) always unexpected, unpredictable, and undesired effects. Moreover, technology evolution is marked from very fast changes, fastened to actualization mechanisms, thanks to which the immediate adjustments to innovation tend to take the root into the profound society structure, by chaining together the "*homo technologicus*" with the permanent presence of such innovations and evolution[1].

Can the impact of technology being predicted with absolute certainty? Today, the present scenarios and the hypothesis of the future are, often, built through conjectures filled with high degrees of predicting and diagnostic competences. Nevertheless, one thing is sure: the asymptotic evolution of new technologies requires, as *conditio sine qua non*, a corresponding and updated education, which would be able to allow a fair adaptation to the continuous changes.

What impact these things just said had and will have on the labor market?

Anticipating what will be the subject of this thesis work, the advent of new technologies, the emerging of new professional opportunities, new markets, new sectors, and the continual quantitative and qualitative modification of human-machine interaction, have brought radical changes in work's structure and essence. These work's transformations can be read either under an optimistic, than a pessimistic lens. From one perspective, technology advance will definitely bring a bunch of new opportunities in almost every field of applicability: smart cities, wearable devices, interconnected sensors and items, smart manufacturing organizations, and a quite all customization of every individual need thanks to huge amount of data available. From the other perspective, instead, several academic studies, as well as other reliable sources, have shown that the increasing automation of some tasks, mostly related to routine and ruled-based tasks, is laying on the line a very big portion of the labor market.

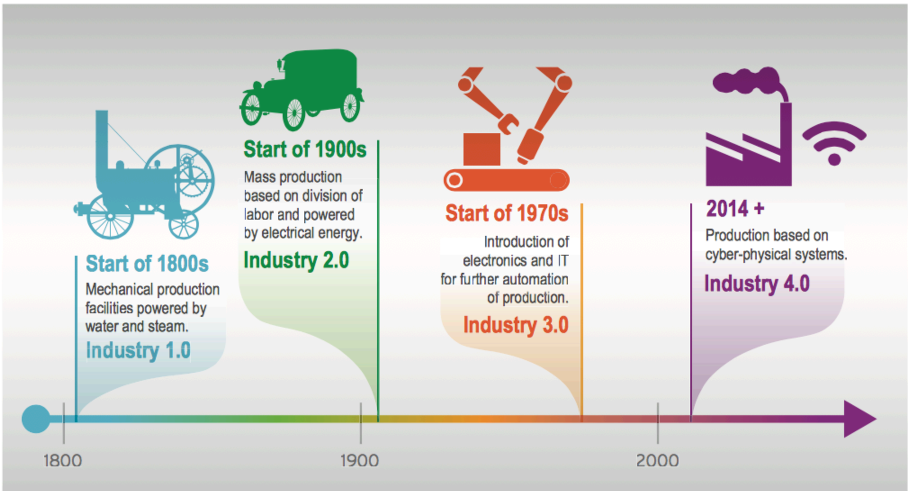
[1] "L'avvento di Homo Technologicus", Giuseppe O. Longo, Scienzainrete.it, 18.03.2015

My study, with obvious humility, will attempt to illustrate possible scenarios and feasible applications that the evolution of technology will necessarily imply.

The thesis will be structured as follow: the first part, from chapter 1 to 3, will regard the different Industrial era, from the first Industrial revolution to the futuristic concept of Industry 4.0 and Internet of Everything. In order to give a reliable interpretation of the abovementioned contents, it is correct to make an initial distinction between the meaning of Industrial revolution and the term Machine age, used as title for each chapter.

Figure 1 represents the different time frames associated with the four stages of the Industrial Revolution.

Figure 1: The fourth stage of the Industrial Revolution



Source: Cognizant (2014), from Industry 4.0, or Zukunftsprojekt Indstrie 4.0.

The Industrial Revolution kicked off with the invention of the steam power engine and the first mechanization of manual work at the beginning of the 1800s. The second Industrial Revolution has been associated with the beginning of the mass production techniques implemented by Henry Ford and its first concept of "smart factory" in the early 1900s. Going ahead, over the past thirty years, with the advent of electronics and IT revolution, the entire world assisted to a radical transformation in terms of living and working attitudes. Then, the third Industrial revolution employed electronics and information technology to achieve increased automation of manufacturing processes, which have brought to a machine take over of a substantial proportion of manual and cognitive jobs. The last Industrial revolution refers to the evolution of PCs into smart devices that has also been accompanied by other trends that combine miniaturization and the unstoppable growth pace of the Internet. These result in the convergence of the physical world and the virtual world in the form of Cyber-Physical Systems, and the rise of the Internet of Everything, the concept of Industry 4.0 and the new future of smart factories.

In this thesis work the different stages of the Industrial revolution are represented under the term of Machine Age, following and adapting, to some extent, the categorization made by Brynjolfsson and McAfee (2014). Thus, within the First Machine age, presented in the first chapter, are grouped the first and the second industrial revolution, covering the period from the 1800s to the information revolution; following, the Second Machine age is going to represent the third industrial revolution, and the rise of a social and economic problem called the “hollowing-out” of the labor market; finally, will be presented, as the Third Machine age, the last industrial revolution, which involve the technical integration of CPS into manufacturing and the use of the Internet of Everything in almost every sector and industrial processes.

The second part, instead, will stress the accent on the possible implication of technology progress, through a cross comparison analysis of several scenarios based on different methodologies. The final goal would be drawing a future action plan, strong enough to face the challenges that technology advancements will definitely bring with it.

To You

PART I:

Overview of the three Machine Ages

Chapter 1:
The first machine age: from Industrial Revolution to Information Revolution

1.1 Introduction: Industry and Industrialization

It is essential to make a distinction between "industry" and "industrialization"; the latter is considered to be a fundamental component of the industrial revolution, that is that phenomenon occurred about three centuries ago that gave birth to the current world where we live in, that from the beginning has been separated between "industrialized countries" and "non-industrialized countries".

It isn't correct to define the "industry" as a more or less modern phenomenon; indeed, it represents a crucial component in the process of civilization and usually it dates back to 10000 years ago. Down to the Pleistocene, the first industrial products have been the rough silica's tools used as work tools and hunting weapons. From then on, artisans, workmen and technicians ensued. Since his appearance, the human being needed to transform the raw materials into objects or suitable products in order to satisfy his necessities and to improve his standards of living. Starting from the ancient times, he made and learnt how to use simple utensil till more complex machines so to both extend and enhance the realization of his needs.

The relationship between the human being, the machine, and the product that comes from it, it is gradually changing but in a more radical way. Today, the interaction between human, machine and technology is increasingly evident.

This first chapter will go through the first stages of the Industrial Revolution, from the early 1800s till the end of the 1900s. It will be presented the socio-economic and political evolution that the first technological inventions had brought to human lives. Trying to understand the impact of this phenomenon, it would be also possible to lay the foundations for the further understandings of the other industrial revolutions that are the natural consequence of what happened in this first period of time.

1.2 The First Industrial Revolution

Man’s need to improve his conditions, through the creation of new objects, has been constant over time. In the several epochs, it is undeniable to consider that the most productive and creative impulses arose from the violent contrast among human beings; wars, and the lesser conflicts, have generated inventions, techniques and realizations that sustained the social conditions during peace times. Examples are many and sometimes unexpected; during the XX century’s conflicts, the inventions that successively have had a great impact on the society were the following: stainless steel, the use of daylight savings time, the first calculator as the progenitor of the computer, till the theory followed by the realization of the uranium nuclear reaction.

Over time, the most relevant demonstrations of the abovementioned process, the ones that had an impact on the humans, occurred only starting from the XVII century.

There have been several sudden upheavals in the social environment, that are linked to an epoch defined as “Industrial Revolution” with the intent of indicating the transition from an economic system based on both agricultural and trade business, to a new system based on the development of the English manufacturing industry between the XVIII and XIX century, that gradually expanded in the whole Europe.

The span of about 3 centuries doesn’t fit with the word “revolution” that, in people minds, it represents a quick and violent uprising that subvert the entire social structure; here the word “revolution” highlights the transformations and innovations made by the industrial production at that times, that not only influenced the economic environment, but they also involved the social structures, political events and cultural and moral values of the whole European civilization.

This phenomenon appeared in England since the early 1700s (about 1740); the *humus* that enabled the development was, on the one hand, the applications for the production of technical inventions by craftsmen and scientists, on the other, the large amount of raw materials that fostered the industrialization.

"It is not exaggerated to say that the first phase of industrialization is almost exclusively the result of the direct and indirect effects of the diffusion of three technical innovations: the use of carbon coke in the production of cast iron, the mechanization of spinning and the stream engine"[2].

It is appropriate to start the history of innovation in the industrial age, from these three components that have been the basis of the industrialization development, in Europe and in the rest of the industrialized countries.

In 1733, John Kay invents the *fly shuttle* that enables the English textile industries to steer the textile machine by using only one worker, against the two before this innovation. Since then, the apparel workers wove more wire than the spinners could produce.

In 1764, James Hargreaves modifies a Thomas Highs invention and patents (1770) the *spinning Jenny*; also in this case the machine invention brought to the drastic reduction of the specialized human labor since it permitted only one worker to manage, at the same time, more spindles of spinning.

In this context, it is identified the leitmotiv of the industrial revolution; this was the first real "technical innovation in the textile sector and the one that opened the doors to the industrial revolution, becoming a symbol of that time"[3].

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[2] Enciplopedia delle scienze sociali, Paul Bairoch, 1994 Treccani, http://www.treccani.it/enciclopedia/industrializzazione_(Enciclopedia_delle_scienze_sociali)/

[3] Francis Espinasse, "Lancashire Worthies", Simpkin, Marshall, & Company, 1874, pag. 322

In 1712, Thomas Newcomen, invents the machine at atmospheric pressure; in 1768, the Scottish mathematician James Watt, (…).
It comes the Watt's steam engine. Until then, the only forces available to the human being, beside his own, were those generated by animals and water; all the products, included the ones coming from the new-born textile industry, were very expensive because their production was possible only thanks to the human labor force. With the aid of the stream engine and its mechanical energy, suddenly textile production increased exponentially, and the price of the finished goods decreased significantly. This innovation, together with its consequences, brought the artisans of that time to not compete with the looms moved by Watt's machine; hundreds of looms were operating in the rising large structures; modern factories arose and with them also the labor class, the salaries and the industrial capitalism. These led to an irreversible transformation of the socio-economic environment of that time.
During the first industrial revolution, it is no less important the iron industry, which responded to the needs related to build an increasing number of textile machines using the iron. Once again, England had the initial supremacy over the rest of Europe thanks to the new process for the use of carbon coke in place of the charcoal, and to the huge fossil coal deposits (from where the carbon coke is derived) on its territory.
The combination of these innovations, linked by a common denominator (industrialization), created significant changes by revolutionizing both industrial production and socio-economic context of each country. This led to the abolition of distances through the construction of railways and steamers that enhanced the transfer of people and goods.

1.3 The Technological Innovation

At this point, the concept of technological innovation begins to take shape and it could be defined as "the deliberated activity of enterprises and institutions aimed at introducing new products and new services, as well as new ways to produce, distribute and use them"[4].

Joseph Schumpeter introduces, in his book *Capitalism, Socialism and Democracy,* the concept of "innovation's economy", claiming, in contrast with John Maynard Keynes, "that evolving institutions, entrepreneurs, and technological change were at the heart of economic growth, not independent forces that are largely unaffected by policy" (Schumpeter, 1962).

What social consequences did the industrial revolution cause? What analysis is it possible to make for this epoch? First al all, as already mentioned, with the creation of the "modern factory", a new social class arose: the modern proletariat, described as "the largest and poorer class" by Henri de Saint-Simon[5]. He believed that technique and industry were not enough to reach the social happiness. The proletariat didn't have any external resource able to support itself; its own labor force, which if sold to the capitalist, yielded wages, represented the only resource. During the first start of the industrial revolution, the conditions of the lower classes deteriorated, due to the new urban conglomerate and work in factories quality of life. It is in this era, when the Government of His Majesty, aiming to witness the harsh conditions of the workers' poverty, carried out numerous investigations. Yet, there was an objective improvement produced by the industrialization of the XVIII century: the transition from demography of the old type, slow and irregular, to a rapid and steady population growth largely due to the consolidation of economic growth, but also due to the decline of morality that accompanied those days.

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[4] "Innovazione tecnologica" Chapter 4 of "La produzione e la diffusione della conoscenza Ricerca, innovazione e risorse umane", Giorgio Sirilli, July 2010

[5] "Le Nouveau Christianisme", Claude-Henri de Rouvroy de Saint-Simon, 1825

The same new technology of steam engines, sets in motion humanity, allowing travel, trade, and ensuring to the most advanced countries, to expand by colonizing lands, previously difficult to reach.

1.3.1 The industrialization's reactions: Luddism

In this context, however, were not missing some social reactions to the nascent industrialization of those times; in particular, the first protests by the workmen took place among which the most known was the *Luddism*. It seems to have taken the name from a worker, Ned Ludd, who destroyed some weaving looms in protest, during an "impetus of passion"[6].

The uprising reacted violently to the introduction of new machines, considered as being the cause of unemployment and low wages unable to ensure a decent life standard.

Right after, from Nottingham, where the records show in 1811 the first demonstration of the movement, the revolt, fomented by the English Jacobins, spread in the major industrialized cities of the United Kingdom becoming a real movement of "insurgency"[7].

In this emerging era of technological innovation, the machine becomes for the first time a sort of threat to the workers, not only for their jobs, but also for their own life. Indeed, also as a result of the first Luddism reactions, the "Framebreaking bill" was enacted in order to combat this problem. It was a law allowing to judge and condemn, even to death, all "(…) those who destroy or damage looms for stockings or lace or other machineries or equipment used in the manufacture of knitting on the loom or any other good or commodity on looms or similar machinery"[8].

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[6] George Gordon Lord Byron (2002), "The Works of Lord Byron. Letters and Journals" page 97, Adamant Media Corporation

[7] Salvadori, L. "Il Luddismo", Roma, Editori i Riuniti, 1987, pages 115-116

[8] Neil Websdale (13 September 2001). *Policing the poor: from slave plantation to public housing*. UPNE. p. 226. Retrieved 20 February 2012.

The law of 1812 was an act of the British Parliament that had the aim to discourage the *Luddism* or similar movements that had as objective the destruction of mechanical looms; then, it was introduced the concept of a capital crime to machine (stocking frames)[9]. Lord Byron strongly opposed himself by declaring to the House of Lords: "Imagine one of these men, as I have seen them – thin for the hunger, sunken by desperation, careless of their life, that your Lordships consider maybe less then a loom, imagine one of these men taken to Court to be judged for this new offense: at that moment, two more things are needed to convict him, and these are, in my opinion, twelve butchers for jury and one Jeffrey as judge[10].

Despite such an authoritative voice, the law passed as an emergency measure by an overwhelming majority and with the consent of the British Crown on March 20th, 1812.

Predictably, the *Luddism* movement reacted violently to the new law, and after one month from its approval, it guided one of the most famous and violent attacks against a manufacturing factory. In the following months, it went so far as even the assassination of the Prime Minister Spencer Parceval[11], who persuaded the Crown of the existence of a large paramilitary organization with insurrectionary aims to be hindered with the help of the army.

1.3.2 The technological unemployment

The Luddism evoked the fear that the emerging technological innovations in the production system could have led to a permanent

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[9] Karly Walters. "Law, "Terror", and the Frame-Breaking Act" (DOC). University of Birmingham. Retrieved 20 February 2012

[10] George Jeffreys was a magistrate particularly cruel known for the punishments inflicted during the Monmouth rebellion ended in 1685, Salvadori, L. "Il Luddismo", Roma, Editori i Riuniti, 1987, pages 115-116

[11] Gillen, M., "Assassination of the Prime Minister: the shocking death of Spencer Perceval", London, Sidgwick & Jackson, 1972.

destruction of jobs, representing for the first time, the concept of technological unemployment.

The school of thought derived from the movement claimed that the technological progress destroys more jobs than it creates, causing widespread economic damages till the permanent and definitive destruction of jobs.

In 1930, John Maynard Keynes mentions a new disease and he writes: “We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely, technological unemployment. This means unemployment due to our discovery of means of economizing the use of labor outrunning the pace at which we can find new uses for labor. But this is only a temporary phase of maladjustment" (Keynes, 1930). The main thought was that technological change is bad for workers because it generates unemployment.

According to William Easterly, the above mentioned is “Luddism fallacy, one of the silliest ideas that have ever being conceived during the long tradition of silly ideas proposed by economic theory”[12].

With more products, obtained from the work of the same number of employees, there is more income for each worker. And if any worker, as in the case of the first Luddism, remains unemployed, it is because he knows only the old technology.

Over the past 250 years, the economies that invested in both the industrialization and the consequent technical progress, didn’t show, during long periods of time, any upward trend in unemployment. Instead, Britain, Germany, United States recorded a growing trend in income per worker. Therefore, as from the Solow-Swan model affirms, the continuous growth of productivity and standards of living,

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[12] Reviewed Work: *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics* by William Easterly, Review by: Romain Wacziarg, *Journal of Economic Literature*, Vol. 40, No. 3 (Sep., 2002), pp. 907-918

cannot be sustained except by a steady technical progress. It is theorized that the different economies converge towards a "steady state" or "uniform state", where both the growth and technical rates are equivalent. Nowadays, after 200 years since the defeat of the Luddism, the Google CEO, Eric Schmidt, warns: "Today, the race is between computers and people, and people are the ones who have to win".

Once again, the Luddism becomes fashionable, "and if we were entering an era of geometrically accelerated technological progress where artificial intelligence, robotics and nanotechnology all together will represent a much deeper threat to jobs, wages and to social stability than it has been commonly imagined? And what if it is not just the individual "not-qualified" to risk, but the majority of us?"[13]

1.4 The second industrial revolution

As a result of the modernization process initiated by the first industrialization, the historians and economists call the "second industrial revolution" the epoch whose development process is chronologically placed between 1856 and the Great depression of the late nineteenth century.

The features of this second phase, in part derive from the first revolution: innovation in technology, new scientific discoveries, and the emergence of a new capitalist class; along with new sources of energy, they enabled to consolidate the absolute domination in world trade of the industrialized countries in Western Europe. This flywheel made possible the development of sectors that didn't exist before, or that had a limited economic importance; Deep changes were made in terms of production process and an exponential growth was needed for investments and costs. In order to support these commitments, the

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[13] Martin Ford, "The Lights in the Tunnel: Automation, Accelerating technology, and The economy of the Future, 2009

family-owned businesses were not enough and, indeed, the corporations started to assert themselves, by inevitably tracing strong dependencies on credit from the banks.

In the XVIX century, the scientific revolution of the previous century became increasingly linked to the technical innovation. During this period, the scientific discoveries were no longer hidden in the laboratories; instead they became an incentive for new inventions. The eighteenth century was also characterized by the birth of modern chemistry, initially in England, but later with Lavoisier in France thanks to the discovery of oxygen and hydrogen together with the one of chemical phenomena such as combustion. This was the epoch of the experiments on electricity, with the Alessandro Volta's battery and the lightning rod of Benjamin Franklin; the Montgolfier brothers, thanks to the studies of Lavoisier, invented the first flying object built by human (1783).

1.4.1 The effects of the industrial revolution on culture: The Enlightenment

The industrial revolution, even with narrow and winding situations, produced a deep renewal in the political and social life of the period that led to the birth of an important cultural movement widespread from France to the rest of Europe: The Enlightenment. For the followers of this movement, the knowledge had to be useful, meaning that it had to contribute to what they thought were the main goals of human life, that is, the welfare and happiness of individuals but also the progress of the human society. The movement was driven by the need of letting the intellect prevailing over the darkness of ignorance, contributing to the human progress by means of spreading the culture among people; the intellectual was thus the educator for the entire humanity.

Not surprisingly, the most famous French Enlightenment work was the *Encyclopedie,* aimed at spreading the culture and the progresses achieved since then, especially in the field of science and techniques.

1.4.2 The monopolistic capitalism

The most important discoveries and innovations, that will allow then to reach the current times, are without any doubt, those of electricity, oil and chemicals. For each innovation, there are new ones and more specific that allow developing other sophisticated innovations. For this reason, it is LECITO to mention a consequential process of industrialization. This process starts from the invention of electricity to the bulb; from that of chemical processes operated on oil to the invention of combustion engine and the era of the automobile.
This was an epoch that brought profound changes also in the financial system: together with large factories were realized also large concentrations of capital, and as a result, large companies were formed creating a damage to small businesses. In fact, if the first revolution was marked by a phase of economic freedom of small artisans and businessmen, the next one was characterized instead by a strong organization of the new industry in monopolies, cartels and trusts among producers. In a short period of time, there is a switch from free enterprise to monopolistic capitalism, which is the strong industrial concentration in the hands of few international trusts that controlled "vertically" al the processes of production, from the raw material to the final product. This concentration of capital and tools brought the small enterprises, unable to face the competition of the big ones, to be assimilated by these latter or even disappear.
Such big market gave rise to the need of having huge amount of capital available only from the big banks, that were not more satisfied by lending money to industries or enterprises, but soon they pointed to their manage by the massive acquisition of shares. Thus, banks and industries merged, also the banks monopolies with the industrial ones,

including financial capital and industrial capital, giving rise to the so-called financial capitalism.

Due to the banks' influence on the economic life, a new form of cooperation and alliance between political governments and banks was formed. Indeed, the economic power established with the industrial concentration immediately sought protection by the political power, which became a way of ensuring both the expansion of capital and the containment of the workers' masses.

1.4.3 The imperialism

The governments' decisions were influenced by the economic and financial interests of the banks and soon, with the colonialism, such conditioning was operated even outside the national borders with funds to developing countries, in exchange for raw materials and cheap labor.

The economy itself becomes colonial and the debtor countries were generally obliged to reinvest the funds received for the purchase of products and machineries of the creditor countries as happened for the English capital that found a fertile field in the British Empire. In this case, it is possible to mention the economic Imperialism, as the " natural product of the economic pressure of a sudden increase of capital, that cannot find employment at home and needs foreign markets for goods and investments"[14]. There seems to be a strong link between capitalism and imperialism so as to justify its necessity: "as expensive, as risky this process of imperial expansion may be, it is essential for the continuity of the existence and progress of our country"[15]. Later, Lenin himself, by taking the work cited in Hobson, makes further considerations: "The Imperialism emerged from the development, as a continuation of the fundamental qualities of

[14] Hobson, J.A. (1902), "Imperialism: a study", source available on: https://www.marxists.org/archive/hobson/1902/imperialism/

[15] See footnote 14

capitalism. But the capitalism became capitalistic imperialism only at a specific and very high stage of its development, when (…there was) the replacement of capitalistic monopolies to free competition. To give the briefest possible definition of imperialism, means to say that imperialism is the monopolistic stage of capitalism"[16]. The First World War itself is the result of imperialism; rather it is an imperialistic war that aimed at annihilating the state competitor to conquer the colonies.

1.4.4 Fordism

Henry Ford has been among the many characters of his era who contributed with his own inventions, but also with his intuitions, to deeply revolutionize its era and to even lay the foundations for the contemporary's one.

Even in this case, it would take the cue from a previous process of industrialization. Indeed, few years before, two German inventors, Karl Benz and Gottieb Daimler, invented the first combustion engine based on which Ford imagines, designs and plans the first vehicle moved by energy generates from the oil combustion. Beyond the dynamics from which the modern vehicle's production will take inspiration by, Ford's more important intuition was to design a process, faster, more efficient and economic for the spread of the famous Model T: the one that refers to the internal assembly line, another example of the rising necessity of the human-machine interaction. The Ford's aphorism "Coming together is a beginning; keeping together is progress; working together is success"[17] laid the ground for an innovative organizational and industrial system that was later called "Fordism" and implemented starting in 1913 in his car

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[16] V.I. Lenin, "*L'Imperialismo fase suprema del capitalismo*, in *Opere*," vol. 22, Roma, Editori Riuniti, 1966, cap. VII, pp. 265-266

[17] "21 Quotes from Henry Ford on Business, Leadership, and Life", Erika Andersen, 31.05.2013, Forbes, http://www.forbes.com/sites/erikaandersen/2013/05/31/21-quotes-from-henry-ford-on-business-leadership-and-life/

factory based on the principles of the Taylorism[18]. This innovative production process was aimed to increasing production efficiency through rigorous planning of individual operations and phases of production, and through the general use of the assembly line.

The practical application of the rhythm and the scientific organization of the work of Frederick Taylor lay the foundation for the idea that the new models of organizing production could trigger a virtuous cycle, which can power a virtually unlimited growth. Inside the Fordist'philosophy, the factory is the central place of all strategic decisions: is the production that creates the market, so much so that Ford used to say that all the production is sold. From a practical standing point, the scientific training of workers, the standardization and simplification of processes and the introduction of the assembly line, make possible large-scale productions. Meantime, the concentration of activities in large industrial plants allows to exploit economies of scale and to gradually reduce the unit cost of products and, therefore, their selling price. As mentioned before, another critical factor in understanding Fordism, is the "piece rate differential", the new remuneration mechanism by which wages are determined by the quantities produced over a period of time. Despite this model was widely criticized for the possible impacts on the quality of jobs, it contributed to a sharp increase in wages of workers in factories and then to feed the virtuous circle.

