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TECHNOLOGICAL UNEMPLOYMENT

The economic impact of technology

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ABSTRACT

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The progress made in the field of robotics and artificial intelligence, the rise of the Internet of Things, the processing of mass data, the emergence of 3D printing or the revolution announced of self-driving cars are now fueling worries about a "jobless future".

This thesis researched these concerns which are not new: as at each new wave of significant innovation, at least since the Renaissance, the fear of technological unemployment linked to the substitution of man by the machine resurfaced. History has shown, however, that successive technological advances, those related to the automation of production, have, on the contrary, accompanied so far, a growth in employment, even if the nature and structure of jobs have at the same time deeply evolved, as well as their distribution in space.

Furthermore, and by summarizing the outcomes of several retrospective and prospective, this thesis will try to conclude regarding if the current technological developments, dominated by digitization and marked by a considerable potential for automation, considering their nature, their scale and the speed of their diffusion, are likely to have a different impact on employment.

Key words
Automation, employment, firm’s strategies, industrial employment, Taylorism, Technology, unemployment.

CONCEPT DEFINITIONS

Cyber-physical system is a system where computerized elements collaborate for the control and command of physical entities

The Great Depression: The most severe economic recession in the history of the industrialized world

Caring jobs: Jobs involving supporting and helping others with special needs and problems

WEF: World Economic Forum

IFR: International Federation of Robotics

PwC: PricewaterhouseCoopers

OECD: Organisation for Economic Co-operation and Development

ITIF: Information Technology & Innovation Foundation

RRTC: Routine Replacing Technological Change

PIAAC: Survey of Adult Skills

UBI: Universal basic income

ABSTRACT

CONCEPT DEFINITIONS

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1 INTRODUCTION

The study of the impact of technology on employment has taken a turn this decade, marked by the brisk expansion of the number of academic or press articles, whether general or specialized. However, this inclination seems to be not limited to the academic and research field. It is today expanding beyond, reaching the general public through social medias or YouTube videos. However, it would be inaccurate to present this concern as purely contemporary. The fear of a massive unemployment resulting from technological progress was not born yesterday. In 1930, A certain John Maynard Keynes, famous British economist, evokes a "new disease": technological unemployment. He summarizes the problem in this way: following the discovery of new means of production, it sometimes becomes possible to save labor. If it is not possible to find an allocation to this saved labor force, then unemployment emerges. A threat that the economist John Maynard Keynes already defined in 1930 as "technological unemployment". However, Keynes specifies that this phase should only be temporary and that it should enable us, in the medium / long term, to drastically improve our living conditions. Keynes also had a very optimistic vision of the future: according to him, in 2030, everyone will be much richer while working only 15 hours a week (Keynes 1930).

For others, that is a time when we will discover ways to save the use of labor at a faster pace than our ability to create work and new opportunities, as we can actually observe the growing intensity of debates on this subject, and their spread in society. Regularly, whether from tainted declarations in optimism or pessimism, we see the emergence of the idea of a "fourth industrial revolution" accompanied by singular changes in the world of work, an overflow of technology.

To define the problem with hindsight, this work researched the topic in two parts, and both parts adopted a documentary analysis method, the first part deals with documents within a retrospective approach, while the second part, rather within a prospective approach.

This thesis, which deals with the analysis of the link between employment / work and new technologies, aims to provide complementary analyzes in the articulation of general literature and economics. Indeed, this choice of combination has from the beginning been chosen to combine the quantified vision that economic science can bring to the enlargement of the dimensions of the problematic by general literature, seeking in a second time to emancipate itself from a pure statistical vision of the subject.

This view of the subject is all the more pertinent because of the nature of the matter, based on forecasts, which by its inherent nature leaves room for many shadows. In the theoretical part, a variety of literature was considered by the author, ranging from, business and economic papers, to history books and journals.

The objective of this thesis is to show with the help of the literature available that technology is not a threat for employment, and that the conception of the job stealing robot falls into simple reasoning, seen the high number of variables related to the matter as technological progress is not without consequences for employment. Technological unemployment is an expression introduced by John Maynard Keynes in 1930.

Today, it refers to a situation of unemployment resulting from the rapid development of mechanical, technological and digital progress. Several studies approached the matter in a retrospective and prospective way, or in other words by mobilizing previous data, and by prognosticating and prevising how technology, including the digital and AI would affect employment in the future. Today, it remains difficult to predict how this phenomenon will affect jobs within the future considering the complex nature of the phenomenon, being subject to several variables and factors more or less, near impossible to predict.

But, and apart from the work time predicted in 2030, it seems that Keynes is a good visionary. His point of view largely reflects the traditional view that economists have of technological progress: innovation brings growth, and therefore a rise in the standard of living.