Thanks to changes in the organization of the factory work, incomes of workers could have increased without a decrease in profits, but rather an increase of it. The demand results in increases in the amount of consumer goods and, thanks to higher wages, is realized mass production, which is accompanied by higher labor productivity.

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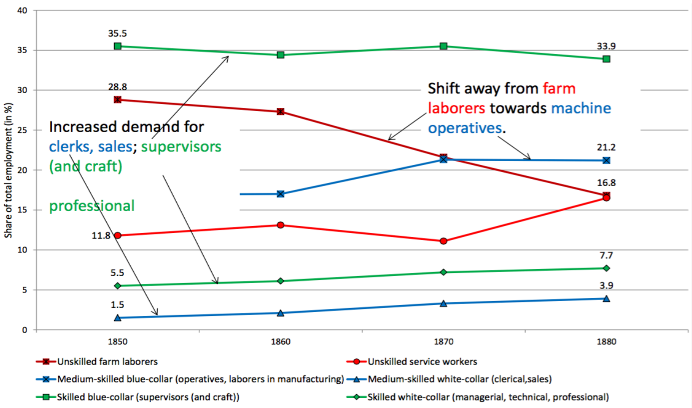
[18] "The principles of Scientific Management", Frederick Winslow Taylor, 1910, pdf available on:
http://nationalhumanitiescenter.org/pds/gilded/progress/text3/taylor.pdf

1.5 The beginning of Information Revolution

The small hint that was started on the first and second industrial revolution, together with the effects that these have produced in the socio-economic environment from the XVIII century to the present day, where innovative concepts like the factory system, efficient production and assembly line, human-machine interaction, have been exasperated and just mentioned. However, the abovementioned concepts were enough to ask some questions. What is the impact of new technologies on the world of work? The better productivity is always corresponded with more employment? What skills do workers have acquired?

Industrialization offered new, highly- paid opportunities for a small number of skilled carpenters, metalworkers, and machinists; but most industrial jobs were unskilled, repetitive, badly paid, and came with poor working conditions

Figure 2: Skill-upgrading in the US occupational distribution, 1850-1880



Source: (Katz & Margo, 2013)

According to the study of Katz and Margo, (2013) over the period 1850 to 1880, the introduction of purpose-built machinery (e.g. assembly line) and the rise of large factories resulted in the shift from farm laborers to machine operatives. In manufacturing, for instance, there was an increased demand for clerks, supervisors and managerial, technical and professional occupations. In services, increased demand for unskilled service workers (e.g. travel), medium-skilled services (e.g. sales) and skilled services (e.g. managers).

However, the same analysis showed that the manufacturing distributions exhibit hollowing out between 1850 and 1910 with a declining share of skilled artisans, and rising shares of operatives and white collar workers.

The same questions have become even more insidious if made glancing at the recent time. The invention and the subsequent completion of the electronic processor, the advent in the 1960s of the interconnected communications networks, the invention of the cell phone-based transmission, finally to the new tools used to build real products prototypes just by sending data between two or more devices, are all the pillars of a new age and a new and more global revolution, this time, technological. The period after the first industrial revolution and among the second one, has been defined as Information Revolution. This began with the digitalization of individual enterprises, which created networks of increasingly ubiquitous computers over the period 1950-1990.

In this new information society, raw material and cheap labor can no longer sustain economies (indeed, they have not sustained economies for more than a century, as attested by the industrial divide). ICTs were instrumental to the creation of a flexible economy where production can be located at any point of the globe. Knowledge, rather than labor, is the key element for sustainable development in this global economy. By enabling fast and low-cost collection, processing and dissemination of information, the new technologies have become essential to economic growth. ICTs also promote international cooperation and provide powerful tools for research and development (Jurich, 2000)

Jeremy Rifkin, in his book "The End of Work: The Decline of the Global labor Force and the Dawn of the Post-Market Era" (Rifkin, 1966) in asserting that from the very beginning, the human civilization is structured largely around the concept of work, he also warns that "today, for the first time, human labor is being systematically eliminated from the manufacturing process; within the next century, the mass work in the market economy is likely to be deleted in almost all industrialized nations of the world. A new generation of sophisticated computer and information technology is introduced in a wide range of work activities: intelligent machines are replacing humans in endless tasks, forcing millions of workers and employees to queue in the employment offices or worse, those in the public service" (Rifkin, 1966).

The security of many CEOs and most orthodox economist, who predicted an unprecedented abundance of material goods, does not convince Rifkin. He writes, "Millions of workers remain skeptical. Every day a growing number of employees turn out to be out of the game; every day, in offices and factories around the world, people wait and pray, full of fear, hoping to be able to escape once again. As an unrelenting epidemic that moves from town to town, this new disease of the economy…spread from market to market, destroying lives and destabilizing entire communities" (Rifkin, 1966). Rifkin evokes again the thought of Keynes and definitely repudiates William Easterly and the "Luddite fallacy". Trying to summarize the vision of Rifkin, he ultimately "challenges the cascade effect theory, according to which the long wave of technology and productivity fail to spread to the masses in the form of lower prices, greater purchasing power and more jobs, in a virtuous circle where the greatest demand, stimulated by lower prices stimulate production and hence employment"[19].

However, the evidences expressed by the author's thought are already perceivable. The worker, the ticket issue clerk, the secretary, the

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[19] Caruso, E., "Come vincere le sfide della concorrenza. Le fonti del vantaggio competitivo", Tecniche Nuove, 2003, pag. 34

minor officials and ranks of employees with simple tasks are jobs undergoing to an inexorable decline.
The vision of Rifkin on the impact of new technologies on the labor market may seem excessive, maybe too pessimistic, since from the time of the first industrial revolution transformations imposed by industrialization had destroyed certain tasks, but also creating, however, at the same time, new ones. It's true that the message of Rifkin encourages weighting the link between market globalization and information revolution, which has significantly contributed (and will contribute) to shape the world where everyone lives.

1.6 Conclusion

In this analysis, it must be accepted that the transition to future technology will accelerate the trend to replace the physical labor, with automated production, rather than digitized.
The man's need to create always new tools, to always upgrade its quality of life and way of living, had brought to a succession of inventions and innovation, which goes under the name of Industrial Revolution.
The combination of several innovations, linked by a common denominator, which was the industrialization, created significant changes by revolutionizing both industrial production and socio-economic context of each country. A first milestone could be considered the creation of the steam engine, which laid the foundation for the implementation of new machines that revolutionized the UK industries in terms of higher production and few workers needed to perform a single task. This brought to the first protests and the rising of the concept of technological unemployment.
With the beginning of the second Industrial Revolution, new discoveries brought to a huge expansion of markets boundaries that led to a sort of limitless technology advancements potential. During

this period, the scientific discoveries were no longer hidden in the laboratories; instead they became an incentive for new inventions.

From a study conducted by Katz and Margo, (2013) over the period 1850 to 1880, it was shown that the introduction of purpose-built machinery (e.g. assembly line) and the rise of large factories resulted in the shift from farm laborers to machine operatives. In manufacturing, for instance, there was an increased demand for clerks, supervisors and managerial, technical and professional occupations. In services, increased demand for unskilled service workers (e.g. travel), medium-skilled services (e.g. sales) and skilled services (e.g. managers). However, the same analysis showed that the manufacturing distributions exhibit hollowing out between 1850 and 1910 with a declining share of skilled artisans, and rising shares of operatives and white collar workers.

The first two stage of the Industrial Revolution are just the beginning of a process of polarization of the labor market, which will become deeper as the technology advancements will continue to grow in the following stages.

Chapter 2:
The second Machine Age

2.1 Introduction

In the recent years, researchers have devoted significant resources in the attempt to explain a phenomenon, termed "job polarization", which is affecting the job market in some of the advanced countries worldwide. Acemoglu (1999), Goos (2007), Goos M. A. Manning (2009), Autor (2010) among others, argued that, since the 1980s, employment is becoming concentrated according to the occupational skill distribution. The hollowing out of the middle class (Holmes 2012) (Holmes, 2010) (Goos and Manning, 2007) and others, can be linked to the gradual disappearance of jobs focused on what several scholars, like Frank Levy and Richard J. Murnane[20], identified as "routine" tasks: activities that can be performed by machines following a defined set of rules.

This trend is becoming even more evident in an era in which computerization and globalization represent the drivers of employment and unemployment literatures as well as job, wages and earnings inequalities.

This second chapter analyzes the so-called "second machine age"[21] and the impact exerted by the diffusion of technologies belonging to the second industrial revolution. Starting from the classification of job tasks and the way in which they are performed, this chapter discusses the changes occurred in the demand for new skills as a results of increased computerization and of the globalization of many economic sectors and illustrates how the labor market is becoming more and

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[20] See for example "How computerized work and Globalization Shape Human Skill Demands", Industrial Performance Center, Massachusetts Institute of Technology, IPC Working Paper Serie, August 2005.

[21] See the book of Erik Brynjolfsson and Andrew McAfee "The second Machine age: Work, progress, and prosperity in a time of brilliant technologies", W.W. Norton & Company, New York, 2014

more polarized with the unavoidable consequence of the rising of inequalities and the continuous decrease in the job skills.

Finally, the last paragraph addresses some projections on the job mobility of workers in the next decades.

2.2 The impact of computerization and globalization in the job demand

Historically, computerization has been confined to manual and cognitive routine tasks involving activities that can be expressed as a set of explicit rules (Autor *et al* 2013). Computers will therefore be useful and productive only when a problem can be specified and all the criteria for its success can be quantified and evaluated (Acemoglu D. a., 2011).

The extent of which job computerization could be determined depend upon both the ability of a programmer to write a set of procedures that a computer can use in each possible contingency, and by the technological advances that allow engineers to sufficiently specify such problems.

According to this explanation, the task categorization made by Autor, *et al* (2003), which distinguishes jobs on a two-by-two matrix, with routine versus non-routine task on a axis, and manual versus cognitive task on the other, could be a good starting point in understanding the contents of this work.

Figure 3: Autor task categorization

	Routine tasks	Nonroutine tasks
	Analytic and interactive tasks	
Examples	• Record-keeping • Calculation • Repetitive customer service (e.g., bank teller)	• Forming/testing hypotheses • Medical diagnosis • Legal writing • Persuading/selling • Managing others
Computer impact	• Substantial substitution	• Strong complementarities
	Manual tasks	
Examples	• Picking or sorting • Repetitive assembly	• Janitorial services • Truck driving
Computer impact	• Substantial substitution	• Limited opportunities for substitution or complementarity

Source: Autor and Levy and Murnane (2003)

Routine tasks are those activities that follow explicit rules and so, that can be accomplished by machines, as discussed before; non-routine task, instead, are not sufficiently well understood and codified by engineers. Each of these tasks can be of either manual or cognitive nature, depending on the relation they have with physical labor or knowledge work.

However, following the recent technological advances and the progressive price declining in the real cost of computers (MGI, 2013), computerization is now entering domains and procedures that refer as non-routine task as well.

Before going into details, it seems appropriate to draw a scheme of the abilities and the limitations of computers in order to understand the impact they have in the changing of jobs in the economy.

Next paragraphs address Levy and Murnane work (2013), which distinguish the set of activities that allow computers do to what they do and do not do (yet).

2.2.1 How computers perform their activities

By recalling what it is written in the Introduction, it can be said that technology, to some extent, changes the way a job is performed by changing how specific task are done into detailed set of rules.

Easy tasks like dispensing tickets in an airport or combine car's pieces with industrial robots in order to fasten the production, are examples of tasks that, because of their simplicity in terms of combination of different actions, are perfect candidates for being substituted by computers. Nevertheless, there are examples[22] in which computers can just complement human skills in carrying out tasks in a more efficient and fast way but can not substitute them completely.

In order to understand when a specific outcome occurs, it has to be clarified that all human work involves the cognitive processing of information while computers just execute rules. Under this light,

[22] The authors explained the example of a vascular surgeon in which the help of a coil inserted into an arterial, transmit real time images on a screen.

computers can substitute humans in performing a task when two other conditions occur: the information condition and the processing condition (Levy, 2005). While the first one is quite easy to understand since refers to the identification and the codification of tasks in a form that computers can process, the second one could be divided into a sub-set of rules: deductive rules and inductive ones. Deductive rules are those expressed as a logical or sub sequential procedures easy to identify and process and are called rule-based logic. The second sub set of rules, instead, are used to describe information that can not be classified as a series of logical steps; these rules are the result of the estimation of several models based on the relationship of information inputs and the processed output of samples of historical cases. This kind of information, processed as inductive rules is described as pattern recognition.

2.2.2 What computers do not perform yet

Levy and Murnane (2013) stressed the accent on the best strength of human mind: the flexibility. The latter is the ability to process and integrate many kinds of information to perform a complex task. On the other hand, the computers' strengths refer to the speed in processing information and on the accuracy of the results, not in flexibility, because computers are best at performing tasks for which it is easy to identify logical rules or statistical models.

Even if a lot of tasks have been simplified through an imposed structure in order to be computerized, there are still many that computers cannot perform because of the absence of either the Information Condition or the Processing Condition.

In a situation in which they need to understand relationships between things or to go beyond a defined scheme, computers lack the common sense needed for the right response. Driving through a city or comply with new signals or temporary lights on a road, requires a very high level of common sense that it is not yet translated perfectly into codes or rules. Google' driverless car for example can detect and respond to stop signs that aren't on its map, a feature that was introduced to deal with temporary signs used at construction sites. But in a complex situation like at an unmapped four-way stop the car might fall back to slow, extra cautious driving to avoid making a mistake[23].

The Processing Condition can be equally problematic for complex cognitive problems, but also for simple physical task like walking in a crowded room quickly and safely. In a more generic meaning, cognitive complexity arises in solving new problems, problems that engineers or coders, didn't know before or didn't imagine it could happen. In these situation the human mind flexibility can fit the new information and design a specific outcome that computer cannot.

A conclusion can be summarized in Figure 1 in which the authors identified the different task that can and cannot be computerized highlighting the fact the human work includes both high skilled and low skilled task.

Figure 4: Varieties of Computers Information Processing

Increasingly Difficult to Program →

	Rules-Based Logic	Pattern Recognition	Human Work
Variety	Computer Processing using Deductive Rules	Computer Processing using Inductive Rules	Rules cannot be Articulated and/or Necessary Information cannot be Obtained
Examples	Calculate Basic Income Taxes Issuing a Boarding Pass	Speech Recognition Predicting a Mortgage Default	Writing a Convincing Legal Brief Moving Furniture into a Third Floor Apartment

Source: Frank Levy and Richard Murnane

To this point, Levy and Murnane, identified a sort of new skills, typically related to the human being, that work with the pattern

[23] Gomes Lee, "Hidden Obstacles for Google's Self-Driving Cars", MIT Technology Review, August 2014, http://www.technologyreview.com/news/530276/hidden-obstacles-for-googles-self-driving-cars/

recognition and the information processing: the expert thinking and the complex communication.
Expert thinking is related to the ability of solving problems for which there are no rule-based solutions. These problems require the abovementioned pure pattern recognition and information processing that cannot be programmed on a computer as of today. In these kinds of tasks, computers can act just as complements to humans by making information more readily available.
On the other hand, the tasks requiring the so-called complex communication are tasks involving the interactions with humans to acquire information, to explain it, or to persuade others of its implications for action, such as a manager's speech that motivates people or a teacher who interacts with their students and make them more passionate about a specific topic.
Going back to the two-by-two matrix described by Autor, a recent study made by Frey and Osborne (2013) examines how the computerization is expanding into the performance of non-routine tasks and in so doing it is affecting the large portion of the job market.
By recalling the meaning of routine and non-routine task, Brynjolfsson (2011) explains how the recent technological breakthroughs are due to the effort to turn non-routine task into well-defined problems. By doing so, computerization is becoming no longer confined to routine task, but, thanks to increased opportunity to engage in the processing of massive amounts of data (MGI, 2011), is spreading the most non-routine tasks both cognitive and manual.
In the cognitive non-routine tasks, the phenomenon is evolving throughout the years on the evidence that, in managing large datasets, machines scale better than human labor (Campbell-Kelly, 2009) and, on the same time, on their absence of human natural biases.
Several examples can be found in different domains in which the comparative advantage of computers is likely to change the nature of a

wide range of occupations; from the legal and financial services (Markoff, 2011), to the health care (Cohn, 2013).
Moreover, the continuous improvement of sensor data[24], and the declining costs of digital sensing, are the principal drivers of the acquisition of big data useful to monitoring applications ranging from city lights, water quality and other public property (Ackerman and Guizzo, 2011).
An increasing trend is also related to the advances in user interface that enables computers to respond actively and directly to a wider range of human requests, thus acting as complement of high skilled labor or in some cases as substitute.
Thinking about the vocal assistances that almost everyone has in their smartphones such as Apple's Siri, Google Now or Microsoft Cortana that are able to recognize spoken words, interpret their meaning and interact with the user according to what she said. This kind of technology is evolving over time and is now used in a lot of call centers, thus, eliminating work places. Another example is the increasing uses of algorithms in jobs that require subtle judgment such as the one of a Financial Advisor. In many of its tasks, the decision making of an algorithm could represent a comparative advantage over human operators or may serve as inputs to them. Artificial Intelligence algorithms are able to process a greater number of financial announcements, press releases, and other information than any human operator, and then act faster upon them (Mims, 2010). Moreover, advances in Machine Learning allow a programmer to leave complex parameter and design choices to be optimized by any algorithm (Hoos, 2012) and, as a consequence, the same algorithms can automatically detect bugs in software more precisely than humans (Kim, 2008). According to this scenario, an algorithm can better keep track of itself

[24] By using the term *sensor,* it implies the device that detects and responds to some inputs from the physical environment.

and the whole of a program in working memory, without being checked and subject of humans' intervention.

Although the impact and the extent of these latter developments is not defined yet, estimates by MGI (2013) highlights that around 9% of the global workforce (230+million full-time knowledge workers) could be substituted by sophisticated algorithms.

In the manual task environment, on the other hand, industrial robots are having a huge impact upon employment especially in routine tasks of most operatives in manufacturing. Volkswagen, for example, is going to replace about 32,000 employees with robots in order to obtain a price advantage over the competitors by reducing the cost per hour and by eliminating the human biases[25]. In a similar manner, the computerization of logistics is being aided by the increasing cost-effectiveness of highly instrumented and computerized cars that contain on-board computers that completely eliminate the mechanical connection between "the wheel in your hands and the wheels on the road"[26]. These will permit, thanks to the advances in sensor technology, an algorithmic vehicle controller to monitor its environment to a degree that exceeds the human capabilities.

This emerging technology will affect a variety of logistic jobs through the replacement of agriculture vehicles, autonomous robots able to transport food and samples in hospitals and so on (Bloss, 2011).

According to MGI (2013), technological advances are contributing to declining costs in robot with an average of the 10% annually over the past decades. As a consequence, a lot more users and factories will use them as Markoff (2012) explains talking about Foxconn, in China, or Philip Electronics in Netherland.

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[25] See full articles on http://www.manufacturingglobal.com/peopleskills/170/Volkswagen-to-replace-human-workforce-with-robots-in-Germany-to-meet-demand or http://www.wired.it/attualita/tech/2014/10/15/volkswagen-gli-operai-costano-troppo-assumeremo-robot/

[26] See "Nissan's Steer-By-Wire System Brings Us Closer To Autonomous Cars", Damon Lavrinc on http://www.wired.com/2012/10/nissan-steer-by-wire/

As robots cost decline and technological progress expand, robots will likely continue to take advantages on an increasing set of manual task in manufacturing, packaging, agriculture as well as in performing more complex tasks in the food preparation, health care or elderly care (Robotics-VO, 2013) (Namdev, 2014).

In this scenario, robots can thus be expected to gradually substitute for labor in a wide range of either routine or non-routine low-wage manual tasks, where most US job growth has occurred over the past years (Autor and Dorn, 2013), and then to diminish the protection of these jobs from computerization.

2.3 The task restructuring

The very used task model of Autor *et al* (2003), has been utilized in order to deliver intuitive and accurate predictions in topics concerning that: computers are substitutable for human labor in routine relative to non-routine task; and that greater intensity of routine inputs increases the marginal productivity of non-routine inputs.

However, as explained in the previous sections, computer capital can now be used as perfect substitute as well as for a wide range of tasks defined as non-routine. Under this light, the task model of Autor is not suitable in predicting the impact of computerization on the task content of employment in the second machine age.

A kind of reinterpretation of the task model of Autor was provided by Osborne and Frey (2013) especially because of the recent developments in machine learning, due to the continuous increase in availability of big data, that allow for patter recognition, and thus enable computers to rapidly substitute for labor in non-routine tasks. What the authors pointed out, however, is the presence of some inhibiting engineering bottlenecks to computerization. The new task model thus predicts that the pace at which these bottlenecks can be overcome will determine the extent of computerization in the twenty-first century. In other words, the model predicts that computerization can be extended to any non-routine task that is not subject to any

engineering bottlenecks to computerization. Osborne and Frey then identified several engineering bottlenecks, corresponding to three main tasks, which will set the boundaries for the computerization.
The three bottlenecks related to task categories can be summarized as follows:

1.1. ***Perception and manipulation tasks.*** Human perception is something that has not been yet identified reasonably enabling sophisticated sensors and lasers to identifying objects and their properties in a cluttered field of view. Said that, jobs and tasks that relate to unstructured and to a subtle work environment can make jobs less susceptible to computerization.

   To some extent, the difficulty of perception has a correlation with tasks related to manipulation and, in particular, with the handling of irregular objects. The main problem is in the planning of the correct sequence of actions required to move an object from one place to another.

1.2. ***Creative intelligence tasks.*** Creativity is a very broad concept and difficult to specify. Creativity, to some extent, is the human ability to create ideas or artifacts that come up instantaneously with the power of the mind: is a natural and biological phenomenon extremely related to the human kind and to its evolution. Ideas include poems, novels, musical compositions, the draft of a convincing speech, whereas artifacts are objects like paintings, advanced machineries and so on. Recalling what Levy and Murnane (2005) said about the common sense, one process of creating ideas involves making unfamiliar combination of familiar ideas in order to find some reliable means or frameworks that make sense. In principle, such creativity in robots has been developed over time and some approaches already exist. Suzuki (2014) provides an example of an evolutionary painting algorithm, which takes example of paintings of a given style and progressively mutates them – cutting and splicing and flipping elements, throwing out at each evolution any images that don't match the user's initial stylistic choices. But there are also some who would teach computers to paint like humans, to push them beyond the point of being just a mere algorithm instead of an extension of the artist himself. Harold Cohen[27] is the pioneer of this regard: he is a former artist who created AARON, a drawing program, that has generated thousands of line drawings, which have been exhibited in several galleries worldwide. There are also some examples regarding software able to compose music, like the one of David Cope[28], or software created for teaching computers to be writers or storytellers, as the one of Automated Insight[29] which transform companies data into stories. The main problem in the computerization of creativity is stating the creative values of the novelty and, because creativity involves not only novelty but also value, and because values are highly variable among each person or culture, it follows that many arguments about creativity are rooted in disagreements. Finally, if the problem of clearly encoded in a program such values (Boden, 2003) will not be overcome, it seems unlikely that occupations requiring a high degree of creativity will be automated.

[27] For further information visit: http://www.aaronshome.com/aaron/index.html
[28] For further information visit: http://artsites.ucsc.edu/faculty/cope/
[29] For further information visit: http://automatedinsights.com

1.3. ***Social Intelligence tasks.*** The range tasks of human social intelligence involve negotiation, persuasion, care and all the activities that have a relation with the human interaction. While algorithms and robots can now reproduce some aspects of human interaction (Breazeal, 2003)[30] (Feil-Seifer) (Gockley *et al* 2005), the complete recognition of natural human emotions and social interaction, remains a challenge. This task is also related to the common sense information possessed by humans, which is difficult to articulate and to to be provided by an algorithm. For these reasons, the probability of an occupation being automated by computer capital is very low at least for the next decades.

2.3.1 The job susceptibility

In this section the focus will be addressed on the "real" impact that technology has on the job environment in the second machine age. For this purpose, it will be used the recent study made by Osborne and Frey (2013) in which they try to answer to a specific question: "how susceptible are jobs to computerization?"

Starting from the task model of Autor *et al* (2003), the authors then used data from an online service developed for the US Department of Labor, the O*NET. The decision of using the latter relies on the fact that it provides open description of specific tasks as well as the key features of an occupation as a set of variables. This was important for two main reasons: to objectively rank occupations according to a mix of skills and knowledge; and to subjectively categorize them based on the variety of tasks they involve.

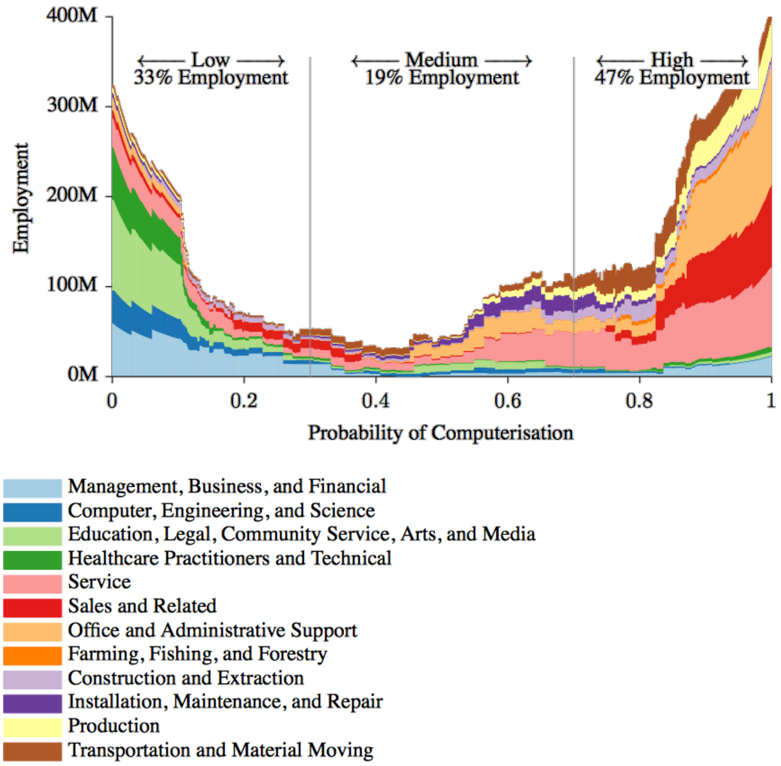
In order to be forward-looking, Osborne and Frey examine the existence literature along with their drawbacks and then they built up a new approach based on both the hand-labeled of 70 occupations,

[30] Breazeal is also the CEO and Co-founder of the first family robot JIBO.

assigning 1 if automatable, and 0 if not, and the objective O*NET variables corresponding to the bottlenecks to computerization.

Based on the available data, they distinguish between high, middle and low occupations depending on their probability to be computerized. The finding shows that almost the 47% of total US employment is in the high-risk category.

Figure 5: Jobs distribution based on the probability of computerisation



Source: Osborne and Frey (2013)

The extent of which computerization will be determined in next decades, depend upon the abovementioned engineering bottlenecks to automation and by the following of two waves of computerization. What the authors predicted was that in the first wave, the most workers in transportation and logistic, together with office and administrative support occupations are likely to be automatized. However, this wave of automation will be followed by a persistent slowdown due to the increasing in inhibiting engineering bottlenecks.

The second wave will mainly depend on these bottlenecks related especially to creative and social intelligence tasks. The final predictions are intuitive: occupations related to management, business or finance, and in general all the jobs/tasks that require an intensive use of social intelligence, are largely confined to the low risk category. On the other hand, the computerization of occupation in the medium risk category will mainly depend on perception and manipulation challenges due to the constant technological improvements in such tasks.

Finally, what is remarkable from the recent evidences, is that computerization is becoming one of strongest drivers for a phenomenon called job polarization, which will be analyzed in the next paragraph.

2.4 The "hollowing-out" and the job polarization

By definition[31], the "hollowing out" is the deterioration of a country's manufacturing sector when producers opt for low-cost facilities overseas. In this analysis, the term hollowing-out will be used, instead, as synonymous for job polarization.

The job polarization is the process by which, dividing the total share of employment in three ranks of jobs, low, middle and high ranked jobs[32], it is possible to identify an expansion of high-ranked and low-ranked jobs over the middle ones. Thus, more high-level jobs are created, such as managers or technicians, but there is also a relative growth of the share of low-level jobs. These increases in employment shares are both related to a decrease of middle-level jobs, such as administrative or production jobs.

The phenomenon has been highly observed in UK, US, and many other developed countries, and most of the literatures agree on the possible causes of it.

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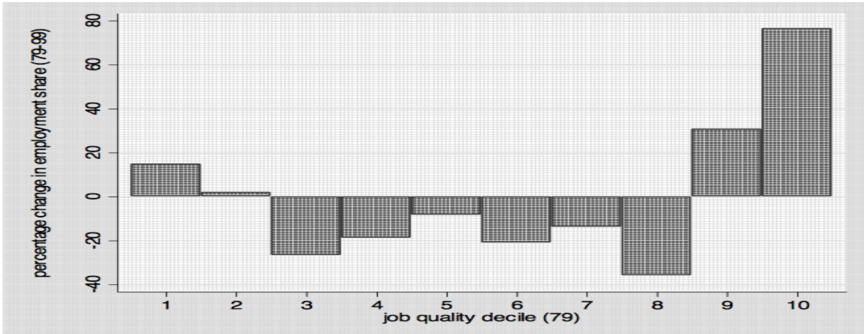
[31] Definition taken by Investopedia. www.investopedia.com

[32] The jobs are ranked according to their initial wage.

One of the most relevant papers explaining the job polarization, is the one of Goos and Manning (2007) in which they classified jobs, according to the Labor Force Survey, on their wages and then by dividing these in decile where decile 1 represents the 10% of jobs paying the lowest wage.

Figure 6: Employment share by job quality decile, 1979-1999 UK

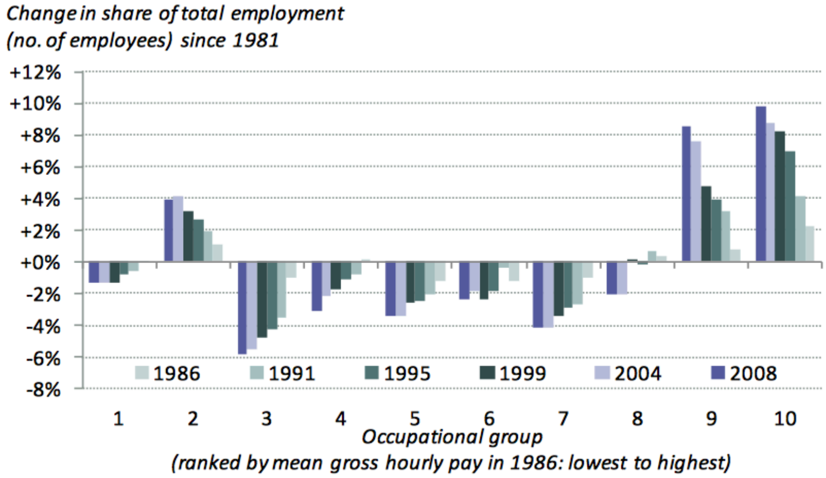


Source: Goos and Manning (2007)

The results have shown that the largest increase in employment share has been experienced by decile 10 followed by decile 9, so that, the largest growth in jobs was related to the high-level jobs. The only other two decile that have increased their shares are decile 1 and 2, representing the low-level jobs. The decile in the middle, instead, have all seen a decrease in their employment share over all the period studied.

Holmes and Mayhew (2012) also replicated the results of Goods and Mannings, by studying a longer period of 1981 to 2008. They ranked jobs again by mean average pay and then divided into decile. The findings highlight an employment share growth in decile 1,9 and 10 with the largest increase in the latter two.

Figure 7: Employment share by job quality decile, 1981-2008 UK



Source: Holmes and Mayhew (2012)

Evidences also show the change in percentage related to employment shares growth in the categories associated with the different decile.

Table 1: Jobs occupation growth rate, 1981-2008 UK

	1981-86	1986-91	1991-95	1995-99	1999-04	2004-08	1981-2008
Professional	19.1%	5.9%	4.9%	10.0%	3.6%	3.7%	56.4%
Managerial	11.5%	19.6%	13.8%	-1.8%	-1.4%	6.8%	56.7%
Intermediate	14.0%	15.5%	3.0%	0.0%	11.9%	3.2%	56.6%
Routine Admin	-6.0%	-11.4%	-4.4%	0.9%	-11.8%	-9.3%	-35.8%
Routine Manual	-13.1%	-12.1%	-10.4%	-6.8%	-17.5%	-5.8%	-50.4%
Non-routine Service	12.6%	10.9%	11.0%	5.4%	16.7%	1.0%	72.2%
Non-routine Manual	1.8%	-4.3%	-15.0%	-5.3%	20.8%	0.8%	-4.3%

Source: Holmes and Mayhew (2012), by Labour Force Survey 1981-2008

In the period considered, high-level jobs such as professional and managerial, or jobs with a high level of human intermediation, had an overall high growth related to routine and non-routine occupations.

The US also represents a pool of observations very similar to the UK pattern of polarization. For example, Autor and Dorn (2013), by using the US census data, obtained a very large sample sizes and they grouped occupations into one hundred percentiles of their 1980 mean hourly wage distribution, and then plotted the change in the share of aggregate hours worked in each percentile for the period 1980-2005. The results have shown the U-shape curve with positive changes in employment share in the first percentiles, and then from the 60th percentile upward.

A similar result was also found by Autor *et al* (2006) by changing the method of ranking from the initial wage to the average education level. The highest employment growth in occupation was in both low and high initial mean education levels over the period 1990-2000. The only difference with the other findings was in the timing of the change: for the 1980-1990 period, the relationship is linear, with larger employment growth for occupations with higher initial education levels. This could probably suggest that the polarization took off in the early 1990s.

Nevertheless, Mishel (2013) pointed out that the phenomenon of polarization has been occurring since at least the 1950s in the US, reflecting skill upgrading. The gradual disappearance of the middle-ranked jobs could be therefore not the defining characteristic of job polarization, but rather the increase in the share of low-level jobs that was dominated, since the 1950s, by the continuous growth of the service sector.

Researches on the job polarization have also been done in other European countries. In Germany, Spitz-Oener (2006) created her own Skill Index, based on levels of education, and ranked occupations in Germany into decile as Autor and Goos. She then plotted the change of employment shares for each decile over the period 1979-1999, and obtained similar results to those in the UK and US.

Another example is offered by the study of Andermon and Gustavsson (2011) made for the Sweden over the period 1975-2005. The case of Sweden was considered very interesting given the very different labor market compared to those of the other countries studied. Indeed, in Sweden, there is a greater importance of unions, employment protection and welfare support together with a similar wage distribution. For these reasons, it was of interest to see whether similar patterns of polarization have emerged in such a protected labor

market. Andermon and Gustavsson created a wide range of non-empty industry occupation cells, and then ranked them into quintiles according to the 1975 mean wage. The results have shown the same patterns of UK and US, with positive employment growth in quintiles 1,4 and 5 and declines in the others. Furthermore, they divided the period in two set, and they found out that there were a constant increase in low level relative to middle-level jobs up to the 1990s, whereas the biggest growth in high-level relative to middle-level jobs has been concentrated in the second set of period from 1990 to 2005.
In addiction, other studies have considered multiple countries in the same research, as the one of Goos *et al* (2009), in which the authors used data from the European Labour Force Survey, to investigate the polarization in sixteen European countries. The final results were similar over the countries, highlighting evidence of job polarization with the employment share of the lowest-level relative to the middle-level jobs increasing over the period from 1993 to 2006, while the employment share of the highest-level jobs increases in every country and across all the period studied.
Finally, the work of Oesch and Menes (2011) compares polarization in four countries, very different in terms of labor market institutions. What they found was the largest increase in employment shares for the highest-quintile jobs, in all of the four countries without no distinctions. The biggest differences were observed at the bottom end of the labor market in which there was an expanding employment share in Spain and UK, but not in Germany and Switzerland due to the more protected and less flexible labor market of the latter two.

2.4.1 Causes of job polarization

In the attempt of explaining the reason for hollowing out of the job distribution, the technological change seems to be one of the most appropriated. In particular, Autor *et al* (2003) have been developed the theory of task-based technological change (TBTC), highlighting the case that, first, the impact of technological change does not depend on the skill level of the worker, but rather depends on the task that the worker is doing. This, together with the price falling of computers, and the feature of repetitiveness of routine jobs, led to an exponential increase in technological substitution.

In order to undertake their analysis, Autor *et al* defined first the tasks involved in many occupations listed in the Dictionary of Occupational Titles, and then they classified them into five types: routine manual and non-routine manual, non-routine analytic and non-routine interactive and, finally, routine cognitive.

The authors then analyzed the changes in employment by occupation, to better determine the changes in the task involvement. The findings shown that both the types of non-routine cognitive work had experienced an up-warded trend since the 1998. On the other hand, both routine cognitive and manual and non-routine manual task had declined throughout the period of study.

Furthermore, to relate these trends to technological change, Autor *et al* created an industry level data set, in which the change in the use of tasks is determined by changing occupation structures. In this way, they measured technological change by the change in the percentage of workers in the industry who used a computer in their jobs: the results have shown a strong positive and significant relationship.

However, Autor *et al* in their researches did not mention specifically the hollowing-out and job polarization. The link between the TBTC and the job polarization was indeed made by Goos and Manning (2007) who pointed out that the routine jobs affected by technology are most often found in the middle of job distribution concerning routine tasks such as administrative office tasks and skilled production jobs.

There are also other theories of job polarization discussed in the literatures. One of these was made by Goos *et al* (2011) in which they argued and estimated that an alternative cause of the hollowing-out is the offshoring and the global competition for labor, whereby firms in their home country, take advantage of lower labor costs in foreign' to offshore part of the production process.

The jobs more likely to be offshored are production jobs, as Apple does with Foxconn in China, or administrative tasks such as low-legal tasks or the well known customer call-centers provided by many Indians. Instead, highly skilled managerial or professional jobs are unlikely to be offshored, because the foreign countries with low labor costs don't have a comparative advantage in the provision of such jobs.

Goos *et al* (2009) also hypnotized another possible cause that is related to the phenomenon of income inequality. The idea, expressed in the study, was that the simultaneous emergence of "cash rich-time-poor" and relatively low-income individuals has led to an increase in demand for personal services, as the rich spend their money in buying services that they do not want to do, while, on the other hand, low-income individuals provide a supply of persons willing to undertake such work. Even if the final results of the investigation showed an upward-sloping trend for the low-wage employment in the countries with greater income inequality, the slope of the line is not so emphasized suggesting that the relationship exists, but is weak.

Other authors who investigated the hollowing-out are Michaels *et al* (2010) who undertook their analysis across nine European countries plus Japan and US. The uniqueness of this paper is in the fact that, now, the focus is on the skills of workers, rather than the tasks of jobs. Indeed, the authors distinguish between high, middle and low qualified individuals, and measure the wage bill share of each group within each country over the period 1980-2004. The results of Michaels *et al* reveal a positive and statistically significant coefficient on ICT (Information and Communication Technology) in the high-qualified individuals and, a negative and significant coefficient on ICT in the middle-qualified workers and, finally, a positive but insignificant coefficient in the low qualified. Under the assumption that highly qualified workers are employed in high-skilled jobs, and so on, these results are consistent with the relationship between job polarization and routinisation discussed above.

Furthermore, the study of Autor and Dorn (2013) provides additional evidence for the link between TBTC and job polarization by using a different methodology and the US labor market. In particular, this is a regional level study, focusing on commuting zones in US. The authors measured the routine task intensity in each zone, based on the occupations of the workers, and then they regressed the change in the share of routine employment against the initial level of routine intensity. The results have shown a negative and statistically significant coefficient, highlighting that the decline in routine employment has been greater in the zones with an initial higher share of routine employment. The conclusion of Autorn and Dorn argues that areas are more likely to invest in new technology, the higher the initial proportion of routine jobs that can be cheaply computerized.

A variation and a kind of reinterpretation of the theory of Autor and Dorn and Goos and Manning, is provided by Bloom (2011) in which he had data on firms in twelve European countries over the period 1996-2007. The authors correlated different indicators of technology on the growth of Chinese imports. The results pointed out a positive and significant coefficient, which imply that almost 15% of the technological upgrading in Europe between 2000 and 2007, was due to Chinese imports. Therefore, Bloom *et al* talked about "trade-induced technological change" because new technologies were introduced in order to maintain a competitive advantage over countries competing with low labor costs. The conclusions of the paper argued that, globalization and international trades and competition could itself be driving technological change.

A related analysis to that by Bloom (2011) is undertaken by Autor *et al* (2013), also by recalling previous studies (Autor and Dorn, 2013) (Autor *et al*, 2013), and Akcomak *et al*, (2013) with the explicit intention of comparing the roles of technology and globalization. The findings have shown that both globalization and technology have had their largest effect on reducing employment in the middle occupations. The main difference, in terms of the two effects, is that, while globalization and competition, especially from China, has reduced employment in all the three occupations (high, middle, low occupations), technological change is mostly associated with growth in employment in the highest-ranked occupations, and with a almost zero change in employment in the lowest-ranked ones.

The conclusions of all the studies done by several authors, in which they have tried to explain different causes of job polarization, lead to a suggestion that seems to define the technological change as the main cause of the hollowing-out, while offshoring only affects the employment levels but it has no significant impact on the way how task are organized within jobs.

2.4.2 Wage polarization and job polarization

Having argued in the previous sections the existence of the phenomenon of the "hollowing-out" in different countries worldwide, now, the focus will be in discussing some of the potential impacts of such job polarization.

What it is going to analyze regards the possible relationship between the job polarization and wage distribution, so, whether wages have been polarized in the same way that job did.

By "wage polarization", the literatures (Autor and Dorn, 2013) (Antonczyk *et al*, 2010) means whether there has been faster wage growth at the top and the bottom of the wage distribution, which is unrelated with the concept of "polarization of the wage distribution" that means the movement of employment to the extremes of the wage distribution.

Holding the wage in each occupation constant, job polarization should lead to an increase in observed wage inequality. Indeed, if the number of high wage-jobs increase and the number of low wage-jobs

decrease, under the phenomenon of the job polarization, then the ratio between the final percentiles and the last ones should increase as the wage structure of the first ones will be larger.
In order to better understand how might job polarization influence the wage distribution, it is useful to consider the supply and demand model. According to the theory of supply and demand, a decrease in the relative demand for workers in middle-skill occupations results in a decline in the relative wage for those workers. Similarly, an increase in the relative demand for workers in low- and high-skill occupations leads to higher relative wages for these workers (Tüzemen, 2013).
Job polarization is a demand side variable: recalling the routinisation theory (Acemoglu *et al*, 2011), it has reduced the demand for labor in non-routine cognitive jobs and, given the position of such jobs in the occupation scheme, this lead to the prediction of an increased demand for labor together with an increased in employment share, at the top of the distribution, and a falling demand in the middle of the distribution. Nevertheless, the routinisation hypothesis says that technological progress will have few effects on the non-routine manual jobs at the lower end of the job hierarchy, since the tasks mostly do not involve technology, and labor cannot be substituted by technology. It is more difficult to explain the increased employment shares of low-paid jobs using the demand-side routinisation hypothesis.
However, several authors analyzed data to look for evidence of wage polarization analyzing whether wages were growing faster at both low and high ends of the distribution.
For example, Machin (2009) and Mieske (2009) both looked at the growth rate in wages at each decile of the initial wage distribution over the period 1979-2008. In Mieske results, the growth rates in real hourly wages are presented as annualized changes, averaged across the years within each of the three decades studied. What the author found was no evidences for wage polarization as the growth rates of

real wages were highest in the middle of the distribution with a single exception of decile 6.

Similar results were found by Machin (2009) who analyzed the growth in wages at specific percentiles instead of decile as in Mieske. For every decade starting from the 1980s, he found that the growth rate of wages has raised in the 10th, 25th, 50th, 75th and 90th percentiles, thus, with no evidence of wage polarization.

Other authors, such as Goos *et al* (2011) or Autor and Dorn (2013), have found that job polarization doesn't consequently lead to wage polarization. The first author, indeed, found that changes in wages across different occupation are not strongly correlated to the technology and offshoring variables. Thus, these variables affect employment, but not wages due to the labor market institutions that prevent some free movements of wages.

Autorn and Dorn, on the other hand, did not find any relationship between routine task intensity and growth in wages. The main reason is that, even considering the job polarization phenomenon, a routine occupation as the clerical one, has experienced a growth in wages, even if moderate. For this reason, while technology has replaced several routine clerical workers, for those that remain, probably the nature of the job and tasks, have become less routinely, more specialized and demanding and, thus, better paid on average.

The explanations mentioned above are important in considering the causes of the change in the labor market, as well as in getting the idea of the probability, or potential, for the middle-ranked jobs to continue to exist.

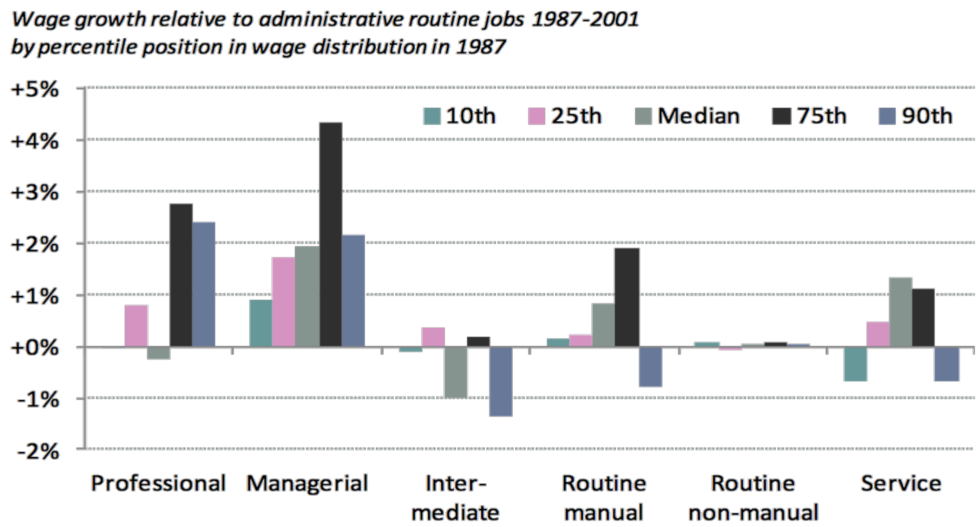
If it would be considered as the main cause of changing in the labor market the pattern of jobs and wage changes as a main demand-side explanation like the routinisation, then it would have expected the pattern oj jobs changes to be similar to the wages one, considering that the demand shifts affect wages and employment in the same way. However, the U-shaped pattern, typical of the hollowing-out pattern,

according to the studies of the authors mentioned above, is not replicated.
The first consideration after this is that there are other factors playing, especially in the lower end of the lower market distribution, where strong growth in the number of jobs is related with only small changes in the real wages. This would suggest that supply-side effects have to be considered as important variables at the lower end of the labor market: with an increased supply of labor to low wages jobs increasing the share of employment in such part of the distribution, lowering the average wage below what they would have expected to receive.
Considering how was the wage distribution been affected, Holmes and Mayhew (2012) provided an analysis of the causes of the changes in the wage distribution, over the period 1987-2001. They included the changing occupations performed, thus the effects of job polarization discussed above, along with other factors such as the educational attainment, the female participation in the job environment, in the overall changing composition of workers and jobs in the labor market. They also considered the impact of these characteristics on the wage distribution as the return to each of the latters relative to a base category for each characteristic. It is these wage returns that will change as the demand for and supply of the various characteristics change (Holmes and Mayhew, 2010). Thus, the job polarization could be considered as just of one of the several factors that could have changed the wage distribution.
What the authors found was that the growth in real wages has been greatest at the top end of the wage distribution, with zero evidence that it is lowest in the middle of that. This is consistent with polarization in which more people in low and high wage work should push the earnings of those at the top and bottom of the distribution away from the median wage, indicating an increased incidence of low

wage and high wage work, and decreased employment in middle wage jobs (Holmes and Mayhew, 2012).

In terms of the impact that the latters characteristics have on the wage distribution, the relationship has shown a positive effect at low wages, which is entirely responsible for the growth in wages at the bottom end of the distribution. So, the returns to some of the characteristics at the lower end of the labor market have improved over time. Holmes and Mayhew (2012) looked at the differential between the increased return to occupations at the lower end of the distribution, and the growth in demand for workers in low-wage jobs, relative to routine administrative jobs.

Figure 8: Impact on wage distribution of changing occupational wage differentials



Source: Holmes and Mayhew, 2012

Managerial and professional occupations have recorded wage increases relative to these routine jobs, while intermediate non-routine occupations have not experienced a growth in relative wages at all. Within managerial and professional occupations, the largest change in wage differentials seems to be at the top of the distribution. One interpretation of this is that there is a widening of earnings within the good non-routine occupations, which suggests many of these apparently good jobs are less-well paying than has been previously suggested. Similarly, wages in service occupations around the median rose, while those at the bottom end declined, relative to administrative occupations. This would also be indicative of a widening of pay within a previously more homogenous group.

In conclusion, there is no evidence of wage polarization: even though evidences have continually been found of the rapid growth of real wages at the top end of the distribution, there have also been no evidences to show faster wage growth at the bottom relative to the middle part of the wage distribution.

2.5. Implications of Hollowing-out

The evidences illustrated in the previous sections, have shown that the category of jobs related to the middle of the initial job distribution; have declined in employment share over time. However, this does not necessarily means that there are fewer middle-ranked jobs at the end of the period than at the start. The main point is that the hollowing-out classifies each job by its initial position in the distribution although it couldn't be its final position. Thus, previously low-ranked jobs may move up the distribution and previously high-ranked jobs may move down (McIntosh, 2013).

Accordingly to the researches of UKCES (Wilson and Homenidou 2012) (Brown, 2014), this section will look, therefore, on how the distribution of jobs looks today as well as projections for the next future.