2 RACING AGAINST TECHNOLOGY

In our modern economy, technology is progressing fast, at a speed where employment cannot cap with, resulting in the elimination of several jobs and professions. This chapter will focus on the notion of unemployment from an economic point of view, the popular perceptions about technological unemployment, and other theories surrounding it, the different type of unemployment, their terminology and concepts.

The unemployment term is often used by economists and specialists to refer to the situation of an individual, a company, or an entire economic sector activity characterized by a lack of work or activity. It may refer to the process of resulting of elimination of jobs triggered by the rapidly progress of technology, namely technological unemployment. Technological unemployment is the job loss due to technological change. This change arises from the introduction of technologies that reduce the workload done by workers and the introduction of automation. Just as horses, used as a first means of locomotion, have been gradually made obsolete by cars, human efforts have been affected by technological change. Another example are poor weavers during the first industrial revolution, or during the first World War, the bombe machine, invented by Alan Turing, which allowed the deciphering of intercepted enigma codes in a few hours, a decoding process that would occupy humans for years. Some contemporary examples of technological unemployment are telephone switchboards, automatic road tolls and automatic level crossing (Scheler 1931, 25).

According to Cowen (2011); the median income of American households has stopped growing because of a slowdown in technological innovation. For Erik Brynjolfsson and Andrew McAfee, the authors of "Race Against the Machine", it is rather because of an acceleration of innovation, at a rate that many workers are not able to follow (Brynjolfsson & McAfee 2011, 12-13). While according to the economist Jeremy Rifkin, we are currently in a phase of the history of humanity in which fewer and fewer workers will be needed to produce goods and services (Rifkin 2016, 16). Taking the USA as an example, in fact, Figure 1 shows that productivity growth in the United States averaged 4% by year 2000, which is higher than in the 1970s, 1980s and even 1990s (Cobet & Wilson 2002). And this has nothing to do with a stagnation of innovation. However, the 2000s were the first decades since the Great Depression where no net job creation was observed (Irwin 2010).