Table 2: Employment levels, 1990-2020 projected

All Industry Sectors					
Employment Levels (000s)	**1990**	**2000**	**2010**	**2015**	**2020**
1. Managers, directors and senior officials	2,284	2,540	3,016	3,279	3,560
2. Professional occupations	4,181	4,820	5,843	6,189	6,712
3. Associate professional and technical	3,050	3,561	3,926	4,138	4,476
4. Administrative and secretarial	4,437	4,078	3,698	3,466	3,312
5. Skilled trades occupations	4,736	3,767	3,526	3,389	3,295
6. Caring, leisure and other service	1,446	2,142	2,719	2,801	3,032
7. Sales and customer service	2,309	2,479	2,608	2,555	2,610
8. Process, plant and machine operatives	2,819	2,349	1,950	1,829	1,737
9. Elementary occupations	3,504	3,454	3,173	3,209	3,274
Total	28,768	29,192	30,458	30,855	32,008

Source: Wilson and Homenidou 2012

The table below represents historical information on employment trends for the nine SOC2010 major groups starting from the 1990s up to the projections for the next decade.

The key features of the table have been the strong employment growth in the top three occupations or white-collar groups such as managers, professionals or technicians. All three have grown strong over the period 1990-2015 and are forecast to keeping growing faster in 2020. With some easy calculations, it is possible to highlight that from the 1990s to the projections for the 2020, these three figures have experienced a steady growth employing about 50% more in workers in 2020 relative to the starting date. Related to the total employment, the shares of managers, professionals and technicians have grown from 8%, 14,5% and 11% respectively in 1990, to a forecast of 11%, 21% and 14% in 2020. By 2020 a roughly one-half of all employment, is expected to be in these three occupations.

Below the three top occupations, it is possible to spot the trend of hollowing-out, translated both in terms of actual number of jobs and employment shares for middle-level occupations. Indeed, skilled trades occupations and administrative jobs, have experienced the largest falls in terms of number of jobs, about 1.2 million and 0.75 million between 1990 and 2010 respectively, and both are expected to continue this pattern in 2020 mainly as a consequence of the increasing use of computers and IT systems.

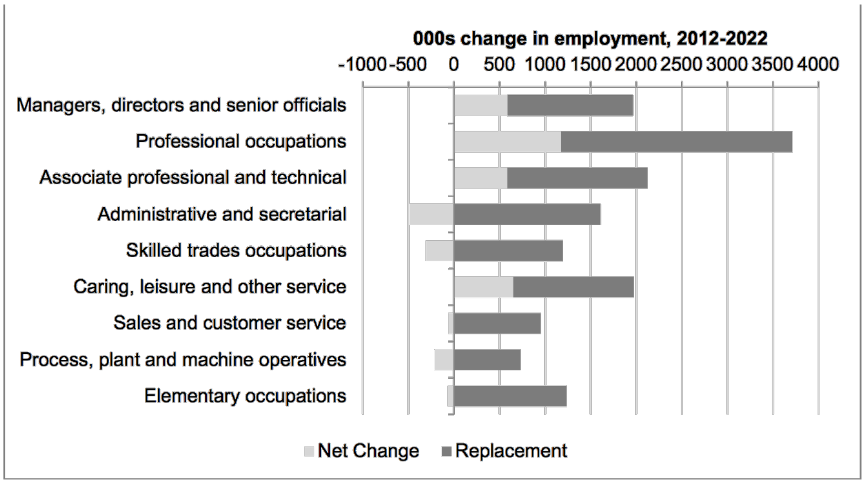
In the remaining part of the distribution, the lowest four occupations, there are different trends to be considered. The most significant growth has been in the caring and leisure jobs, which have doubled its employment numbers from 1990 to 2010 and it is going to keep growing in the projections, albeit at a lower rate. The sales and customer service occupation group has also been the beneficiary of employment growth, but modest job losses are now projected, especially for the less skilled sales occupations sub-category.

Finally, declining employment levels are projected for skilled trades occupations and process, plant and machine operatives, and elementary occupations. However, based also on what it was written above, these are now expected to see some modest growth especially within the service sector, appear to be finding a need for such occupations. This is another example of some polarization of the demand for skills, which has been attributed to the difficulties of automating some relatively low skill jobs that require a human response. Indeed, overall, taking the lowest four occupations, the numbers of employment have grown by about 0.4 million over the period 1990-2010, but it is also forecast to continuing its growth by a further 0.2 million by 2020.

The conclusion of Wilson and Homenidou (2012) is that these projections largely continue the historical trends highlighted above. As noted, indeed, employment has been increasing most rapidly amongst non-manual occupations, especially those that derive employment opportunities from the services sector of the economy. For most manual occupations, especially those tied to traditional manufacturing and the primary sector, there has been a steady decline in employment levels.

Although the total number of intermediate jobs is declining, it does not mean that there are not still job openings in these kinds of occupations, due to replacement demand. Taking again the concept of job polarization, in its Working Future projects, Brown (2014) explains that the largest share of growth is likely to come from the high-skill end, rather than the low-skill end, of the labor market; there will be nearly 21 million more managerial, professional and technical jobs than there were in 2012. Although there is a fall projected in overall numbers of administrative and skilled trades roles, departures from the existing workforce means around 2 million new jobs to fill in these middle-skill occupations by 2022 as well.

Figure 9: Total change in employment, 2012-2022



Source: Brown (2014)

Manufacturing will be a smaller part of the workforce, but jobs requiring scientific and engineering skills are increasing in importance – 350,000 more roles than in 2012, over 900,000 job openings. As the Baby Boom hits retirement, health and social care becomes a leading growth sector, with 1.6 million job openings for caring personal service roles. And after a tough time in recession and recovery, the construction industry will have over 1 million job openings to fill by 2022.

The latter is the idea of replacement demand explained by Wilson and Homenidou (2012) in which the authors demonstrate that, even if some occupations are declining in terms of employment share and effective numbers of jobs, every occupation category is going to need significantly more workers over the next decades.

Table 3: Forecast total replacement demand 2010-2020

2010 - 2020 Net Change	Replacement Demands	Total Requirement
544	1,306	1,850
869	2,315	3,184
551	1,450	2,000
-387	1,695	1,309
-230	1,383	1,153
313	1,144	1,457
2	938	939
-213	845	633
101	1,243	1,344
1,550	12,319	13,869

Source: Wilson and Homenidou (2012)

In every occupational group, the net requirement for workers is positive, as replacement demand is substantial and easily outweighs any negative structural demand. Thus, even in the range of occupations defined as middle-ranked, around 1.3 million more administrative workers and 1.1 million skilled trades workers will be needed.

Over the next decades, there is expected to be a net requirement of almost 14 million new job openings. Replacement demand accounts for over 12 million of these, and retirements from the workforce could be considered as the principal component of the latter.

2.5.1 The job mobility

The phenomenon of hollowing-out or job polarization, has influenced the job environment changing the way of considering the mobility of workers from a mere way of changing type of occupation, to a sort of forcing due to the advances in technology.

The new job mobility could be interpreted as a double-side issue: to one extent, there is the need to understand where the workers, that had been forced to move due to replacement, have gone in the job distribution; on the other, has to be figured out if the declining of the middle-level distribution has affected the opportunities for promotion and career enhancement on entry-level jobs (McIntosh, 2013).

The first issue presented above, has been largely considered in a series of reports made especially by Holmes (2011) and Simmons (2011).
For example, Holmes used the data from the National Child Development Study to track the individuals' mobility over time. His focus was on the mobility of routine jobs, on how many individuals lost their jobs and where they went after the change; he then considered professional, managerial, intermediate professional, service, manual non-routine as the main occupation categories and studied the transition from one to another.
Furthermore, in order to consider the routinisation as a possible cause of influence, Holmes, separated the job mobility attributed for technological reasons, to job mobility for normal or necessary reason. Therefore, he added an additional dummy variable, "routinisation", measured as the overall change in employment in routine jobs in each period considered.
The results of the study have shown a positive and significant coefficient on the routinisation variable in each category except for the managerial one. The explanation is that in period when technological change was greater, fewer workers remained in routine jobs, and instead they moved into all other occupations except managerial. In addition, he revealed that the main distinction between the workers who jumped out from routine jobs, especially upward in the job distribution, and those who remain as routine workers, is the extent of the intermediate qualifications: the workers who have higher level of qualification, are more likely to escape to higher occupation level, compared to those with no or fewer qualifications.
A similar study was undertaken by Holmes *et al* (2011) and Holmes and Tholen (2013) in which the authors not only have used the cohort of individuals from the National Child Development Study, but also the younger cohort from the British Cohort Study, covering the period from 1981-2004 with the firts, and from 1996-2008 with the second,

and also the Labour Force Survey in order to have the whole workforce (from 1992 on).
The results reveal that routine employment has fallen in both cohorts, but the younger cohorts in BCS are more upwardly mobile, in the absence of routinisation. Indeed, The younger cohort was far less likely to be employed in routine jobs at a comparable age (37.9 per cent compared to 45.7 per cent). By 2004, the final year of data for both cohorts, employment in routine occupations has fallen below 30 per cent for younger and older workers. Older workers are slightly more likely to be working in the top end managerial and professional jobs but all non-routine categories have grown in employment share. Compared to the whole workforce (LFS) the occupational distribution of the two cohorts matches reasonable well. For both groups there are relatively more managerial, professional and intermediate workers and less routine and service workers than in the workforce as a whole, which might reflect the absence of migrant workers in the cohort studies (Simmons, 2011).
The issue of job mobility was also studied in the American labor market by Autor and Dorn (2009). As for the study of job polarization, the authors considered commuting zones in the US, and studied the change in employment over the period 1980-2005, in many occupations: routine-intensive jobs, high-skill non-routine jobs, and low-skill non-routine jobs.
The final results have shown that in areas with a higher initial proportion of routine jobs, starting from 1980, there was a larger fall in the routine employment over the next years and for all the three age groups identified (16-29, 30-54 and 55-64). Furthermore, the study reveal that in the group of young workers in the high- and low- skill non-routine jobs, and among the first age bracket, there is a growth in the share of workers that move both up and down the occupation hierarchy. On the other hand, among the older age groups, there is an opposite trend highlighting that there is no evidence for older workers

moving from routine into high-skill non-routine jobs, but, instead, they are much more likely to move into low-skill non-routine jobs. The conclusion of Autor and Dorn is that in the US, when technological progress reduces the number of routine jobs, most of those displaced move down to low-skill non-routine jobs, with the exception of young and well-educated workers.

2.6 Conclusion

Following the first machine age, which was the industrial revolution that made much manual work obsolete through the introduction of new and innovative machineries, nowadays the attention is on the Second Machine Age as Brynjolfsson and McAfee (2014) define it. In this era, the technological progress has allowed and will allow for the automation of many cognitive tasks leading to social and economic impacts as those during the industrial revolution.

In the first part of the chapter the starting point was the matrix task scheme made by Autor and Dorn (2009) and, so, the main distinction between routine and non-routine task as well as manual and cognitive tasks. The technological advances and the continuous decline in prices for computers (MGI 2013), have led to a substantial increase in tasks that can be performed by computers. Even the tasks related to the perimeter of non-manual non-routine tasks, can now be coded and expressed in advances algorithms and, thus, performed by machines.

The recent study made by Osborne and Frey (2013) highlights a critical situation in the US labor market. Indeed, recalling several studies and task model (Autor 2003) (Acemoglu *et al* 2011), they predict that around 47% of jobs are threatened by computerization. They divided the occupations in three broad groups; low-, middle- and high- level jobs, according to the level of qualification needed to perform it. The results have shown that the middle-level jobs are those in major threat because of the routineness of their tasks that can be easily computerized.

A similar phenomenon was also studied by different authors for different region of the world (Andermon, 2011) (Antonczyk, 2010) (Autor *et al* 2013) (Goos and Manning 2007) (Holmes 2010) (Oesch, 2011). The findings identified the same pattern of declining of the middle-ranked jobs and, thus, the rising of the hollowing-out or job polarization of the job market (McIntosh, 2013). A possible consequence of job polarization was studied in terms of wage and earnings polarization (Holmes and Mayhew 2012) (Holmes 2010) (Machin, 2009) (Autor 2009) even if a strong coefficient of correlation was not found. Indeed, there is no evidence of wage polarization: even though evidences have continually been found of the rapid growth of real wages at the top end of the distribution, there have also been no evidences to show faster wage growth at the bottom relative to the middle part of the wage distribution.

The main cause attributed for such a phenomenon was correlated to the technological advances, even if other factors like the globalization and, thus, the offshoring of some specific occupations was taken into account.

Finally, Wilson *et al* (2012), Brown (2014) (Simmons, 2011) (Holmes and Tholen 2013) tried to make projections about how the distribution of jobs looks today as well as projections for the next future together with the job mobility of the workers that were displaced from their jobs due to the technology. According to their analysis, even if the declining of the middle-level jobs is a matter of facts, with an increasing employment share at top end of the distribution, over the next decades, there is expected to be a net requirement of almost 14 million new job openings. Replacement demand accounts for over 12 million of these, and retirements from the workforce could be considered as the principal component of the latter.

Chapter 3:
The third Machine Age: from the Internet of Things to the Internet of Everything

3.1 Introduction

The next wave of technological progress will be completely different from the latter two. The first one who explained what the next reality will be like, was Kevin Ashton in 1999 with the name of "Internet of Things"[33]

In 1990s, Internet connectivity began to proliferate in enterprise and consumer markets, but was still limited in its use because of the low performance of the interconnected network. In the 2000s Internet connectivity became the norm for many applications, routine manual tasks, non-routine manual tasks as well as some cognitive tasks, and today is expected to be as main part of many enterprises and many industrial and consumer products to provide easy and fast information through databases of big data.

Nowadays, and especially in the very near future, the Internet of Things (IoT from now on) is thought of as connecting things to the Internet and using that connections to provide some kind of useful remote monitoring or to control those things. The true promise of the IoT is just starting to be realized, when invisible technology operates behind the scenes dynamically responding to how we want things to act (Chase, 2013).

In this last chapter of the first part of the thesis, the attention will be shifted to the definition of Kevin Ashton and all the possible related applications and challenges.

[33] For further information visit: http://www.leighbureaultd.com/speakers/KAshton/

In the first section, an introduction of what IoT is will be provided, together with all its related data, trends and the impact on the machine-to-machine markets, as well as on the service industry.
Going ahead, some numbers of the value of the so-called Internet of Everything will be provided and then, in the last sections, the concept of Industry 4.0 and smart factories of the future will be analyzed and discussed.

3.2 The Internet of Things of today

The world, as all people know, is entering a new era of computing technology where everyday objects are embracing the Internet.
While the first two stages of the Internet's development had profound implications for the technology industry, and to some kinds of jobs and tasks, the implications of the IoT will prove even more its widespread very nature as a trend that will reach and touch every industry, beyond tech, from manufacturing, to healthcare, to retail, to transportation and homebuilding (Goldman Sachs, 2014).
The IoT has many definitions among scholars and literature; however, each definition shares the same idea that the first version of the Internet was about data created by people, while the next version is about data created by things. Kevin Ashton, in a quote from an article published in the RFID journal, explained its vision: "If we had computers that knew everything there was to know about things…we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best"[34].
From the 1999 until now, the definition has been changed as a consequence of the technological progress and the infinite ways that have been implemented for computers and machines using software and algorithms. Nowadays, a definition that can meet the potential of

[34] Kevin Ashton quote on: http://www.rfidjournal.com/articles/view?4986

this phenomenon is provided by Gubbi *et al* (2013), explaining that in the IoT paradigm, many of the objects that surround our lives will be on the network in one form or another. Thanks to the Radio Frequency IDentification (RFID) and the huge amount of sensor network, technologies will rise to meet a new challenge in which information and communication systems are invisibly embedded in the environment. The natural consequence is the generation of enormous amounts of available data, which have to be stored, processed and presented in an efficient and easily interpretable way. The IoT allow, and will allow, physical items to be connected with the virtual world, and to be controlled remotely and act as physical access points to Internet services.

According to the statistics of Cisco (Evans, 2012), in the 2015 the number of "things" connected will exceed the number of people on the earth, and in 2020 the number of things connected will be around 50 billion relative to the 2-3 billion people that will have access to the internet in the 2025 (MGI 2013). All the "things" connected are enhancing a radical change of current Internet into a Network of interconnected objects that, not only harvests information from the outside environment, through the sensors, and interacts with the physical world, but also uses existing Internet standards to provide services for information transfer, applications, and communication. Indeed, smart objects will play a key role in the IoT vision: embedded communication and information technology would have the potential to revolutionize the utility of them, and the potential itself is continuously evolving due to the advances in microelectronics, and the constantly falling price of processors, communication modules and other electronic components.

In the term "things", it is present not only the everyday objects including electronic devices, such as smartphones or tablets, or the product of higher technological developments, such as smart vehicles and equipment, but also things that are difficult to imagine as electronic or technological. Many others thing are related to this term, as for instance the location of the object, the time information provided by the object, the condition in which it operates, and finally, by the people using that specific objects (Chase, 2013).

The more physical objects and smart devices connected, the more the impact and value that IoT brings to the daily life: with such high degree of interconnection, people can make better decisions as taking the best routes to work thanks to social and interactive maps, or choosing the best restaurant or the store with the lowest price. Everyday new services will emerge to address society challenges such as remote health monitoring[35], smart parking and smart cities and everything related to the environment (smart water, smart environment, smart metering…) as well as the business industry sector[36].

Indeed, it is the latter segment the one which can benefit the most from the IoT, in terms of improvement management, tracking assets and products, new smart business models, and especially cost savings through the optimization of resources and equipment.

3.2.1 IoT elements and Technological trends

In order to obtain the concept of seamless ubicomp, there are specific components required for the IoT from a high level perspective (Gubbi, 2013). There are three main elements: Hardware, in terms of made up of sensors, actuators and embedded communication hardware; Middleware, on demand storage and computing tools for data analytics; and Presentation, the ability to create easy way to understand data and visualization and interpretation tools which can be accessed on different platforms and designed specifically for any kind of applications.

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[35] See for example: http://www.informationweek.com/mobile/remote-patient-monitoring-9-promising-technologies/d/d-id/1110968?

[36] 50 Sensor Applications for a Smarter World: http://www.libelium.com/top_50_iot_sensor_applications_ranking/

Radio frequency Identification is the major breakthrough in the embedded communication paradigm, which enables design of microchips for wireless data communication. They help in the automatic identification of anything they are attached to, acting as an electronic barcode (Welbourne, 2009) and, thus, they are used in many different applications as the transportation or bankcards. Today, the one dimension bar (ID) code has made a significant contribution to the supply chain and other business such as asset management; with the advances into the two-dimension (2D), bar codes have provided a richer source of data. Now, RFID together with its ability to collect continuously and permanently data in its environment, is providing the best source for identification of goods or tagging solutions to improve their tracking and monitoring process (Chase, 2013). RFID has the potential to access to streams of data that will provide information system with real-time data and it also has the flexibility to be putted into extremely small spaces and locations. With technology development in areas like chip design, microchips, manufacturing, new ways of RFID usage will emerge for applications such as remote house control and real-time vehicle tracking.

Another important recent technological advancement is in low power integrated circuits, and especially in wireless communications that have made available low cost and low power miniature devices for use in remote sensing applications. The combination of these factors has improved the viability of utilizing a sensor network consisting of a large number of smart sensors, thus, enabling the collection, processing, analysis and dissemination of valuable information, gathered in different environments (Akyildiz *et al* 2002).

Moreover, one of the most important outcomes of this emerging field is the creation of a huge amount of data. Thus, storage, ownership and expiry of the data, become a critical issue. Data have to be stored and used for smart monitoring and actuation: it is important to develop artificial intelligence algorithms, which could be centralized or distributed based on the specific need. Said that, cloud computing is one of the enabling platforms to support IoT due to its ability to provide several platforms from which to access IoT data and on which customized IoT application can be developed[37].

Finally, the last step in the process of data processing is the visualization of these. Visualization is critical for an IoT application as this allows the interaction of the users with the environment. Technological progress has brought very easy and intuitive way for interacting with data and applications such as the touch screen technology, through the use of smartphone, tablets or smart TVs, which have also changed the way in which information are provided from the 2 to the 3 dimensions.

3.3 IoT possible application scenarios

The European Research Cluster on the Internet of Things (IERC)[38] vision on IoT is that "the major objectives for IoT are the creation of smart environments/spaces and self-aware things for climate, food, energy, mobility, digital society and health applications". The outlook for the future is the emerging of a network of interconnected uniquely identifiable objects and their virtual representations in an Internet alike structure that is positioned over a network of interconnected computers allowing for the creation of a new platform for economic growth (Vermesan *et al* 2013).

When the IERC emphasizes on smart environments or spaces, it spreads out the concept of IoT into a wide range of different scenarios, ranging from smart cities to smart living, from smart transportation to smart building, from smart health to smart energy.

Smart products have a real business importance, because they can actually provide energy and efficiency savings of up to 30 percent, and generally deliver a two- to three-year return on investments. This

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[37] For further information visit the articles' page of Louis Columbus on: http://www.forbes.com/sites/louiscolumbus/

[38] http://www.internet-of-things-research.eu

trend will help the deployment of Internet of Things applications and the creation of smart environments and spaces (Vermesan *et al* 2013).

By following the structure of the IERC and the report of Vermesan and Friess (2014), this section will provide the possible application of IoT in several different scenarios that share the common development of technology, as well as the diverse needs of potential users.

3.3.1 Smart Cities

The first concept of smart city was introduced by Rifkin (2004) as a strategic vision of a modern and efficient production of the city. Now it could be defined as a city that monitors and integrates condition of all its critical infrastructures, including roads, bridges, tunnels, airports, subways, water, communication and so on, and, thus, can better optimize its resources, plan its own maintenance when there is the need, and monitor security aspects while maximizing services to its citizens (Vermesan and Friess 2014).

The topic of smart cities is a very “hot” one also under a financial perception; John Chambers, Cisco CEO, indeed, estimated the opportunity for IoT, in the private and public sector combined, to be around US$19 trillion over the next decade[39], by describing how IoT in smart cities could transform the retail industry through smart shopping carts and virtual concierges, reduce city energy costs in term of city lights or waste management optimization through connected garbage bins.

This will lead to the evolution of smart cities with eight smart features, including Smart Economy, Smart Buildings, Smart Mobility, Smart Energy, Smart Communication and Technology, Smart Planning, Smart Citizen and Smart Governance (*see infra*). Therefore, cities and their relative services represent an ideal platform for IoT research and development, taking into account city requirements and

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[39] “Cisco CEO Pegs Internet of Things as $19 Trillion Market” on: http://www.bloomberg.com/news/articles/2014-01-08/cisco-ceo-pegs-internet-of-things-as-19-trillion-market

transferring them to solutions enabled by IoT technology. There are many projects initiatives for smart cities focused on IoT such as the FP7 SmartSantander projects[40], the OUTSMART projects[41] or the project of making Barcelona a smart city[42].

Therefore, by 2020 it will be possible to see the development of Mega city corridors and networked, integrated and branded cities[43]; and, with the rapid expansion of city borders, driven especially by the increase in population, by 2023 there will be around 30 mega cities globally, with 55 per cent in developing economies like China, India or Latin America[44].

In the long term, Smart Cities vision, systems and structures will monitor their own conditions and carry out self-repair as needed. The physical environment, air, water, and surrounding green areas, will be monitored in optimal ways, thus creating a living and working environment which is clean, efficient, safe, and that offers advantages in terms of effective use of resources (Vermesan and Friess 2014).

3.3.2 Smart Energy

Nowadays, it is possible to identify three major factors that have an impact on the energy sector. They underpin why this entire sector needs to be restructured and turned into an intelligent and efficient supply system. New interconnected system solutions are needed, in which information and communication technology will play a key role in providing the necessary information networks and intelligence systems (BDI initiative Internet of Energy, 2010).

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[40] PDF available on: http://www.smartsantander.eu/downloads/Deliverables/smartsantander-tutorial.pdf

[41] For further information visit: http://www.fi-ppp-outsmart.eu/en-uk/Pages/default.aspx

[42] For further information visit: http://smartcity.bcn.cat/en

[43] Forbes, "The World's Fastest-Growing Megacities", Joel Kotkin and Wendell Cox, available on: http://www.forbes.com/sites/joelkotkin/2013/04/08/the-worlds-fastest-growing-megacities/

[44] Frost & Sullivan: "Global Smart Cities market to reach US$1.56 trillion by 2020", November 2014, available on: http://ww2.frost.com/news/press-releases/frost-sullivan-global-smart-cities-market-reach-us156-trillion-2020/

The first factor is the depletion of global fossil fuel resources: one of the biggest challenges in the paradigm of the future policy in energy supply is the awareness that such a supply should no longer be based on fossil resources, but on various renewable resources. The second one is related to the changed regulatory environment, which is placing greater demands on the energy system's data network. In light of this, more and more players along the value chain (power generation, transmission, distribution) must communicate and interact using shared interface. The last factor, which is also related to the first one, is that as a result of technical developments and rising energy prices, more power from renewable resources has to be fed into the power grid in the future: this will mean a much greater degree of flexibility from the supply structure that will continue to exists and to work in tandem (BDI initiative Internet of Energy, 2010).

Because of the high volatile nature of energy supply, an intelligent and flexible electrical grid is demanding, and it has to be able to react to power fluctuations by controlling electrical energy sources and sinks and by suitable reconfiguration. Such functions will be based on networked intelligent systems and devices, largely based on IoT models.

Future energy grid is characterized by a high number of distributed small and medium size energy sources and power plants, which may be combined virtually ad hoc to virtual power plants. In Smart Grids networks, embedded devices are making the electricity grid itself, the homes, the factories etc. smarter, enabling and increasing the collaboration among them; it is expected that all devices will offer their functionalities as services that other entities can discover and use (Karnouskos, 2010). One example of a possible actuation of such a methodology is the "Future Energy Grid" project and the focus on the evolution of German power system for the year 2030 as explained by the work of Danekas *et al* (2011).

Furthermore, the migration paths from the current energy system to an integrated Internet of Energy will represent a good opportunity for a multitude of new business models to be created. In fact, in the future, power grid operators will be able to increasingly evolve into information service providers; new services, such as energy management at the customer's premises, will emerge. New players will enter the market, such as operators of virtual power plants for balancing energy (BDI initiative Internet of Energy, 2010).
Finally, the Internet of Energy provides an innovative concept for power distribution, energy storage, grid monitoring and communication. It will allow units of energy to be transferred when and where it is needed. Power consumption monitoring will be performed on all levels, from local individual devices up to national and international level (Vermesan O. B., 2011).

3.3.3 Smart Mobility

The concept of Internet of Energy can be correlated and used in a wide range of new possibilities and applications, especially in the field of the connection of vehicles to the Internet. In the Internet of Vehicles (IoV) paradigm, each vehicle is considered as a smart object equipped with a powerful multi-sensor platform, communications technologies, computation units, IP-based connectivity to the Internet and to other vehicles either directly or indirectly. In addition, every vehicle could be able to interact with other vehicles, roads and people. IoV enables the acquisition and processing of large amount of data from different geographical areas via intelligent vehicles computing platforms able to offer various categories of services for road safety and other services to drivers and passengers (IEEE, 2014). The integrated information services of vehicles, vehicle safety, and economic performance will contribute to a more intelligent urban transportation system and advance social and economic development: traffic efficiency, traffic safety, parking facilities and many other controls, will have a huge impact on millions of people and business (APEC, 2014).

However, there are big challenges related to the difficulties in representing the human behavior in the design, development, and operation of cyber-physical system in autonomous vehicles. Issues of safety and security will continue to be extremely important: coordination and communication are the basis for a correct implementation of IoV. By adopting open standards, for example based on cloud systems (Gerla), the IoV can be integrated into an effective system for the smooth sharing of information among all the players.

Today, self-driving cars are already in the prototype phase and the technology is shifting into computer-controlled vehicles (i.e. the Google car) that integrate smart systems like smart phones and smart vehicles on-board units, which acquire information from the user, from on board system, and from the outside.

Concluding, the concept of IoV is the next step in the future smart mobility and transportation environment and it requires to creating brand new mobile ecosystems based on Market2Market communication protocols in order to provide reliable infrastructures and to consider safety and security constraints.

3.3.4 Smart Home

With the continuous advance in Wireless communication and information technology, the applications of smart homes technologies are arising. The trend is becoming even more evident due to the fact that many electronic devices have started becoming part of the home IP network, and also due to the increasing rate of adoption of mobile computing devices such as smart phones and tablets that can interact with the other devices connected to the personal network.

These smart homes are ones that can interact intelligently with their inhibitors to provide comfort and safe living. This interaction may range from simple control of ambient temperature to context-aware and mobile agent based services (Al-Qutayri, 2010).

The way in which smart homes work is based on open platform that employ a network of intelligent sensors to provide information about the state of the home; these sensors monitor systems such as heating, water, metering, ventilation and air conditioning[45].

Compared to the home of today, the smart home of the future will contain far more connected devices. Market research house Parks Associates, for example, forecasts that the number of connected devices and sensors in an average US home will increase from four to sixteen in 2015. At that time, 13% of all US households are forecast to have energy management systems installed and nearly 20% are expected to have monitored security systems in place – up from 2% and 18% today respectively. In the smart home of the future, these devices will be integrated into intelligent, interconnected and interoperable systems (GSMA, 2011)[46].

The benefits are high and easily to pinpoint for both the household and the managers or ownership of the buildings platforms. For consumers, the main value of smart home services will be in having information and control of connected devices in the home no matter where they are. Through different application installed on their smart phones, they can control and interact with the home IP network anywhere and anytime is necessary. For companies that currently focus on single-category services such as energy supply, entertainment or security monitoring, the emerging smart home environment will create several opportunities to widen the range of services offered, and to intensify the relationship with the households. Furthermore, the combined revenue from the smart metering, home

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[45] IBM Data Magazine, “Connected Devices for Smarter Home Environments”, available online at: http://ibmdatamag.com/2014/04/connected-devices-for-smarter-home-environments/

[46] Articles on market home research online at: http://www.parksassociates.com/industry-reports#digital-home-support-services

automation and home energy management segments is forecast to be worth more than $44bn in 2016 (GSMA, 2011).

As any other IoT implementation, even in the smart homes environment, there are challenges related to security and trust as well as the need for a high degree of interaction and communication between all the players in order to create a reliable interconnected platform for the monitoring and the managing of the smart homes and buildings (Clinckx *et al* 2013).

3.3.5 Smart Health

According to the European Commission definition, smart health is referred to everything is related to innovative, smart, networked and technology driven solutions that generate healthcare advantages in cure, care and prevention by introducing new ways and applications to treat, manage and monitor patients and diseases (Verzijl *et al* 2015).

The market for health is, currently, characterized by solutions that are application-specific and that are build up for diverse architectures. On the one hand, these solutions were designed to decrease costs of healthcare delivery, but, on the other hand, in order to achieve long-term goals of per-capita cost reduction, new applications, platforms and solutions have to be made, thus, transforming the healthcare sector. In this scenario, the IoT applications, especially through solutions made up for mobile devices, software companies or research organizations, can be used to disrupt the actual relationships between patients, doctors and hospitals and to start a brand new way of interaction, data collection and monitoring of the latters. The market potential, regarding the mobile health industry, is high and is continuously growing, as forecasted by the market researches (Verzijl, 2015)[47]: the global market is estimated to reach EUR 49.3 billion by the end of 2020, at an annual growth of about 13%.

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[47] Statistics token by Statista Portal available on:
http://www.statista.com/statistics/295771/mhealth-global-market-size/

The concept of smart health involves deploying computing, information and networking technologies to aid in preventing disease, improving the quality of care and lower the overall costs. All these things could be realized throughout systems that are able to manage chronic disease, that are used to capture patient health data from a variety of sensors by applying algorithms able to analyze the data and share it through wireless connections with hospitals, medical professional or health research organization (Computing Community Consortium, 2011). Nowadays, thanks to the improvement of mobile devices and professional apps, it is possible to track, monitor and collect data through a bunch of different applications designed for different diseases. For example, Apple, with the brand new release of iOS 8.2 has developed a platform (Health) that allow third parties to build up applications for the tracking and the sharing of users data, in order to help organization and professionals in the prevention and the study of new diseases. These health platform applications can deliver remote monitoring for patients who are in home environment or reside in remote areas; moreover, hospitals can not only offer much-needed, lower cost care than a hospital visit, but also deliver patients care in a more precise and comfortable settings[48]. In addition, the health organizations are trying to adopt a new way of healthcare information management through the adoption of health ID cards or smart cards (Gemalto) (Smart Card Alliance, 2012). These technologies will provide benefits in terms of cost minimization for the healthcare providers, the patients and the payers, by reducing identification and registration process time and possible medical errors, by improving patient care, and finally, by increasing the operational efficiency among all the value chain.

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[48] Article of Susan D. Hall, " ER overcrowding spurs growth of remote monitoring market", FierceHealth, July 2012, available on http://www.fiercehealthit.com/story/er-overcrowding-spurs-growth-remote-monitoring-market/2012-07-12

The main challenges in the adoption of such technologies are related to the formal legislation, the associated need for organizational change, and the very high investment costs. For example, in some European countries, using electronic records and communicating their content across health organizations or professionals, is not legal because of issues related to the insecurity in terms of privacy, cyber-security and governance (Verzijl, 2015).

3.3.6 Smart Logistic

The different IoT applications create opportunities to achieve efficient solutions in the retail sector by enabling solutions ad hoc for the right person, content, time and the right place. Nowadays, in order to be successful and efficient, companies must be adaptive and somehow connected with the changing tastes and priorities of the population. A kind of personalized experience with the users is what they are demanding in this digital and complex environment, and, thus, connectivity anytime, anywhere and for any devices, will be a key ingredient for success.

In 2013, decision-makers and leaders agreed that the concept of Logistic Supergrid, and other related topics such as the supply-chain on demand or the logistic on demand, had the potential to become the business models of future logistic companies (DHL Trend Research, 2014).

With the continuous increase of the amount of big data available, market leaders in such industry were seen to build out advanced way to manipulate data, analyzing them in order to forecast the demand for a specific product and, thus, creating a sort of real-time logistic service boosting the efficiency and reducing the overall risks and costs. In addition, the increased customer expectation in terms of fast and reliable delivery services, has forced the providers to explore and create new delivery systems. As an example, DHL has started using the Parcelcopter, which was used to deliver pharmaceutical goods in German (DHL Trend Research, 2014); Amazon, with its drones and the adoption of robots like “Kiva”, is also trying to pursue an ideal one-day delivery in USA by shortening its supply chain while increasing efficiency: the company, indeed, has generated three times per employee more revenue related to Walmart, who did not use such technology (Perspectives, 2014). In this context, the introduction of the 3D printers in the end-to-end logistic services, has also lead to new rooms of improvements by extending the players value and supply chain by reducing the inventories, the lead time or by customizing both products and delivery.

Retailers, on the other hand, are using sensors, beacons, scanning devices, and other IoT technologies to optimize internal systems: inventories, resources, performance improvement can be obtained through real-time analysis, automatic replenishment, notifications, store layout and more, as for example the case of 7-eleven stores in Japan (Chopra, 2005).

3.4 The value of the Internet of Everything

Cisco (Bradley *et al*, Cisco 2013) defines the Internet of Everything (IoE) as the networked connection of people, process, data and things. The benefit of IoE could be derived from the compound impact of the connected network, and from the value this increased connectedness creates as everything comes online. The final though, in this respect, is that IoE is clearly the future source of value.

Cisco itself, estimates that 99.4% of physical objects are still unconnected, thus, only about 10 billion of the 1.5 trillion devices globally are connected: going into deep, the number of connectable things per person is about 200, highlighting the fact that there is still a huge potential of connecting what is now unconnected (Evans, 2012).

The growth of Internet, and then of the IoE through the number of things connected, is growing at an unprecedented rate, driven by several factors: first, technology trends, including the increase in processing power, storage, the rapid growth of cloud, social media, and mobile computing, have made possible the creation of a huge amount of value from connectedness; second, barriers to entry or to connectedness are continuing to drop; third, the technology progress has made possible to build up a computer or a camera to the size of a grain of salt, making the form factors continuing to shrink; finally, companies cannot longer rely solely on internal core competencies, but, instead, they need to capture all the value that comes from external sources, especially through connections enabled by the IoE.

In this context, the bottom-line value that can be created or will migrate among companies and industries based on their ability to harness IoE, the Value at Stake, is predicted to be around \$14.4 trillion for companies and industries worldwide in the next decade (Bradley *et al*, Cisco 2013). Those that harness the IoE potential in the best way, will reap this value in two different ways: either by capturing new value created from technology innovation, and either by gaining competitive advantage and market share relative to other companies less able in taking the best of the IoE revolution.

From a survey, held by CapGemini (2014), of senior business leaders around the globe, 96% said that their companies are already investing budgets in IoT; however, a research made from the same consultant company, showed up that 70% of organizations do not yet generate service revenues from their IoT solutions. In another example, Zebra Technologies and Forrester Consulting (2012) show that only 15% of organizations had an IoT solution in place, but around 67% had plans to implement one in the next five years. Accenture (2015), instead, reveals that the 73% of businesses have yet to make any concrete progress, and just the 7% have developed a comprehensive strategy with on going investments.

To help executives capture more value from IoE, Cisco (Bradley *et al*, Cisco 2013) commissioned the realization of an international survey of around 7.000 businesses and IT leaders of 12 of the largest economies globally, which represent the 70% of the world's GDP.

The final purpose of the survey was to estimate how much of the potential Value at Stake companies are actually realizing as a function of their IoE capabilities. The findings have shown that companies have had the potential to realize roughly $1.2 trillion in value at the end of the 2013; however, these firms were set to realize just $613 billion, thus, failing in capturing over the 47% of the potential IoE Value at Stake.

The study of the Value Index made by Bradley *et al* (Cisco 2013) was also useful in order to identify which country, among the developed, is realizing the greatest value in terms of share of IoE value. German companies, for instance, are realizing the highest percentage of their potential value with a 62.2%, thanks to the new application concept of Industry 4.0 and smart manufacturing (see 3.5); Japan is a follower, with a roughly 57.7 %[49]. The other developed countries, nevertheless, have invested and will invest in IT and have extensive experience in using and implementing different types of technology.

Top firm in leading country[50] category continually innovate how to develop, produce, sell and deliver their products, largely because they are forced, to some extent, to compete against firms, in the same local market, that use technology applications and business process innovation in a similar way and with a similar emphasis. However, pursuing countries like India, Brazil or China, have developed sectors of their economies that are benchmarks among the world's leader. India, for example, has an IT sector that is growing year by year and can compete successfully with those of high-tech leading countries[51];

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[49] "Japan is well known for its scientific research. Indeed, many research scientists of Japan have made immense contribution in various fields like automotive, general transportation, electronics, machinery, earthquake engineering and so on.", 12 Most Technologically Advanced Country, Richer Lifestyle, http://www.richestlifestyle.com/most-technologically-advanced-countries/6/

[50] Bradley *et al* (Cisco 2013) grouped into four high-level categories the countries studied. The categories are Leading, Performing, Pursuing and Beginning. These categories are aggregates of firm capabilities

[51] India Information Technology Sector Profile, available on: http://www.ficci.com/sector/21/project_docs/ficci_website_content_-it.pdf

China, as well, has the most sophisticated factories and is investing heavily in IT. In general, even if, due to the relative smaller size of their economies, developing countries are not so mature in terms of IoE levels, companies in such emerging markets are more optimistic than the ones in developed countries about their potential and ability to realize IoE value and, thus, to gain an always bigger share of the Value at Stake.

3.4.1 Drivers and Business Value Framework of IoE

The IoE is already a big success in the transformation process across many industries, and it will bring even more value in the next decades. The utilization of the IoT can help organizations utilize their business infrastructure and assets in a completely new and more efficient way, stimulating innovation while offering new services and delivering additional stream of revenues. Recalling the Value at Stake of about $14.4 trillion that the IoE can and will create, the four main industries, according to Cisco (Bradley *et al*, Cisco 2013), that will benefit the most with an impressive 56% of grabbing value, are manufacturing, retail trade, finance and insurance, and information services. In these industries, more than in others, IoT offers compelling business benefits and value that organizations must take in consideration and cannot ignore to afford.

According to Cognizant (2014) and Cisco (Bradley *et al*, Cisco 2013), there are five main drivers of the enormous value that IoE can create are five.

The very first one regards the cost savings through improved asset utilization, process efficiency and productivity. For example, General Electric[52] estimated the potential cost reduction if intelligent machines and analytics were able to cause even a tiny reduction in fuel, capital expenditures and inefficiencies in the main industries. In the commercial aviation, through improved flight planning and

[52] Example taken from Cognizant Report (2014)

operational changes, the cost savings in terms of jet fuel would be around $30 billion; in the oil and gas industries, increased availability of key equipment sets, reducing fuel consumption, would result in $90 billion savings in capital expenditures.

Thus, IoE reduces selling, general, and administrative expenses and costs of good sold by improving tracking assets, by using sensors and connectivity, and then businesses can benefit from real-time insights and visibility into their assets. The total value that can be grabbed from cost savings and asset utilization is estimated to be around $2.5 trillion up to the total of $14.4.

Following, employee productivity is also estimated to be $2.5 trillion, as a consequence of better labor efficiencies that will result in fewer or more productive man-hours, and by also offering employees just-in time training, and by reducing the mismatch of required versus available skills.

From a customer perception, IoE increases customer lifetime value and raises market share by adding more customer for a total estimated value of $3.7 trillion.

Furthermore, organizations can use real-time operational insights to make smarter decisions and reduce operating costs; indeed, IoE can eliminate waste and improves process efficiencies across all the supply chain and the logistic of a company, with an estimation of $2.7 trillion. They can actually use real-time data from sensors and actuators monitor, to check, track and thus improve process efficiencies, reduce energy consumption and also minimize human intervention.

Finally, another big share of the Value at Stake pie, estimated by Cisco to be $3.0 trillion, is represented by the innovation and opportunity in revenue growth. According to Deloitte (2014), nearly three-fourths of enterprises that had express interest in adopting IoT solutions are looking for new business opportunities and brand new way to fortify their existing lines of products. They are, actually, articulating new propositions and applications to use IoT in order to make revenues grow, shape new products by innovating processes and, thus, open up new markets (as for example Apple did with the launch of the tablet), provide better products and services through real-time insights and better management of customer lifecycle. IoE also increases the return on R&D investments, reduces time to market, and, everything that lies in uncovering the additional and disruptive value that is and can be enabled by having real-time feeds from the outside, is potentially a breakthrough potential in IoT. Finally, organizations can also benefit from innovation, in terms of revenue stream generated by possible new business models. CapGemini (2014), for instance, provided a set of monetization models for the IoT: they used two variables, i.e. relationship with customer and complexity of IoT monetization model, and built up four innovative business models in order to get the best of the IoE intrinsic value. Starting from a very simple model in which organizations charge a price-premium for the product's connected features, for example the use of a mobile application that is connected to a material object, a feasible next step concerns relational models as the data or service revenue systems. Finally, there is a more advanced and collaborative model, the ecosystem building model, in which organizations create a platform where they make money from both other product vendors and end consumers[53]. Because there is no a unique and right model as the best in terms of applications for the IoT, different companies, with different critical success factors, will use the most suitable model in order to meet their needs (CapGemini, 2014).

The homogeneity of value for each area suggests that companies must examine how IoE can impact every aspect of their business processes, from the customer acquisition and management, to the product/service

[53] Amazon could be considered as an example due to the fact that it sells its own Amazon label brand products, while being a platform that match vendors and consumers.

innovation, and finally to both cost-cutting and new revenue-raising activities.

What could be considered as universal, to some extent, for every company is a framework, developed by Deloitte (2014), to find business value; this framework tries to answers to the question on from which metrics can IoT benefit the most from letting companies to obtain a sustainable competitive advantage. The three main metrics regard financial metrics, operating metric, and different approaches to performance improvement. In terms of financial metrics, organizations have revenues, expenses and assets that support the latters; while, so far, most of the investments were made around efficiency in terms of assets utilization, the next trend will be based on revenue growth through innovation and/or market disruption. Operating metrics refer to three main core processes: customer, product, and facility lifecycle. Investments in IoT were focusing mainly on the last process, by optimizing facility utilization and then reducing the overall costs; however, with the advancements in technology and the availability of huge amount of real-time data and connected devices, new insights and applications in understanding and managing customers and products can result, nowadays, from IoT investments. Finally, once again, IoT has been very useful to pinpoint solutions for a single given problem such as the inventory "out-of-stock" or a "machine down", without taking much consideration of what could have been learned from IoT data over time. Thus, rather than focusing on optimizing a single issue, the true business value of the IoE lies on the understanding of past and future transactions (i.e. either sale and purchase transactions, either operations on a machine), in order to use that knowledge to deliver and derive sustainable value over time.

3.4.2 Issues and Challenges

As everything that deals with outstanding potential and innovation, issues and challenges are always the counterpart in the final balance.

Several studies made on the identification of IoE opportunities and challenges (Cognizant, 2014) (CapGemini, 2014) (Chen, 2010) (Vermesan and Friess 2013) (Alberti and Singh s.d.), agree on different aspects that organization must overcome and work closely with, in order to benefit the most from the potential and value of the IoE.

Security and privacy concerns are the very first challenges to be discussed. As largely explained before, deriving value from IoT depends on the ability of organizations to collect, and manage big quantities of data. In order to grab real value out of these, securing such data has to be considered a priority. The IoT creates a huge system of interconnected devices that are used, also, for personal activities: smart phones, tablets, wearable items are used everyday for everything and by billion of people. Hackers and, in general, attacks on private data can happen at multiple levels, from the device itself, or from the communication network over which the data are carried out and transferred. Customers today are increasingly aware of these kinds of issues, however, there is a common concern especially on the types of personal identifiable data that could be “stolen”, and brings to a slower rate of adoption of smart devices. For these reasons, organizations must be, first of all, aware of hacking and other criminal abuses, and, second, they must build up IT ecosystems with the highest degree of security and transparency in terms of privacy information.

Following, because the number of vendors, technologies, and protocols used by different class of smart devices is increasing over time, the need for a complete and easy interoperability among them is a must. Recalling the estimates of Cisco (Evans, 2012) about the 50 billion devices that would be connected in 2020, a lack of consensus on how to apply standards and protocols for smart devices will make difficult for organizations to integrate applications and devices that use different network technologies. This means that organizations need to ensure that smart devices can interact and work with different services and systems. In order to achieve this goal, all the players in the IoT ecosystem, starting from the hardware, software and other vendors to cloud network service providers together with the same end customers, need to acquire the ability to share data across existing IoT technologies. This will facilitate innovation and will develop solutions that have a greater potential to drive business value and customer satisfaction.

Recalling that one of the main elements in driving the IoE value is the amount of data available, and then routing, capturing, analyzing, storing, and using these data in the most efficient way possible, represents a huge challenge. Today, the application development infrastructure, especially of the M2M, is highly fragmented and proprietary (Chen, 2010). As more and more devices will enter the market, more data will be formed and then, a lack of a common and, to some extent, standardized application development framework and IoT protocol, could hinder the growth of the market potential. Boosting the challenges means that most organizations need to make significant investments, often without clear and quantifiable returns, in acquiring new capabilities or facilities to make the IoT works perfectly and, thus, to sell IoT-based services. Organizations will also need to develop skills to seize potential components breakdown and replacements, using periodical maintenance practices in order to let the business run efficiently and effectively.

The aggregation and the non-rapid face-off of these factors, will definitely delay monetization efforts and slow-down the value acquisition from the IoE pie.

3.4.3 Business strategies to unlock the value of the IoE

In order to take advantage from the IoT, organizations should focus on how to implement and let interact their existing infrastructure with the new intelligent and interconnected assets. Investments, in terms of acquiring ability to manage, monitor and control remote assets, will definitely result in measureable improvements in profitability and revenue[54].

Having explained above the issues and the challenges that organization are and will face in the IoE landscape, to unlock the value and the potential of interconnected devices and systems, the best strategies are natural consequences of the IoT understanding and complexity and, thus, the identification of areas that can stem all the issues related to growth and potential benefits.

The Internet of Things will enable organizations in every industry to offer a bunch of new services or even to change their existing business models. A study made by TATA Consultancy (Misra *et al*, TATA 2014), which could be considered as the Ecosystem platform discussed above (CapGemini, 2014), is focused, principally, on the outstanding potential derived by the creation of IoT platforms that allows device monitoring, application developments, and data management. At the very first point, an IoT platform should be able to let the user plug in different devices and manage them remotely. Moreover, it should also be able to work with other software and applications and let third parties to host apps. The very important focus in the platform approach is on sensor data acquisition and management. A very huge number of data from sensors, gateways, devices and proxies, would flow into the platform and the CIOs will play a crucial role in the specification of the equipment needed, the machines that will provide such data and the determination of how these should be captured, stored and analyzed to gain useful insights that can lead to an overall operational improvement.

In very general terms, the study made by Deloitte (2014) contains useful insights regarding the strategies that an organization can follow in order to unlock the business value of the IoE. As mentioned

[54] "The Internet of Things, on its way to mainstream adoption", m2m Telefonica, October 2012, https://m2m.telefonica.com/blog/the-internet-of-things-on-its-way-to-mainstream-adoption

previously, data acquisition and management are the central points in the IoT ecosystem, and the first strategy argued regards the cost-reduction and risk management deployments as a consequence of management alignment. Indeed, because the CIOs are not focused or extremely interested on revenue growth and innovation, working at the executive level, by reaching other executives like CMOs or CFOs, will result in leveraging IoT components among different business functions, and will ensure the designers of interconnected solutions across all the management levels.

Furthermore, with the rising volume of data generated by all the connected devices, the forecast of predictive analysis may deliver both customer insights and behavior. Organizations may use data mash-ups to create context simulation and build stronger relationships by shaping customers behavior as well as by tailoring products and services for their needs.

Final strategies are mostly related to the issue of security and privacy explained above. Even if a 100% secure defense from cyber attacks is quite a unattainable hope, technology advances is also focusing on providing greater levels of security. Thanks to real-time algorithms on encrypted data, the process of hacking or attack data is becoming more and more difficult and requires a lot of time. The latter can be utilized to re-encrypt data and enhance the security defenses. In addition, IoT providers can increase the trust of users, either individual consumers or enterprises, by offering full transparency about what data is being collected and how it will be used and shared.

In conclusion, organizations must follow the steps of the IoT maturity model (Bosch, 2014), starting from the consideration that there are four main players in the IoT ecosystem: users, things, partners and enterprises. Then, they should start the process of slowly adoption and adaptation by embracing the opportunities of a connected world in a stepwise approach: from isolated to connected, from connected to managed and optimized, and finally to differentiated by creating new business and revenue models, and by having a fully controlled remote systems based on cloud to cloud mashups. Indeed, three main areas need to be addressed to accelerate economy-wide and cross-industry IoT applications: the concept of new industry models, in which every product is connected and enables a new service reinventing industry practices and business models becomes paramount; the idea that the new source of capitalization will be based on data and from its sharing between players within supply chain and cross-industry consortia; and finally, organizations must prepare their employees for the future of work by breaking the wall of autonomy among the hierarchies and by being willing to reassess their organizational structures and operations (Accenture, 2015).

In this fast evolving technological environment, the only rival for organizations is the absolutely stagnation and the non willingness to change. The awareness of the potential and the possibilities offered by the IoE are the first step to really unlock all the business value related to the interconnected devices of the world.

3.5 Advanced Manufacturing and Industry 4.0

In the previous paragraph, it was mentioned that one of the industry that is taking the best out from the latter industrial revolution is the manufacturing one, especially in German with the new industrial agenda of the Industry 4.0.

According to the statistics of the European Commission (2014) and Roland Berger (2014) the manufacturing industry, along with all its subsectors, plays a central role in the EU economy, accounting for 15% of value added. It serves as a key driver of research, innovation, productivity and job creation, and in 2012, the industry was worth €7.000 billion in turnover, employed around 30 million persons directly and the double indirectly. The footprint of manufacturing is even more significant in terms of contribution to trade and innovation. Indeed, manufacturing goods amount to more than 80% of the total

EU exports and thanks to the latters, EU has a large trade surplus in manufacturing products that reached €365 billion in 2012. Furthermore, this industry generates also the 80% of private R&D expenditure, being one of the world leaders in manufacturing sectors like mechanical engineering, with a 37% of global market share.

However in recent years, the central role of the manufacturing industry in Europe declined especially due to the financial crisis. Over 3.8 million jobs have been lost since the beginning of the 2008 crisis, while in the emerging countries, such as China and Brazil, the number of manufacturing jobs experienced an overall growth of 15 percentage points, relative to the 8% decrease in Germany, the 20% in France, and the 29% in UK. In addition to the fracture caused by the financial crisis, the manufacturing industry in EU was not able to overcome and to adapt to two more significant fractures and situations. The first fracture appeared with the rise of the emerging countries and with the outsourcing of several activities such as logistics, facility management, or other professional services. Between 1990 and 2011, the average manufactured value added of industrialized countries experienced a growth of 17%, while in the emerging countries it increased by 179%, and now, almost the 40% of total manufacturing value added worldwide, is grabbed by emerging countries. The second fracture regards more specifically some industrialized countries of Europe, which were not able to keep their industrialization rate at minimum level. This was the case of France, Spain and UK, whose rates of industrialization have decreased continuously from 2001 to 2011. Other countries like Germany, Sweden and Austria, instead, were able to capture important value added in key sector, while on the eastern side of Europe, other industrialized countries like Poland, and Czech Republic, are establishing new and highly automated plants that will enable the rapid development of high value-added activities, while increasing the percentage of industrial employment.

The importance of the manufacturing industry is also critical to ensure a balanced labor market and skills hierarchy (Roland Berger, 2014). From what was written in the second chapter, it is possible to understand potential consequences of deindustrialization: the latter, indeed, will weaken the European middle-class, because it moves the focus away from mid-salary jobs. The structural change will cause a mismatch of supply and demand on the labor market, causing, in the long run, a polarized society.

For these reasons, the EU is focusing on long-term goals and visions in order to let the manufacturing industry be a key enabler for Europe's challenges. The Europe 2020 strategy (European Commision, 2010), for instance, is concerned not only with the issue of job employment, but also on showing how Europe has the capability to deliver sustainable and inclusive growth by focusing on concrete targets[55]. Moreover, in 2014, the European Commission drafted a report of the Task Force concerning the advanced manufacturing for clean production (European Commision, 2014). Such initiative were understood by the task force as manufacturing technologies and production processes which have the potential to enable manufacturing industries to improve productivity while improving waste and pollution management in a life-cycle perspective. This would meet the climate and energy target of the Europe 2020 strategy. The latter, indeed, underlines the role of technology as the ultimate solution-provider for facing the challenge of increasing Europe economic and job growth. It relies on the fact that, investing in key enabling technologies (KETs), will help innovative ideas to be turned into new products and services that will

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[55] The main targets of the Europe 2020 strategy regard: the level of employment, which is targeted to employ 75% of the 20-64 years-olds citizens; investments in R&D/innovation have to reach the 3% of the total EU's GDP; climate and energy change in terms of lowering gas emission of 20%, 20% of energy from renewables, 20% increase in energy efficiency; education target in terms of lowering the drop-out of students; finally, lowering the number of people in or at risk of poverty.

create new high-skilled jobs, overall growth and will help Europe in addressing its challenges (European Commision, 2013). Advanced manufacturing, along with the concept of factories of the future or smart manufacturing, is seen as a key part of the new industrial revolution. In the third machine age it is expected that smart factories will use highly energy and material efficient processes, will employ renewable resources, and will increasingly adopt new business models that use all the potential of the IoT and the interconnected devices world. Furthermore, because of the technological complexity of many science-based industries, technology development requires interactions among experts from many different disciplines; this interaction often forms geographic clusters of related manufacturing, supply chain, research, and innovation facilities (Swezey & McConaghy, 2011). As a consequence, when a high-tech manufacturing cluster forms, it often attracts the location of R&D activities and will help the entire region in sustaining global competitiveness: thus, Europe as a whole, could benefit from a possible geographical cluster starting from the two countries, Germany and Poland, which are successfully implementing automation in their industries.

According to the study of the European Commission (2014), the global market for industrial automation solutions, including industrial robots, sensors, management systems, is estimated at $ 155 billion in 2011, 35% of it in Europe, and in 2015, it was forecasted to reach, $190 billion. In this context, there are certain advanced manufacturing segments with particularly high growth and potential, such as 3D printing, for which the global market volume is forecasted to increase from $2.2 billion in 2012 to $11 billion in 2021 (Campbell & Ivanova, 2013).

The combination of advanced manufacturing and progress in sectors like the 3D printing, will also play a significant part in making Key Enabling Technologies and new competitive, accessible and affordable products, while enabling costs reduction, resource efficient and timely production and commercialization (European Commision, 2013).

3.5.1 Key elements of Advanced Manufacturing

Advanced manufacturing is an envisioned state of operations in which all relevant and synthesized information is available starting from when, where and finally in the form in which it is needed across manufacturing supply chain, and to all the stakeholders (Cognizant, 2014). From an engineering point of view, smart manufacturing is the application of advanced artificial intelligence systems to enable rapid manufacturing of new products, dynamic response to product demand, and real-time optimization of the overall manufacturing production (Smart Manufacturing Leadership Coalition, 2011). Smart manufacturing (SM from now on), indeed, connects all the aspects of the manufacturing process, from the input of raw materials, to the delivery of final products to the market.

In this context, four essential elements of manufacturing are converging systematically creating a gateway to the new informed manufacturing. Products, people, processes and infrastructures, all linked and connected through networked sensors and data flows, are the main elements at the bottom of the SM applications (Cognizant, 2014). Informed products use embedded sensors to monitor and register information related to their production and operation; in this way, they are uniquely identifiable and locatable in every step of the production cycle, and thus, they will be able to control the individual stages of their production in an autonomous way. In addition, informed products can help in creating innovative business models using the real-time data flow information, and can increase customer intimacy by customizing some aspects of the usability of such products[56]. Following, informed people are essential in leveraging intra and inter enterprises social technology and mobility tools to link individuals across the entire supply chains and to deeper the collaboration and information sharing. Informed people will also allow manufacturers to realize benefits like early verifications of decisions, and rapid response to changes in the supply chain, while addressing unique customers specifications. Moreover, informed processes focus mostly on the information sharing across the value chain. These interconnected processes will provide a flexible and adaptable value chain, and advanced plant efficiency. Products diagnostics data and product performance, along with social tools used by the people, are infused automatically into the manufacturing operations, so production activities could be adjusted and corrected autonomously in time. In addition, informed processes can support mass customization, in which individual customers requirements can be met during the production cycle without sabotage and reconfigure the production lines. Finally, informed infrastructure is the last tile that completes the SM scheme. Informed infrastructure, indeed, responds immediately to changes in its environment from possible shift in user demand and other infrastructures to achieve high level of performance. Under this assumption, machineries are all connected to one another using a system of feedbacks that flow into a kind of loop of data, which provides intelligent and intuitive hints for rapid decision-making. The set of interconnected machines can, thus, monitor, measure, and analyze all the information gathered within its operational environment: in this way there will be an overall equipment effectiveness, costs reduction in terms of intelligent use of

[56] In the White Paper "Exploring the Connected Car" (Cognizant, 2012), in explaining the concept of informed products, as well as informed people, the automotive vehicles are used as example. All the sensors installed on the vehicle, can interact and monitor the way the driver drives and, thus, let the insurance companies to base the prize of the policy tailored on the way the car is driven.

specific machines and servers[57]. The latter elements, along with the nine pillars of technological advancement[58], identified by The Boston Consulting Group (2015), are the basis for the foundation of the Industry 4.0, and will transform the manufacturing productions systems by creating fully integrated data and product flows across the factories, enhancing the machine-to-machine and the machine-to-human interaction.

3.5.2 How Smart Factories will work

Since the beginning of the 21st century, a digital transformation had occurred, along with changes associated with innovation in the digital technology field, in all the aspect of society and economy. Starting from the first industrial revolution and the advent of the steam power and the development of new machine tools, to the second industrial revolution that brought the electricity and mass production, finally to the beginning of the Internet era and the further accelerated automation using electronics and IT. Now, the fourth industrial revolution, or the third machine age (as it was identified in this work), is going to connect physical objects and to create an information and data network. This kind of advance in technology system has been identified as advanced manufacturing or "Industry 4.0" in which the predominant idea is to digitalize and link all the objects into cyber-physical system and marketplaces (Roland Berger, 2014).

In the Industry 4.0 the use of robots, that will replace human workers, is going to increase over time, even more related to the second

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[57] Using software and information feedback techniques, informed infrastructure would enable servers to be powered down intelligently certain times of the day when need is minimal, thus providing significant energy and cost savings (Cognizant, 2014).

[58] The Boston Consulting Group identified nine advancements in technology that will shape the Industry 4.0 and the production of products and services. These nine pillars are: big data and analytics, autonomous robots, simulation, horizontal and vertical system integration, the concept of IoT, cyber security, the cloud computing, additive manufacturing, and finally, augmented reality (The Boston Consulting Group, 2015).

machine age discussed in the previous chapter. According to a study made by Citi (Frey & Osborne, 2015), the annual supply of industrial robots is going to double from 2012 to 2017, with the highest increment in Asia's regions. Smart robots will not only replace humans in most of the manual and non-manual tasks, but in Industry 4.0, robots and humans will work together on interlinking tasks using smart sensored human-machine interfaces. Through these interfaces, when a problem occurs, the worker can control remotely a robot, using installed web cams and precise instructions that can fix such a problem and maybe let the production continues until the next day. Thus, factories can remain open and operating all days and all day long with no more nights turnover or productivity skyrockets.

Putting together, on one hand, the huge potential of sensors and available data, and on the other the increasing number of robots that can operate with and through humans, the ideal SM enterprise would comprise all aspect of manufacturing, from plant operation to the supply chain, and enable virtual tracking of capital assets, processes, and resources throughout the entire product life-cycle (Smart Manufacturing Leadership Coalition, 2011). The final result will be a flexible, agile, and innovative manufacturing environment in which the focus will be on performance and efficiency optimization that would enable business and manufacturing operations working efficiently together.

Summarizing all the concepts said, a possible SM enterprise would work as follow: starting from the suppliers' side, there will be an agile demand-driven supply chain, which operates with higher product availability and minimal inventories. Inside the plant, instead, there will be installed a lot of sensors, which enables reactivity, traceability and predictability for all the product, machineries, and processes connected into a cloud computing system in which the cyber security will be a must. Furthermore, smart interconnected systems can create agile and adaptive factories that can react rapidly to demand and customers' changes. Indeed, during the production cycle, thanks to sophisticated advanced manufacturing systems, like the 3D printers, SM can achieve product scrap elimination, mass production, and rapid product prototyping by just changing the settings of the machine or by adopting a new algorithm. Thus, SM will use advanced manufacturing systems such as the abovementioned cyber-physical systems, or systems based on numerical command that will provide full automation, and a totally interconnected system of machine-to-machine communication. In addition, autonomous vehicles and robots will guarantee flow optimization, lower costs, and real-time autonomy and productivity while providing full transparency in terms of data reporting. The final customers, which represent the last part of the supply chain, are integral part of the SM factories: through real-time data capture and future advanced Internet-to-object communication (i.e. the vast potential of wearable items), the final product or service delivered, could be totally tailored to the customer. Indeed, the very final objective of SM systems will be the transition from a mass production to a mass customization through the right interpretation of big data grabbed from all the players of the supply chain and from the infinite potential of IoT. Moreover, customer and marketing intimacy, a high degree of flexibility, a perfect match between customer's need and mass productions efficiency, can provide on-demand manufacturing systems and high value for the final customers, while optimizing inventories stocks and reducing waste. Finally, SM factories and business management will closely work together trying to use alternative and non-conventional resources such as wind, solar and geothermic and, thus, to provide clean and renewable energy everywhere and also alternative raw materials (Roland Berger, 2014) (Smart Manufacturing Leadership Coalition, 2011).

3.5.3 The German leading role

Although the financial and economic crisis of 2008 has been very tough and perceived from the entire world, especially in Europe, Germany economy recovered quickly. Indeed, in the last few years the German economy has once again become the engine of growth for the Euro zone (ING, 2014). Thanks to several reforms made to increase flexibility in the labor market, and to redefine wage negotiations, German economy has been able to profit from the industrial goods in emerging countries, as well as from new government investments. According to the statistics of Eurostat[59] of 2013, among the European countries, Germany had the lion's share of industrial value added with around the 31%, followed by Italy, France and UK; furthermore, in terms of manufacturing share in gross value added, Germany was the first of European countries with the 22% relative to the EU average of 16%.

Germany successfully implemented the third industrial revolution by delivering more flexible automated manufacturing through the integration of Programmable Logic Control (PLCs) into manufacturing technology, while at the same time managing the impact on the workforce using an approach based on social partnership (Acatech, 2013). Moreover, since 2006, the German government has been promoting the Internet of Things and Services under its High-Tech Strategy in which the main goal is to enhance the leading position of the country in the industrial sectors, and the sustainability of a digital society (German Federal Governement , 2014). Under this scenario, Germany has the possibility to continue its leading role in Europe during the third machine age and the Industry 4.0 era.

Germany has one of the most competitive manufacturing industries in the world; it has been successfully employed ICT for several decades and now it has special strengths as the "factory outfitter of the world" (Deutsche Bank, 2014). Those strengths are largely based on the country's good general education system, its established development

[59] See the report: "Europe's re-industrialization: The gulf between aspiration an reality. EU monitor" (Deutsche Bank, 2013)

partnership between suppliers and users, its market leadership in plant and mechanical engineering, its strong and dynamic small and medium enterprises, and on its position as the leading innovator in automation methods; the technology industry accounts for the 61% of the total manufacturing sector, for a total value of €1,057 billion (ING, 2014). Furthermore, Germany is an international leader in embedded systems and in security solutions and business enterprises software. The German's embedded system market generates around €20 billion annually, and it has been forecasted to reach €40 billion in 2020 (Germany Trade & Invest, 2014).

In 2012, the German government passed the High-Tech Strategy Action Plan, as a deeper implementation of the High-tech Strategy launched in 2006. One of the ten future projects identified in the Action Plan regards the "Industrie 4.0" as a critical step to realize innovation policies and to consolidate Germany's technological leadership. For these reasons, to the Industrie 4.0 project has been allocating funding of up €200 million. Moreover, the ICT 2020, a program included in the framework of the High-Tech Strategy 2020, has its focus in the area of ICT in complex systems, new business processes and production methods. In particular, the application of the framework regards three specific categories: embedded systems, focusing in particular on systems linked to electronics and microsystem technology; utilization of grid applications and virtual infrastructure for high-performance computing software; human-machine interaction along with information processing, service robotics and usability (German Federal Ministry of Education and Research, 2007).

Already several German's enterprises have developed innovative idea to shift their activities to the Industry 4.0 concept, and the four main areas that will benefit the most are: productivity, by boosting the production across all German manufacturing sectors by €90 billion to €150 billion in the next five to ten years; revenue growth, in terms of both manufactures' demand for improving equipment and new data application, and consumer demand for a wider range of customized products, will drive additional revenue of about €30 billion a year; employment, which will increase of about 6% in the next decade, and demand for high-skilled employees will also increase of about 10%; finally, new investments required for adapting production processes that estimated to be around €250 billion in the next ten years (The Boston Consulting Group, 2015). Trumpf, for instance, is an Industry 4.0 supplier and worldwide market leader of laser systems that had put the first social machines to work. Each component is smart, and it knows exactly what work has already been carried out; moreover, customers can receive a real-time picture of the working machine, thus having the chance to provide feedback very early during the production process. Other German companies, which are implementing smart factories, are Siemens, Bosch, Bayer and the BMW (Germany Trade & Invest, 2014) (Roland Berger, 2014).

3.6 Conclusion

In the third machine age, the increasing number of big data available from sensor, actuators, and connected items, will open new scenarios in several fields. The applicability of new technologies, indeed, will be present in everyday life, from smart buildings to smart cities, and will definitely have a huge impact in sectors like the healthcare or the green environment.

Moreover, there is and there will be a huge potential that enterprises have to unlock following specific frameworks and strategies by facing issues and challenges, especially regarding cyber-security systems and data management. The value that the Internet of Everything can generate is estimated to be around $14.4 trillion, but what is actually grabbed now by enterprises is just about $600 billion. New investments will open a bunch of new possibilities in terms of innovative business models application, new source of revenues and the exploitation of synergies across the different business functions that will result in costs savings and an overall efficient and effective flow of operations.

The interesting topic in the third machine age is the concept of Industry 4.0 and advanced manufacturing. Advanced manufacturing is an envisioned state of operations in which all relevant and synthesized information are made available when, where and in the form in which it is needed across manufacturing supply chain, and to all the stakeholders. In this way, inside a smart factory, all the machines will be connected to each other and to the plant itself through several platforms that will grab all the information available from sensors and actuators. The interaction between machine-to-machine and machine-to-human will be extremely enhanced, and thanks to the power of the Internet of things and the huge world of interconnected devices, the manufacturing industry will shift from the concept of mass production, to the one of mass customization. Key enabling technologies systems, along with an agile and demand-driven supply chain, will provide tailored products and services to the final customers, while improving the efficiency of the factory itself through zero inventory costs and a better management of product and customer lifecycle.

Ten years from now, the global manufacturing landscape will look nothing like it does today[60]. Advanced manufacturing technology will shape the way companies interact with all the other players in the supply chain, as well as all the stakeholders. Companies, and nations, that will react now to new technological paradigm will thrive in the 21st century. Those who are devoted to incremental change and fail to engage smart solutions will fall behind.

[60] "What is Smart Manufacturing", Jim Davis, December 4th 2011, SmartManufactuing.org, http://smartmanufacturing.com/2011/12/04/post-test-4/

PART II:

What will be next: an Impact Assessment and future action plan

Chapter 4:
Cross-comparison analysis on future scenarios

4.1 Introduction

In the second part of this work thesis, the goal would be analyzing the actual consideration of scholars, as well as business figures, regarding the real impact and change that technology is having on the job environment, and on the new skills that are required as a must for the worker of the future. The report of Pew Research Center (2014) is a good starting point where there are the concerns of experts (CEO, CTO) about the AI, robotics, and the future of jobs. Half of these experts (48%) envision a future in which robots and digital agents have displaced significant numbers of both blue- and white-collar workers—with many expressing concern that this will lead to vast increases in income inequality, masses of people who are effectively unemployable, and breakdowns in the social order.

The other half of the experts (52%) expects that technology will not displace more jobs than it creates by 2025. To be sure, this group anticipates that many jobs currently performed by humans will be substantially taken over by robots or digital agents by 2025. But they have faith that human ingenuity will create new jobs, industries, and ways to make a living, just as it has been doing since the dawn of the Industrial Revolution.

Following, some scenarios and possible policies will be presented and discussed. By dividing the different methodologies used by different sources, it will be possible to underline the differences, as well as the strengths and weaknesses of the scenarios presented, thus, preparing the ground for a comparison between all.

In every kind of event or situation, there will always be a disagreement on the effects, consequences, and the impact of such a event. The technology advancements and its continuous presence in everyday life and every business it is not an exception. The working paper of Osborne and Frey (2013) has raised huge evidence on the increasing rate of job losses, especially in the middle-level rank, which refers to manual and non-manual tasks, as well as some cognitive ones. Nevertheless, in the third chapter it was introduced the concept of Industry 4.0 and the huge potential that the IoE can generate in very different fields of applications: new sectors, markets and jobs are very likely to be created to make employment increase. In an article written with the collaboration of Rockwell Automation and Time magazine[61], it is introduced a sort of future scenario about the evolution of the smart manufacturing as a natural consequence of three phases. The final path, as smart manufacturing continues to grow, it will inspire innovation in processes and products, thus increasing the all manufacturing knowledge, and it will inevitably disrupt the market, push down prices, open new markets, and offer a broader array of choices to a wider range of people. Although the future possibilities are very encouraging there is a net division on who believes that technology advances will displace more jobs, and who is not confident about it.

The following sections will be structured in groups based on the type of methodology: surveys methodology, futuristic and scientific methodology, and empirical calculations.

4.2 Surveys and Research methodology

Tremendous forces are reshaping the world of work by shifting economic power, wealth, competition and opportunity around the entire globe. In the first part of the thesis the emphasis was on the evolution of technology advances and the increasing awareness of people and companies about the need of changing mindsets. New business models, radical and disruptive innovations, and new way of exploit resources, are all issues and opportunities that business players

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[61] "What is Smart Manufacturing", Rockwell Automation and TIME, pdf available at:http://www.rockwellautomation.com/resources/downloads/rockwellautomation/pdf/about-us/company-overview/TIMEMagazineSPMcoverstory.pdf

have to catch, embrace, and adopt. The real impact of such phenomenon is hard to predict, but the pervasive nature of the change and its accelerating pace is, somehow, evident.

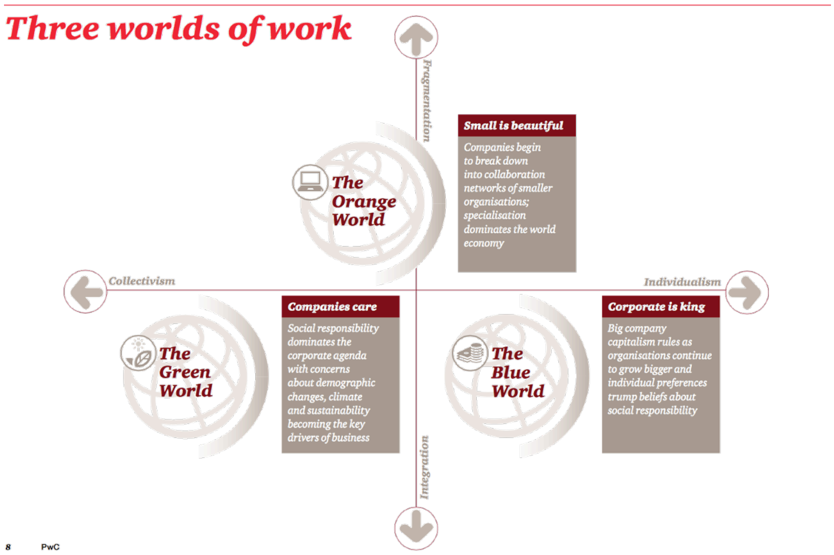
In this paragraph it will presented different scenarios and considerations about the future impact of technology, made by business and governative corporations through the use of surveys, trends studies and event-based approaches.

4.2.1 The three "world of work"

The first study that will be presented is made by PWC (PriceWaterhouseCoooper, 2014) in which are highlighted the results of previous work made by the same organization. The results were three "world of work", which provide a lens through which it is possible to examine how organizations might operate in the future. In this report, PWC looks at 2022 and considers how the characteristics of these three worlds of work are likely to be shaped by coming technology changes. The main methodology used is based on a survey of 10,000 people from different economics and business realities (China, India, Germany, UK), as well as around 500 HR professionals; the question asked to these people refers to their consideration about how their workplace will evolve and how this will affect the employment processes.

In answering to the question of what is the main factor that will transform the way people work in the next five to ten years, the 10,000 people survey has shown that more than half of the participants think that the technology breakthroughs will be the main cause. Furthermore, the forces that will shape these three world, in terms of external variables, are the push and pull of individualism versus collectivism, on one hand, and corporate integration versus business fragmentation, on the other hand. The competition between these forces will be likely to diversify each world, especially for the future of work. In these scenario-based concepts, it will be also important the role of HR in facing some challenges related to new measure of people management and interaction between companies responsibilities, and social welfare of their employees. Thus, organizations will have to adapt themselves and be prepared to undergo these new learning cycles in order to be successful.

Figure 10: The PWC vision on the future of work



Source: PriceWaterhouseCoopers (PriceWaterhouseCoooper, 2014)

Each organization is likely to be a sort of combination of these three worlds of work, thus, it would be important for each company to predict what will be its position within these scenarios, the trade-off between the two forces, and the future implication for their HR department.

The first world of work presented is the blue one, where the big corporations will be the kings. The capitalism will be the mind-set and, profit margins, exponential growth, and market leadership the main purposes in a world in which flexibility and efficiency are considered as a must to compete. Companies will seek money opportunities together with the right people to obtain it: the challenges include how to integrate talents from different markets into the overall corporate culture. Moreover, the need to lead innovation and open up

new opportunities will also see corporations investing heavily in R&D and acquiring smaller start-ups.
Meantime, employees will have access to major benefits such as pension and health assistance that otherwise they will not receive from others. In exchange for job security, companies will introduce performance metrics and data analysis especially made for their talent: sensors will check their location, even during their private lives, and will monitor their health condition with proactive health guidance and treatment to enable them performing more efficiently, reducing sick leave and work for more years before needing to retire. A brand new executive figure will raise, i.e. the Chief People Officer, who will be in charge of people management and the continuous talent seeking processes.

The second scenario is the green world where consumers and employees will force change. Companies will develop a strong social conscience and a higher sense of responsibility; consumers will demand to companies' powerful ethical values and environmental credentials as a must have. In this scenario, the objectives in the consumers' and companies' agenda will be aligned.
The need to travel to meet clients and colleagues is replaced with technological solutions, which reduce the need for face-to-face contact, in order to reduce the carbon's footprint. Furthermore, consumers and employees will seek for green companies that use renewable resource and innovative production cycles: in this context, the idea of smart manufacturing could be viewed as a prerogative that companies have to implement in order to meet people expectations.

The last world of work, which could be considered as the one more likely to become real, is the orange world. In this scenario, global business is fragmented and technology empowers low impact, and high tech business models that rely solely on collaboration networks, and employees' flexibility and autonomy. Big companies will decline, while small business, in which there will be a small core

team that embodies the philosophy and values of the company, will rise embracing the new conception of portfolio careers: the rest of workers will come in and out on a project-by-project basis. People are more likely to see themselves as members of a particular skill or professional network than as an employee of a particular company. By doing so, each worker will have a set of new skills that could be considered as unique and usable for *ad hoc* situations.
The role of technology will be also extremely important in helping companies bringing these networks together, often on a task-by-task basis, with social media heightening the connectivity upon which this world depends. Moreover, orange world companies will use technology to run their businesses, coordinate workforce, and support their relationships with third parties; they will take advantage from disruptive technologies by hiring, every time there is the need, new workers and capabilities, and thus, by staying abreast of new developments and innovation progresses.
In this context, technology advances could be seen as a driver for the emergence of an incredible number of new jobs, where each worker will have different combination of skills and capabilities needed for different purposes.

4.2.2 The UKCES vision

The UK Commission for Employment and Skills report on the future of work (UKCES, 2014), contrary to the one of PWC, has a different aim: it doesn't have the goal to predict the future, but rather to influence and challenge the way of thinking in a new and more constructive method. At the end of this report, there are both, the awareness that technology is re-shaping the workplaces and how workers do their jobs, and the fact that individuals and employees, as part of their career development, are more likely to undertake investments to let their skills-set grow. Thus, understanding what kinds of skills will be necessary to determine individual employability

and earnings potential, is a decision that require critical attention for the entire workforce.
The study's methodology used by UKCES, is build on an evidence-based approach, in which flows into several key elements, such as a comprehensive literature review, experts interviews and surveys, and a full analysis of trends and disruptions. It is a six-step research process, that starts from the study of some evidences (especially from literatures studies), to the identification of thirteen trends that are considered as fundamental in understanding the whole picture, followed by the analysis of key drivers and potential scenarios selection. The research ends with the composition of four main scenarios and an action plan filled with possible policy requirement.
For what merely concerns this work thesis, just three of the thirteen trends highlighted in the report and some aspects of the four scenarios, will be presented, considering their weight in addressing the interpretation of this thesis.
Recalling what was presented in the first part of the thesis, the technology and innovation trends that are shaping the future of work, are essentially three: first, the converging of technologies and cross-disciplinary skills with the consequent elimination of disciplines boundaries and the convergence of technologies that will disrupt products, markets, and will create brand new application fields; second, there is the digitalization of production and the new Industry 4.0 era made up around agile and demand-driven supply chain, that are supposed to increase the overall employment in manufacturing of between 100.000 and 200.000 workers by 2023 (UKCES, 2014)[62] ; finally, there is the development and the continuous increasing of ICT and the era of big data gathered from sensors and actuators placed in

[62] From: Livesay, F. and Thompson, J. (2013) "Making at Home, Owning Abroad. A Strategic Outlook for the UK's Mid-Sized Manufacturers. Report. Royal Society for the Encouragement of Arts, Manufacturers and Commerce, London."

everything is connected to the Internet or other servers, especially thanks to the development in nanotechnology and miniaturization.

The abovementioned trends are considered, from UKCES, to be stable until 2030, and they represent the basis for the emergence of four different "business-as-usual" scenarios. Even if the study regards the UK job market, the final findings would be considered as general for the entire job environment because of the universality of technology advances across developed and developing countries, and the degree of utilization of different technologies in everyday activity.

The four main elements that will be analyzed in each scenario are: the employers and employees point of view, the education and training providers actions, and the policy makers future requirement.

4.2.2.1 Forced flexibility scenario

In this scenario, the mainstream would be focused in greater flexibility and incremental innovation that will result, on one hand, in economy growth, and on the other, in fewer job opportunities for low-skilled workers. Indeed, employers will offer premium remuneration and benefits for high-skilled workers and top employees; employees, instead, are demanding to increase their agility and hybridization of skills, thus creating a portfolio of careers by "selling" their competences on the market every time there is the need. However, this focus on extremely high flexibility and high specialization, will lead to two drawbacks: few time for personal development and leisure time, and the squeezing of the middle-level workforce will lead to a lot of jobs disappearance. Education and training providers will be more commercially focused on employers needs, and will use technology-based learning systems, offering a variety of avenues for qualifications. Policy makers would remain constrained in a vicious circle in which, although they have to promote job creation by easing employment's regulation, often this effort will be at the expense of the job security of middle and low-skilled workers.

4.2.2.2 The Great Divide scenario

In this scenario, despite the huge growth driven by new technology waves in different fields of applicability, the society will be divided in two major groups: the “haves”, which are the ones who have had the opportunity to align their skills set to what the market were seeking, and the “have not” who, due to the increasing income gap inequality, will remain stationary in job uncertainty or zero-hours contracts. Therefore, employers will market themselves to prospective employees, by offering flexible working options by executing their activities through virtual platform connected with every part of the world.

The technology wave will bring a bunch of new opportunities in terms of job creation in fields related to material sciences, ICT, nanotechnology, and all the different technology-based applications. New jobs are also created in the higher value business and professional service industries that are linked to these new technologies: positions for highly skilled workers come with a high degree of autonomy.

The education system will experience a shift from being a public-based service, to being a private institution that delivers higher education just for the ones who can afford it: indeed the social upward mobility will continue to become more and more steep. Policy makers should be focused in reducing income inequalities, and creating the opportunities for everyone to upgrade knowledge and skills set in order to be competitive in the labor market.

4.2.2.3 Skill Activism scenario

In this scenario, the technological innovation driven from the advancements in robotic algorithms, will lead to an automation of professional work, with the consequence of an increase in job losses even in the high-end scale of the labor market. There will be a complete re-combination of professional skills that, now, are shaped on technology literacy. New jobs arise in the field of checking and validating automated systems, while white collar workers could be replaced as smart algorithms will be the automated substitution for high-skilled work processes. On the other hand, what will remain, to some extent, stable and always done by human workers, is related to the health and social care jobs: the human interaction, and the feelings typical of the human being, cannot be replaced from an algorithm, even the smartest.

Nevertheless, employers will face challenges in finding the right employees with the right skills-set related to the job vacancies requirement. Employees, indeed, will face a long period of unemployment, in particular those professional who were redundant by IT automation. The normal mainstream will be project-based works with a very high turnover of jobs, which can be considered also challenging in terms of development of new skills. Education and training providers, together with policy makers, have to foster a dual education model, to allow a better combination of both academic and vocational training in order to meet the employers needs. Government should focus on promoting employment in the health and social care sectors, while focusing also on increasing local and regional autonomy as a way of fostering job growth and skills development.

4.2.2.4 Innovation Adaptation scenario

The scenario presented is the natural succession of a systematic implementation of ICT systems. Education and work training become increasingly delivered through online platforms, and, simultaneously, there will be an increasing number of jobs performed remotely and virtually. Thus, the main task of the HR team will be in orchestrating this huge number of freelancer or short-term employees, with the internal resources. Individual employees, instead, are demanding to stay every time up-to-date in terms of skills sets, in order to compete in the labor market. In the education sector the number of traditional jobs in higher education, will decrease over time, replaced by online learning systems or virtual tutors. It is especially in the latter sector that policy makers have to be committed to: they have to develop a new “compact”, by re-invent education courses (more focused on interpersonal skills or on high engineering sciences), and delivery models, both online and blended learning, in order to meet employer and employees needs.

While there are some differences in the involvement of some situations in the four scenarios presented by UKCES, they share a unique foundation: the continuous technology growth, along with the accompanying changes in customers, and employer needs, and on business models, make for all the workers the skills set adaption absolutely fundamental for a successful participation in the labor market. Jobs that have traditionally occupied the middle of the skills hierarchy and earnings range, such as white-collar administrative roles, are declining at a significant rate due to changes in work organization driven by technology and globalization. Those who don’t’ recognize the potential disrupting power of technology advancements, or those who, unfortunately, cannot afford higher education, are intended to face long period of unemployment and job insecurity, that will bring to a income gap inequality that governments cannot handle.

4.3 Scientific and Futurologists’ vision

Most of the time corporations and businessmen do their forecasting mostly based on numbers and figures related to a specific event. In this section, instead, it will be presented the point of view of some three important futurologists and professors that are completely into specific technological fields, having a wider understandings and knowledge, not only about economic and financial trends, but also about the real development of some technologies that will definitely shape our future.

From the scenarios presented, it will be possible to catch insights about the job environment, as well as what kind of path policy makers should undertake in the near future.

4.3.1 Ray Kurzweil and the concept of Singularity

The computer scientist, inventor, futurist, and director of engineering at Google, Ray Kurzweil, describes the Singularity[63] as "a future period during which the pace of a technological change will be so rapid, its impact so deep, that human life will be irreversibly transformed. Although neither utopian nor dystopian, this epoch will transform the concepts that we rely on to give meaning to our lives, from our business models to the cycles of human life, including death itself" (Kurzweil, 2006).

Kurzweil presents a provocative scenario in which humans are the creator of a new machine-based civilization driven by evolutionary principles, which he extends to the evolution of technology. In fact, he views history as a series of six epochs based on information and technology advancements[64].

Furthermore, the futurist proposes three main premises. The first one refers to ideas and the about the fact that human can solve problems: whether there will be the need, humans will be able to recognize and solve it, because what characterizes the essence of an individual are the patterns that comprise him or her. In Kurzweil's mind, patterns are intelligence and the final message, which is at roof of its personal philosophy, is that humans will be able to achieve immortality.

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[63] On page 7 of his book

[64] The six information-based epochs are: first is the epoch of physics and chemistry, where information is on atomic structures; the second epoch is the biological-DNA epoch; third is the epoch of neuro-patterns; the fourth is the epoch of information in hardware and software design; the fifth epoch is the merger of technology with human intelligence, and, finally, in the sixth epoch the universe wakes, and patterns of matter and energy in the universe become saturated with intelligent processes and knowledge.

The second premises refers to a theory of technology evolution that the author pointed out as "the law of accelerating returns", meaning that the technological change is growing exponentially rather than linearly. As a consequence, each epoch is the preparation for the next one, and in the last one, the sixth, there won't be any distinction between humans and machines, because the latters, will have progressed to be like humans. He also recognizes that the "law of accelerating returns" is an economic theory, in which technology replaces traditional economic measures as drivers of development.
The last premise is accompanied by increased complexity. In its vision, it would be possible to replicate the computational capacity of the human brain: he sees whatever the brain does as a computational exercise, and since the machines already do computation very well, we soon will be able to imitate in machines what the brain does. This is the main message that the author wants to spread out: in less than two decades, humans will be able to achieve and develop the software of human intelligence.
The current and the near future changes will be drastic as humans enter the fifth epoch, in which revolution in genetics-nanotechnology and robotics (GNR) will be exponential. The speed of progress will be likely to change most of the present issues; indeed, as he writes, by 2020 molecular assembly will provide tools to effectively combat poverty, clean up our environment, overcome disease, and extend human longevity.
Although the scenario illustrated by Kurzweil has its foundation on the rapid technology evolution pace, it seems to be quite a "science fiction"[65]. Furthermore, the author didn't consider the effect that Singularity might have in higher education. He writes that humans will move toward a decentralized educational system where every

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[65] Review of Ray Kurzweil*'s The Singularity is Near* from *Technological Forecasting & Social Change* (Vol. 73 no. 2, Feb. 2006), Joseph Coates Consulting Futurist, Inc.

person will have ready access to the highest-quality knowledge and instruction. If everyone has the same high education, there will be less emphasis on factual knowledge, thus it would be probably unsustainable for the human being, doing theoretical science or literature researches, as well as performing even a cognitive and difficult task, because machines will become far better than humans. The Singularity's vision of Kurzweil (from the six epoch on), thus, could be considered as the worst scenario in terms of future employment: machines will become as complex as the human brain is, but without their biases.

4.3.2 Nick Bostrom's Superintelligence

Nick Bostrom is a philosopher specialized in existential risk, anthropic principle, and Superintelligence risk. It is especially on the latter field that he is concentrating his efforts and all his studies and know-how. In his book, *Superintelligence: Paths, Dangers, Strategies* (Bostrom, 2014), he tried to answer to the question of what will be the cause that is going to change everything. He starts its research defining the human intellect as the birth canal of technological inventions, scientific theories, and, in general, everything that has a relation with the human brain. Similarly to his colleague Kurzweil, he defines the brain as chief rate-limiting factor in the development of human civilization. Moreover, he thinks that intelligence can be enhanced in several ways, both biologically and via norms and conventions.

Each of these ways holds great promises, and the author thinks that they ought to be vigorously pursued. Although the smartest and wisest thing the human species could do would be to work on making their self smarter and wiser, the Superintelligence vision of Bostrom predicts that, in the long run, biological human brains might cease to be the "predominant nexus of Earthly intelligence".

In the scenario envisioned by Bostrom, it is possible that one day, humans may be able to create Superintelligence: a general intelligence that vastly outperforms the best human brains in every significant cognitive domain (Bostrom, 2014). Machines, as amply discussed in this work thesis, have several advantages relative to humans: they have faster processing speed, superior computational architectures and learning algorithms.

Recalling the 2006 studies of Kurzweil on brain replication, the approaches of creating an artificial intelligence that would involve the creation of a human brain's map, has been again emphasized and presented. Beside the time the creation of such an incredible artificial intelligence will take, when (and if) it will occur, the scenarios illustrated by the author have nothing that aim for positive.

Indeed, in one type of scenario, the singularity hypothesis, the scientific researches in the field of artificial intelligence and other related disciplines, will culminate in the creation of a "seed AI". The latter is a super advanced and smart machine that is able to improve its own intelligence: the smarter version then will use its greater intelligence to improve itself even further. Bostrom imagines a sequence of four steps of development of such idea. The first one is represented by the creation of the "seed AI" together with the continuous improvement that it can reach by itself: as the seed AI grows more capable, it becomes able to perform more and more work by itself. The second phase regards the recursive self-improvements in which, once the seed AI has becoming better at AI design than humans, it can be capable to develop a cascade of intelligence amplification superpower and, then, to foster the implementation of all the other superpowers[66]. The third phase will be about the covert preparation of AI plans, in which it develops a robust plan to achieve its long-term goals using its strategizing superpower. The last phase, the overt implementation, will see the decline of human power over

[66] For further information go to page 195-196 of the book, Table 8 (Bostrom, 2014).

the machines, that now are completely manipulated by the Superintelligence of the AI. Then, Superintelligence would be the last invention biological man would ever need to make, since, by definition, it would be much better at inventing than humans are: all sorts of theoretically possible technologies could be developed quickly by Superintelligence.

Nick Bostrom, however, explores also a multipolar outcome scenario rather than just the singleton explained before. The author asks himself what could happen if, being understood that general machine intelligence could serve as substitute for human intelligence, machine workers become cheaper and more capable than human workers in performing all kind of jobs. Of course the main impact would be in wages and unemployment due to fact that with cheaply and easy to copy jobs, market wages will definitely fall. Although there still could exist customers that prefer the work done by humans[67], to the extent that cheap machine labor can substitute human labor, human jobs may completely disappear.[68] The potential downside of this possibility is extreme: the level of human subsistence will fall to a point of no return.

Another implication of this multipolar scenario is related to the capital and the social welfare. As a matter of fact, the total factor share of capital, steadily remained for a long time, at 30%, meaning that the 30% of the total global income is received as rent by who owns capital, while the remaining 70% is received as wages by workers. Bostrom classifies AI as capital, and then, with the technology advancements and the machine intelligence that can fully substitute human labor, the share of capital will become roughly the 100% of the

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[67] Let’s think about the handmade jobs, which is at the bottom of the value of several brands.

[68] The author uses the parallel story of the horses that, initially, were used by humans for a lot of activities and they were a complement to the labour of humans. However, with the invention of automobiles and tractors, the demand of equine’s labor significally decreased.

global income. Since humans are the only owners of capital, the total income received by the human population would grow exponentially, even if they would not receive any wages. This will create the biggest income gap inequality ever, with extraordinary rich people surrounding by those who don't own any capital.
Whether these scenarios will become reality or not, humanity condition mostly depend on the initial condition that will be created by, for example, successfully design the AI system, with a human-friendly interface that never can reflect against the human being.

4.3.3 Michio Kaku's physics of the future

The last contribution in envisioning the future is provided by the American futurist and theoretical physicist Michio Kaku in his book "Physics of the future: How Science will shape Human Destiny and Our Daily Lives by the year 2100" (Kaku, 2011). Although there is always a halo of uncertainty about the future, the author trusts in the foundation of modern physics, chemistry and biology that are not expected to receive any major revision in the foreseeable future. Furthermore, there are several reasons to believe that, what the book is predicting for the 2100, is reasonable. Kaku's methodology, indeed, is based on: interviews with more than 300 scientists, those specialized in the forefront of discovery; then, every scientific development mentioned in the book is consistent with the known laws of the physics and the four forces, and the fundamental laws of the nature are largely known and there is a very high probability that these laws would never change; finally, all the prototypes and the inventions of all technologies explained in the book, already exist, and the same author is an insider who has a first hand look at technologies that are on the cutting edge of researches.
The vision suggested by Kaku does not have a direct focus on the impact of technologies on employment, but rather it is a journey through the next 100 years of scientific innovation and discovery. In

order to discuss such progress and advance in technologies, the author divided each chapter in time-frames, from today to 2030, then from 2030 to 2070, and finally from 2070 to 2100, based on a roughly approximation of the various technological trends.

For what concerns the thematic of this work thesis, there are two main factors that could be considered as significant.

The first one refers to the huge number of new inventions that will surround our future lives. Most of the unthinkable solutions that technology advancements would bring already exist and are employing an always-bigger number of people. Thus, it is reasonable to say that, with the rise of new discoveries and innovations, the number of available jobs will go up. However, the problem is always the same: the structure of these new jobs will definitely require a high degree of education, especially in fields like advance mathematics or engineering, that not everyone can afford. The problem of middle-skilled workers would still exist, as computers[69] will most likely to keep growing exponentially.

The second factor that can be deducted from the Kaku's book concerns, once again, the problem of education. He uses the example of his country, the U.S., as a paradigm by writing that "the United States will eventually have to overhaul its archaic, sclerotic education system. At present, poorly prepared high school students flood the job market and universities, creating a logjam … and the universities are burdened by having to create new layers of remedial courses to compensate for the poor high school education system". Thus, even if the Kaku's optimism about the future is quite evident throughout the entire book, the issue of higher education that affects the US and the rest of develop countries delimit that optimism, as it was largely discuss in the previous sections. In the last chapter of the book, Kaku

[69] The term computer refers to every machine that work with microchips and transistors in which electrical signals can travel at the speed of light through a light beam that can contain a limitless number of information.

writes about the problem of the entry-level jobs that, in the new nature of economy, would be completely gone. In his vision, indeed, government efforts have to be made to reorient and reinvest in those sectors that maximize intellectual capitalism. The latter does not mean that there will exist jobs only for software programmers and scientists but in a broad spectrum of activities that involve creativity, artistic ability, innovation, leadership, and social communication. The workforce has to be educated to meet the challenges of the twenty-first century, not to duck them.

4.4 Empirical analysis methodology

The last methodology regards the empirical studies that have been made by several scholars for different labor market of the world, and with different sets of data and variables.

The most significant contributions were largely discussed in the second chapter of the present work, by explaining the process of job polarization that is affecting the labor market.

In this chapter, however, there is a specific focus on the methodologies used be the different authors drawing their empirical models.

One of the most relevant academic papers was provided by Autor and Dorn (The growth of low skill service jobs and the polarization of the US labor market, 2013) where they conducted an empirical analysis of the forces that are shaping the education, wages, and the low level of employment in the US labor market. They started considering computerization as one of the main driver in the low-skilled jobs substitution of routine tasks, and in the decrease of wages paid to workers performing such routine tasks. Another important factor in their analysis is represented by the declining price of computer technology that forced the low-skilled workers to reallocate their labor supply to service occupations, which are very difficult to be replaced because of their high degree of personal skills, such as dexterity, interpersonal communication, and physical proximity. The natural consequence of the latter input, is a change in the wage and employment distribution: if the service occupations are less vulnerable to the automation than routine tasks occupations, then there will be a wage and employment increase in low-skilled service occupations. In order to develop a sustainable model based on their findings, Autor and Dorn extended the model to a "spatial equilibrium setting" and obtained empirical implications on a sample of 722 commuting zones in US. The final results have shown that the variation in routine tasks intensity, across the commuting zones, has proven the prediction of the model: commuting zones that were intensive in routine job activities have experienced greater adoption of new technology, greater reallocation of workers from routine tasks to service occupations jobs (employment polarization, see chapter 2), larger increase in both wages and employment at both ends of the skill distribution, and finally, a larger inflows of both high- and low- skill labor.

Starting from the Autor and Dorn commuting zones model, together with other relevant academic researches (Autor *et al*, 2003) (Acemoglu *et al*, 2011), Osborne and Frey (2013) have revisited the previous models, which were based mostly on the consideration that computerization has been confined in routine tasks involving ruled-based activities, by adding the impact that big data and AI have had in performing other tasks, i.e. manual, non-manual, and cognitive tasks.
By using data from the US Department of Labour, they developed a statistical and probabilistic model on 702 occupations with the final purpose of finding the expected impact of computerization on labor market by identifying the percentage of jobs at risk. The final results have shown that 47% of total US employment is in the high-risk category, in a scale of high, medium, and low risk occupations depending on the probability of computerization. In addition, the results also have shown that most of the employment's shares in the service occupations, were in the high-risk category, thus, overturning

the predictions of Autor and Dorn model (2013). The conclusions suggest, once again, that, as the pace of technology progress is continuing to grow, low-skilled workers have to acquire creative and social skills in order to reallocate their labor supply into jobs less susceptible of computerization.

4.5 Scenarios' comparison

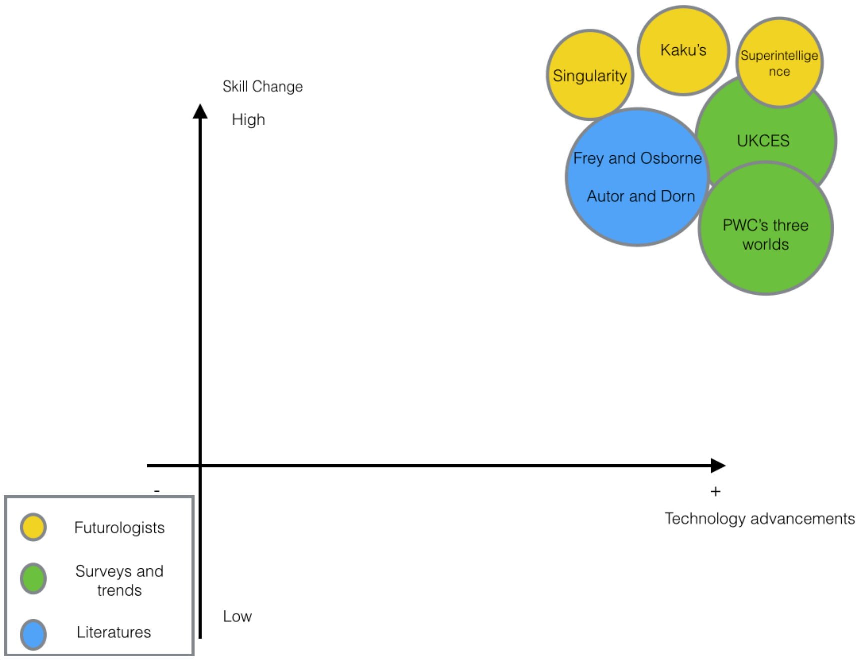
Although the differences in methodologies utilized for every set of scenarios, the thesis that this work intend to demonstrate is the correlation between technology advance and the changes in the skills sets of workers, thus understanding how the employment requirements have changed over time.

In order to have a whole picture of the different scenarios, and to compare these under common variables, two positioning maps will be drawn.

In the first map, as Figure x shows, the two variables identified are, on the y-axis, the skills change, while on the x-axis, the technology advance. The interpretation here is, as the technology progress goes further, the skills-set required by employees will change as well; furthermore, the biggest is the circle representing the scenario, the more reliable is the fulfillment of the latter[70].

[70] According to a subjective interpretation of the contents presented in this thesis.

Figure 11: Scenario's comparison I[71]



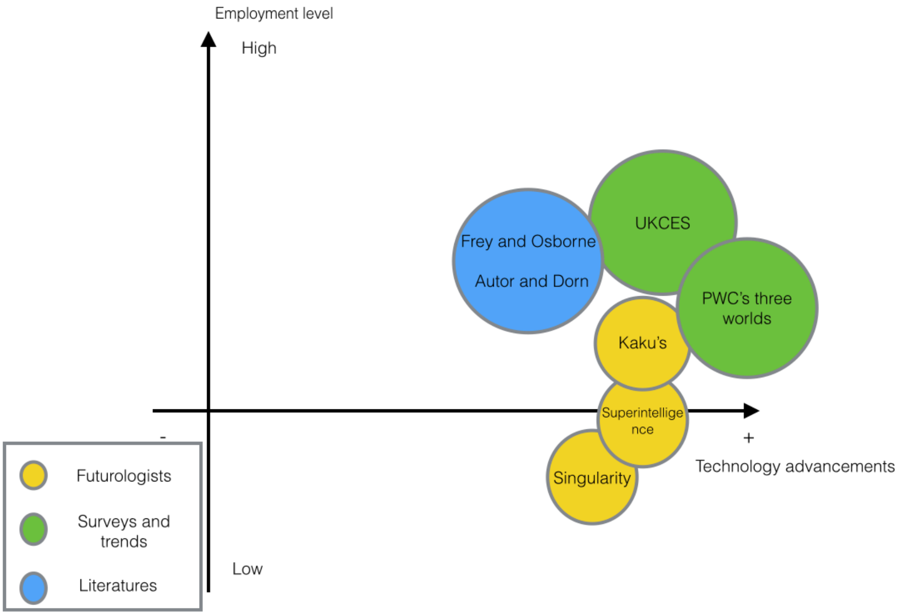
Source: Internal calculations

There is a clear concentration of scenarios on the top right part of the graph, representing a very high correlation between the two variables. Indeed, in every future scenarios, regardless what kind of methodology has been used, the progress of technology and its wide applicability in almost every sectors, has the consequence of modify how a task will be performed, and of change the human-machine interaction. If, in the analysis of Frey and Osborne (2013) the near future will see the share of unemployment increase more in the middle-level part of the labor market, mostly due to the automation of manual, non-manual, and cognitive tasks, once the scenario goes further in the future, every individual worker has to face the challenge of change its skills set.

As the second positioning map shows, the technology advance is also strictly correlated to the level of future employment.

[71] Even though both UKCES and PWC provide four and three, respectively, different scenarios, the differences between each other are not relevant in the understanding of the positioning map.

Figure 12: Scenario's comparison II



Source: Internal calculation

The future that each different scenarios present is characterized by two main situations, each one with its peculiarities and limits.

On one hand, the progress of technology and interconnected devices will result in the disappearance of a multitude of tasks, which would be performed in a easiest, faster, and efficient way by machines and robots. Such tasks are the ones that mainly refer to ruled-based activities and manual tasks: for example, in future concept of smart manufacturing, the production process, as well as almost all the activities of the supply chain, will be performed by intelligence robots and computers that elaborate complex data into streams of information that will match the requirements of the final customer.

The issue in this situation would be the proliferation of a high number of workers that will share similar competences and will be in continuous competition among each other. If non-manual and cognitive tasks would be replaced, there will be a double scenario in which, the ones who have high income and can afford higher education, would have the possibilities to stay up-to-date with the every time changes of skills set required by employs; those who cannot, would have to improve personal and communication skills and try to find a job in the low-level part of the job distribution. Moreover, even for the "high-skilled" workers, there won't be the security of a long-term job relationship with the company or the private employer. Zero hours contracts will be the norm as employs will seek project-based workers and specific skills set for every different business need. However, it should be also considered the situation where advanced manufacturing and the wide applicability of the IoE paradigm, in all the sectors that were explained in chapter 3, would have on employment: indeed, a bunch of new markets will be created with their relative new job places, thus increasing the number of available works at a very rapid pace.

The other situation that could occur, regards the completely supremacy of the machine and the artificial intelligence. In this case the human intervention and prevention will determine the probability of success of such scenario.

Nevertheless, it is from the first industrial revolution, with the Luddism protests, that the advent of new technologies is the cause of human replacement in the job environment: so there is no reason why this trend should come to an end. The disruptive scenarios of Kurzweil or Bostrom, as well as the others that are not so optimistic in terms of employment level and income distribution will become reality if and only if government and institutions do not implement defensive strategies against the race of machines.

How humanity might overcome to these events and put in place a strong action plan in order to let the technology advance being a source of growth and employment, and not the opposite, will be the topic of the last part of this work.

4.6 Action plan for the future

The future is probably the most difficult thought to predict. There are factors that people cannot take in consideration, either because they are not aware of these, either because they are not able to imagine what the consequences of a specific input will be.

However, what can be said as a matter of fact refers to the next change that all individual workers have to face with in terms of their own skills set. Whatever will be the future scenario, there is the funded risk of the creation of swathes of transitional unemployment and a significant role for public policy to shape the process in order to avoid a social breakdown scenario (Meyer, 2014).

According to the article of Wagner on “The Futurist” (Wagner, 2011), one of the easiest way of thinking about what a future career would be like, is to focus on what might be a problem in the future and, then, invent a job that will solve it. Three main approaches could be used in order to have a comprehensive view of future jobs requirements: first retrofitting, which means adding new skills to existing jobs; second, blending, by combining skills and functions from different jobs or industries to create new specialties; and finally, problem solving, which refer to the almost limitless needs of people for solving issues.

But what truly are the skills that workers have to acquire is still hardly to say. For these reason, it was intuitive and visionary the report made by the Institute for the Future (Institute for the Future, 2011) where starting from the study of six main drivers of change, which could be seen as the summary of what has been presented in this thesis, they identified ten necessary skills, among the huge number of undefined skills that future workers have to possess and implement. The six drivers they identified refer to the extreme longevity and the problem of aging population, thus workers have to rearrange their approach to careers, family life and education; following, there is the rise of smart machine and artificial intelligence systems that are shaping workplaces and nudging humans out; related to the latter, there is the large increase in usage of sensors and processing power systems that will provide huge amounts of data to be tracked and manipulated, then there will be an increase in demand abilities to process such data, to make projections, and to build up new business models in order to obtain the best outcome. Moreover, new communication and media tools are increasing their footprint in everyday life, enhancing business productivity through online platforms while enabling workers in performing activities remotely; furthermore, "superstrucutured" organizations will be the new way people will consider companies: thanks to collective intelligence and the new resources grabbed by social connections with multitude of others, organizations will learn how to work, invent, and govern these social tools at a large scale, thus laying the foundation for new organizational concepts and work skills in brand new fields. Finally, the impact of globalization is the long-term trend toward greater exchanges and integration across all the different geographic region of the world. A global connected world will increase, even further, interconnectivity, and will put diversity and adaptability at the center of every organizational operation. The key for success would lie on the perfect integration between local employees and local business processes into the infrastructure of global organizations.

From the analysis of these six drivers, the IFTF elaborated a set of different skills that would probably match the future needs and employers requirements. The very first skill in which human would be always the best at is related to the ability of determine the deeper meaning of what is being expressed. As also pointed out by Murnane and Levy (2013), computers are not (yet) able to codify high-level thinking like interpret and extrapolate the meaning of a word inside a specific context. There is no algorithm or rule that succeed in capturing the different voice's tones rather than the human's variety of expressions during a conversation or again, a masked meaning of a phrase. That said, critical thinking as well as sense-making skills would emerge, as workers would keep capitalize on.

The skill of sense making is strictly correlated to another key element of the human nature: the social intelligence. As mentioned in the chapter 2 (Osborne and Frey, 2013), reproduced human's feelings and emotions is hardly an easy task for robot's programmers. Social intelligence has been always a key skill for workers who need to establish a connection and build relationships based on mutual trust. Then, our emotionality and social IQ will continue to remain a fundamental asset that gives to the human being a sustainable comparative advantage over machines.

Another skill, which is related to technology advance drivers, refers to the concept of adaptive thinking and the proficiency in coming up with solutions and responses beyond that which is rote or rule-based. This statement is shored up by the findings of David Autor (2010, April) in which he plotted the change in employment over the period 1979-2009 and he found out that tasks that involve abstract thinking, such as high professional jobs, will be at a premium in the next decade, mostly due to the fact that they share what the author called "situational adaptability", i.e. the ability to respond quickly to unique unexpected circumstances.

Following, the other skills are mainly related to the ability of filtering information for importance, thus understanding how to maximize cognitive functions, or, again, the ability to translate vast amount of data into abstract concepts and to understand data based reasoning[72].

In order to achieve the goal of educating the new generations with such skill sets, educational policies should be rethink and adapted the new technology and global contest. Generally speaking, when a job is replaced or a job description change beyond recognition, a proactive action plan, in terms of policy institutions, become essential.

Following, some hypothesis of what the future policies should be focused at would be suggested.

[72] The remaining skills presented in the analysis of IFTF would not be reported due to the non perfect alignment with the contents of this thesis work.

4.6.1 Education challenge

Education has always had a central role in everyone's future decisions and job implications. Its importance has grown faster, especially in today's environment, which is facing a tremendous transition into a more technological, interconnected global world.

As pointed out by Levy and Murnane (2013), writing about high school graduates, computerization of work and offshoring has a high weight in the declining employment opportunities equation. In the particular case, the declining fortunes of high school educated workers ha two main consequences. The first one concerns the many people who might face downward economic mobility, and might earn less real income than their parents had earned; the second case regards the education priority in the job mobility context, because education has moved from being one, among the few, source of upward mobility, to the main source.

Furthermore, the problem of education has worsened due to the changing skills that workers are demanding to have. Indeed, today's education challenge stems from the increased complexity of foundational skills needs, thus from understanding how core subjects need to be taught, while enhancing the "learning" and the development of conceptual and adaptive thinking, as well as problem solving skills. In addition, from a report made by the Economist Intelligence Unit (The Economist, 2008) has emerged that only 40%, among private-sectors workers respondents and professionals, believe that current graduates are able to compete successfully in today's global marketplace. The challenge is, not only to equip students with a high level of education in their study fields, but also to arm them with the set of new skills required (see for example the previous section), and the right knowledge to leverage technology in the workplaces.

In this context, the idea of 21st century skills and teaching is arising and spreading out as the new paradigm of high education.

“Learning for the 21st Century” (Partnership for 21st Century Skills, 2008) and “10 ideas for 21st century education” (Innovation Unit, 2012) are reports that articulate a vision of how schools can be prepared and can best prepare their students to succeed. They stressed the accent on few main elements of 21st century learning. The very first is the identification of the core subject, thus to challenge schools and policymakers to expand their focus beyond the basic competencies; how students could cope to the demand of the 21st century is the question at the bottom of the second element, which regards the learning skills. Students need to know more than just the core subjects, thus understanding how to use their knowledge and skills by thinking critically, applying knowledge to always new solutions, analyzing information and capturing the real meaning of it. For allowing students in discovering the new concept of education, educational institutions must understand and integrate technologies into education systems from the elementary grades up: if students are able to leverage technology’s issues or are able to understand its applicability in different fields, the results might be surprising, since technology is, and will continue to be, a driving force in workplaces, communities as well as in personal and every day’s lives. Furthermore, students need to apply what they learn into real life examples; experiences that are relevant to students’ lives, beyond the classroom context, and based on authentic projects are central in the 21st century education system.

Finally, probably the most difficult element that should be implemented and developed regards the new assessment tools of those essential skills. There are, still, few innovative frameworks built *ad hoc* that attempt to identify the individual skills and overall sets of skills of students. For example, the PISA assessment represents a collaborative effort undertaken by the OECD members, and it takes a broad approach to measuring knowledge, skills and attitude. PISA focuses on competencies that students, from 15 years old on, will need in the future, and seeks to assess what they can do with what they have learnt, thus it is a good evaluation metric for evaluating the ability of students to reflect, and to apply their knowledge and experience to real-life issues (OECD, 2013). Another example is provided by the CWRA, which is a tool used by few private institutes as a way to measure school improvement. It is an online assessment that includes a performance task and 25 selected-response items: the final purpose is to measure analytic reasoning, problem solving and written communication, which are considered to be three essential skills for success in college and work[73].

Measuring 21st century skills on a large scale is, however, a very difficult and challenging task. Indeed, measurement tools are very expensive for government and private institutions: the cost to score the CRWA's performance task, for instance, is more than $40 per test. Furthermore, technology can be expensive in terms of implementation of new technological resources (hardware, software, and professional development) and ICT costs for teachers to be trained and prepared to leveraging such technologies. Again, technology can be distracting for students, and also there is the high possibility of a rise in plagiarism and cheating, if the learning methods are not engaging and relevant: contents must be specific, concise and fast (International Education Advisory Board, 2008).

Policymakers should consider different options in order to let education, technology, and employment opportunity grow at the same rate. For instance, there should be a strong government contribution in aligning people and business needs, maybe by defining what the labor market really demands, while investing heavily in the higher education sector with the final purpose of implementing a program of co-operation and co-existence of schools and organizations. This means reducing the mismatch between demand and supply of skills,

[73] "College and Work Readiness Assessment", Virginia Beach City Public Schools, www.vbschools.com

thus increasing the employment ratio: it also requires that business organizations should work more closely with government to support the adoption of new work practices.

Moreover, other knowledge and skills assessment frameworks should be implemented, thus declining the costs of tests checking and to provide a better tool for measuring the teaching methods as well as the students performance in the new skill sets requirements.

Over the next decades, technology advance will put higher education as a necessary step, for almost everyone, in order to compete in a world in which the biggest portion of the population have never knew a life without a computer and all its related things and processes. Enhancing mobility of high skilled and trained workers, but also avoiding the job polarization through long-term strategies for ensuring that low-skilled workers can react and survive to the radical change of the labor market, would be a must for every country. Technology advance could be a source of welfare for everyone if, and only if, there will be an equivalent change in institutions and long-term strategies. For these reason, in 2013, the EU Commission launched the Grand Coalition for Digital Jobs, which is a multi-stakeholders partnerships that is targeting to facilitate collaboration among business and education providers, public and private players to take action attracting young people into ICT education[74]. The European Commission at the end of the European Council undertook another straightforward initiative, again, in 2013. What was highlighted regards the European Structural and Investment Funds that should be available before 2020 and used for ICT education: it includes different sources of funds such as the European Social funds, the Youth

[74] Digital Agenda for Europe: a Europe 2020 Initiative, Grand Coalition for Digital Jobs, 07/04/2015, European Commission. http://ec.europa.eu/digital-agenda/en/grand-coalition-digital-jobs

employment initiative fund, or the European Regional Development Fund[75].

4.6.2 Enhancing technology advancements

From all the things that were mentioned throughout this thesis, it is somehow obvious to state that technology advance is going to produce a massive value due to all the future scenarios and possibilities, in terms of new markets, products, jobs, that can derive from a good and reasonable implementation of it.

Economy-wide productivity and employment can, thus, be enhanced when new technology are diffused and adopted: for these reasons, technology diffusion systems and mechanisms should be considered as a priority for policymakers.

For doing so, there should be a dual long-term strategy for both public and private sectors. Regarding the public sector, the goal would be the improvement of the efficiency of industrial R&D by reducing the tax wedge or by enabling other market mechanism for financing innovation. Furthermore, the technology and innovation sector should be considered as an open market with open trades and regulatory reforms, that enhance the competition among all the players and increase the ability, of firms, to have access to new opportunities also thanks to a greater and integrated public initiatives that should provide cost and risk sharing among industries.

On the other hand, private sector's organizations should consider the idea of building a sort of unique IoT ecosystem in order to provide a single driver for every application. By doing so, there will be a very high degree of collaboration between IoT providers, service providers,

[75] Digital Agenda for Europe: a Europe 2020 Initiative, Potential Funding, 29/10/2014, European Commission, http://ec.europa.eu/digital-agenda/en/potential-funding

private organizations, and final users. Open government approach[76] could facilitate this latter issue by opening up public data and services, thus facilitating the collaboration for the design, production, and delivery of public service. Moreover, the availability of open data could facilitate the creation of new services, new related markets, businesses and jobs, while reducing the government administrative costs and providing a better, responsive and effective service.

In addition, because of there will be an increasingly number of new markets, sectors, thus the emergence of demand and jobs in these new growing areas, government should create an environment that encourages and promote the relevance and the possibilities offered by these new industries related to Interned-based services. By reducing infrastructure constraints, or by incentivizing technology-based investments through the reduction of bureaucracy obstacles or by sharing the risks taken among more players, there would be a general improvement for the creation and the growth of new technology-based firms, which will lead to a direct job creation increase, and to an indirect economy-wide improving, thus the creation of other jobs and an overall greater productivity and welfare.

4.6.3 Cyber-security

It is likely that big data would become the next main source of value for companies, public organizations, and private individuals. Thanks to the interconnectivity of almost all the devices used by people and from the sensors and actuators that would be installed across roads, vehicles, power grids, houses, and so on, a huge amount of sensible and private data would be monitored, analyzed, and collected.

Furthermore, in the recent years it is arising the debate on the Net Neutrality, which argues that every point on the network can be connected to any other network access point, without any

[76] Digital Agenda for Europe: a Europe 2020 Initiative, Open government, 23/02/2015, European Commission, http://ec.europa.eu/digital-agenda/en/open-government

discrimination or limitation. A major focus in the debate is concern over whether the current framework is sufficient for policymakers to enable them to take the necessary steps to ensure access to the Internet for content, services, and applications providers, as well as consumers (Girloy, 2015). Moreover, the principle at the bottom of the Net Neutrality lies on the fact that Internet is becoming the only mean for a global and interconnected world, and its success is based on its architecture that can provide, either that every connected device can connect to every other device, and either the wide usability of its protocols, which are extremely flexible and simple to carry all kinds of information and contents (European Digital Rights). Said that, Net Neutrality is becoming a priority for innovation, competition, and for the free flow of information: it can helps in building sustainable and reliable new protocols for the IoT architecture, thus providing better interconnected services for everyone.

In this context, concerns about Cybersecurity are becoming national policy priority in many OECD countries especially due to the final goal of preserving the openness of Internet as a platform for innovation and new sources of growth. Cybersecurity strategies recognize that the economy, society and governments now largely rely on the Internet for many essential functions and that cyber threats have been increasing and evolving at a fast pace. Most strategies aim to enhance governmental co-ordination at policy and operational levels and clarify roles and responsibilities. They reinforce public-private co- operation emphasizing the need to respect fundamental values such as privacy, and the free flow of information (OECD, 2012).

4.7 Conclusion

The second part of this work has the aim of answering to the question if the technology advance is destroying job or not.

In order to identify a good pattern of results a methodology comparison was performed regarding different future scenarios and

technology applicability. Three scenarios were selected based on: surveys and trends, futurologists' visions, and literatures' analysis.
From a cross comparison analysis, it was shown that technology advancement is, actually, reducing the employment share, especially, of the middle-skilled workers and all the kinds of works related to manual and repetitive tasks, mostly due to a simultaneous change in the skills sets required by employers. Technology advance, indeed, is strictly correlated to an updating of skills for all the workers, either for low- and middle- skilled, and either for high-skilled ones.
That said, technology can be considered, however, as a source of economic and employment growth if, and only if, institutions and governments will implement several reforms that aim to create a sort of bridge between the level of education, the skills sets that workers are requiring to have, and technology progress: education challenge, policies that would have the goal to enhance technology progress with incentives, funds, and R&D improvements, and, finally, guaranteeing a secured and trusted cyberspace in which data and information can flow freely, are all possible action plans for ensure a better future cohabitation between human and machines.

Conclusion

The subjects illustrated in this thesis have been moved toward the greater consideration and presence that technology is having on people's everyday lives and, especially, in the changing panorama that the labor market is facing with. The aim of this work was to demonstrate a possible correlation between the technology advancements and its impact on the current, and upcoming, labor market, thus understanding if the employment is suffering or benefiting from it.

In one of his last book, Eric Hobsbawm, writes something of very high impact but at the same time very meaningful: he writes that even within huge crisis, the "market", has no answers to the main problem that XXI century is facing with: an unlimited and always more hi-tech economic growth…produces a global prosperity that goes to the detriment of a production factor, the human work, which becomes always more unnecessary… (Hobsbawm, 2011).

In order to provide a reliable support, and to show up if the quote of Hobsbawm is very close to what the reality is, the present work has been divided into two parts, trying to study the past events together with forecasted scenarios of the future, with the final attempt to build up a strong study's methodology.

In the first part, the entire focus was on travelling through again the different stages of the Industrial Revolution, which were labeled "Machine Ages". Throughout the decades, relevant innovations such as the steam power, the electricity, the worldwide web (Internet), and, finally, the advanced miniaturization of PCs into interconnected smart devices, have brought significant economic growth, together with the rise of brand new markets, sectors, and revolutionary products. Nevertheless, the counterpart, as quoted by Hobsbawm, is the substantial decrease of tasks performed by humans, due to the automation and the codification of such tasks (manual, non-manual, as well as cognitive) into ruled-based algorithms, perfectly coded for advanced machines and robots. This phenomenon, started with the very first inventions and innovations of the first and second industrial revolution, and that can be summarized into the Keynes term of "technological unemployment" (Keynes, 1930), had become even more undeniable during the second Machine age and the continuous technology progresses. Several studies (Acemoglu, 2011) (Autor and Dorn, 2013) (Autor *et al*, 2003) (Osborne and Frey, 2013) have analyzed the effects of technology advancements, especially regarding the obsolescence of some skills and the rise of new ones, as a percentage of employment share loss. The results have shown that the labor market of different countries, both in Europe and US, is experienced an economic phenomenon called the "hollowing out", or the job polarization, of the labor market by which, dividing the total share of employment in three ranks of jobs, low, middle and high ranked jobs, according to the level of skills sets necessary to perform a specific task, it is possible to identify an expansion of high-ranked and low-ranked jobs over the middle ones. What the scholars have tried to demonstrate, was that one of the main causes of such a phenomenon has to be connected with the technology advancements and the simultaneous changing of the skills-set workers are required to have in order to be successfully competitive in the labor market, against the race of machines.

In the third Machine age, however, the evolution of technology practices has opened new opportunities in different sectors, and has broadened the field of applicability of artificial intelligence and advanced machines. Thanks to the always larger number of interconnected devices and the availability of huge amount of data, gathered from sensors and actuators installed almost everywhere, organizations are implementing new strategies to unlock the value of the so-called Internet of Everything. Furthermore, the important topic in the third machine age is the concept of Industry 4.0 and advanced manufacturing. Advanced manufacturing is an envisioned state of operations in which all relevant and synthesized information are made available when, where and in the form in which it is needed across manufacturing supply chain, and to all the stakeholders. In this way, inside a smart factory, all the machines will be connected to each other and to the plant itself through several platforms that will grab all the information available from sensors and actuators. The interaction between machine-to-machine and machine-to-human will be extremely enhanced, and thanks to the power of the Internet of things and the huge world of interconnected devices, the manufacturing industry will shift from the concept of mass production, to the one of mass customization. In this scenario it will be hard to say if the technology advancements would disrupt more jobs than it would create; however, what is, once again, certain is that workers have to modify or to upgrade their skills-set, by focusing more on communicational and interpersonal skills, as well as in advanced engineering and mathematics fields.

In order to identify a good pattern of results, it was drafted a methodology comparison regarding different future scenarios and technology applicability. There were selected three different scenario's methodologies based on: surveys and trends, futurologists' visions, and literatures' analysis.

From a cross comparison analysis, it was shown that technology advancement is, actually, reducing the employment share, especially, of the middle-skilled workers and all the kinds of works related to manual and repetitive tasks, mostly due to a simultaneous change in the skills sets required by employers. Indeed, technology progress is strictly correlated to an updating of skills for all the workers, either for low- and middle- skilled, and either for high-skilled ones.

That said, technology can be considered as a source of economic and employment growth if, and only if, institutions and governments will implement several reforms that aim to create a sort of bridge between the level of education, the skills sets that workers are requiring to have, and the technology progress. Education challenge, policies that would have the goal to enhance technology progress with incentives, funds, and R&D improvements, and, finally, guaranteeing a secured and trusted cyberspace in which data and information can flow freely, are all possible action plans for ensure a better future cohabitation between human and machines.

Although the efforts made trying to find a correlation line between the subjects presented in this work, many other specific aspects could be taking in consideration in a more scientific way, but given the implications that this argument implies, it was possible to elaborate just a first attempt, not exclusionary, but open to new specific reflections that can be helpful and that may come back to assist in commenting events of similar importance and interest.

Concluding, It would not be correct to deny the role that technologies have had, and have on the global economic and social structure, but it is also required to consider that "when a machine is created to do the work of a Man, something is taken away from the Man!"[77]

[77] Quote from the movie "Start Trek: The Insurrection", 1998

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