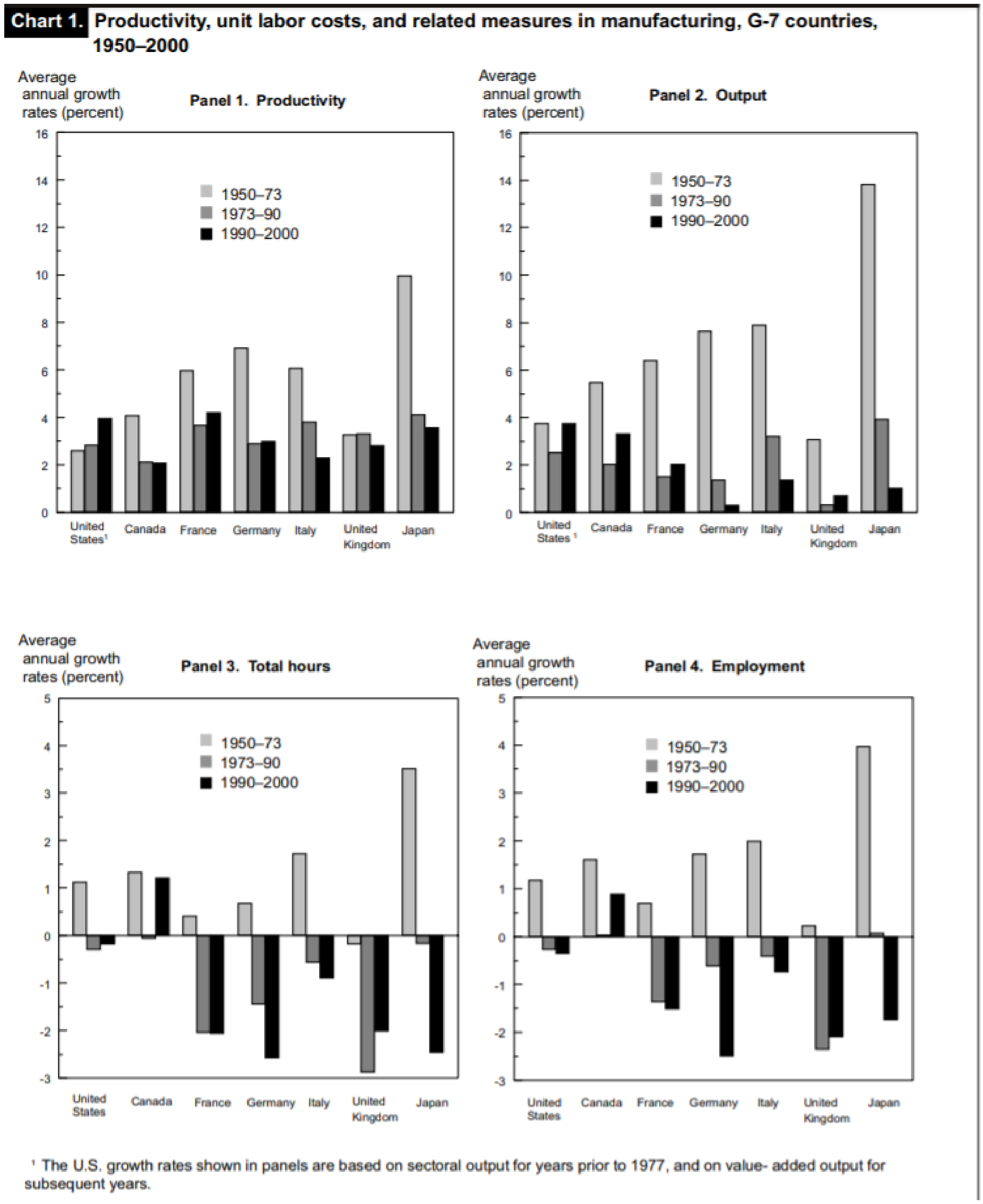

FIGURE 1. USA growth rate prior to 1977, based on sectoral output (Adapted from Cobet & Wilson 2002, 55)

2.1 Technical progress and innovation through history

What was once called industrial revolution in history is today referred to as the mechanization or automation of trades. This kind of innovation, an event of the British history at the end of the 18th century, settled in a rural environment which could not predict it, and which did not know what to do with its craftsmen and workforce, which suddenly got displaced. Most of the other rural communities have seen mechanization come to them. They prepared for it, or tried at least, others simply refused it, and this, of course, up to the limit where the acceleration of economic development has made it inevitable in the end. Most of societies of the Western Hemisphere have witnessed it sooner or later. What was revolutionary, however, was less about the industrialization itself than the perception of a phenomenon, generating an urbanization whose progress was, under certain circumstances too ambiguous to be expected, and suddenly accelerated (Law 1967, 125).

It cannot be disregarded that the big innovations have been harmful for latecomer companies; it cannot be ignored either that all companies will be exposed to this technical progress and some may fail to adhere to its requirements. Companies will have mitigated this danger the day when, resolutely, more importance will be attached to humanities and social sciences conversely to applied sciences. The degree of indifference towards the former gives the same degree of discomforts caused by the latter. In many cases, the great capitalist corporatism had to withstand new social responsibilities that normally, any society well informed would have, assumed of course (Smith 2011, 29-30). Less can be said concerning factory towns (Carroll & Lipartito & Post & Werhane & Goodpaster 2012, 81) where corporate responsibility was often missing, but it cannot be denied that they have solved otherwise insoluble social problems.

Automation does although recall the historical problem of innovations and must therefore be placed in the current of technological progress. What we call innovation is the implementation of a new technique, in purpose of unlocking up new fields of investment and, in general, in the purpose of increasing the yield of production and facilitating operations. But all new techniques, as well as their implementation, originate from technology which is an aspect of our living culture. To solve its own problems, this living culture must to be more willing to opening up to the social science aspect of it as to the applied science one (Naastepad & Budd 2019).

Mankind created technology, at all ages of humanity, it reflected a certain degree of culture. However, it is only during the last two centuries that it led to a mechanization as a substitution for manual muscular energy. The industrial revolution in England at the end of the 18th century, and following century, led to a radical transformation of the rural environment; it has transformed the domestic trades, going further to even annihilated them, in some case. This transformation had been prepared for in a long time, but in a rural society which was unprepared to adapting to it, or unable to take advantage of it. It spread like a wildfire during the 19th century, across Europe and America; it penetrated all levels of the western society industry. The continuous progress of new techniques, and the extensive use of them, has costed the society dear, and that is why criticisms and resistance to it arouse. The bottom of this called secular problem is that technical progress has accelerated at a pace higher than that of social development. During this progress, almost always, societies have had to deal with the problems of a technology that themselves had created (Hobsbawm 1952). England of the 18th century witnessed revolts against the new machine, demonstrations of craftsmen stripped of their tools, deprived of work took place (Hobsbawm 1952, 58-59). The inventors have been threatened. According to Bolton Library and Museum Services website (2013). John Kay, inventor of the flying shuttle had to leave England; Hargreaves, inventor of the spinning jenny, was attacked in his own home, Crompton, inventor of the mechanical spinning mule, went into hiding.

Over the last two centuries, the technological advances that have marked the industrial revolutions, and in particularly the automation of production, have profoundly altered the structure and nature of the jobs in a context of growth in total employment. Mechanization has paradoxically been accompanied by stronger growth and employment growth, in addition to a reduction in dangerous and repetitive jobs (FIGURE 2), and an increase in caring jobs (FIGURE 2), or in other words the transfer of "occupations" to "occupations of well-being ", and this, regarding employment in England and Wales between 1871 and 2011 (Deloitte 2015b, 5-6), but also significant job transfers to more knowledge intensive sectors (Deloitte 2015b, 8). Something that Alfred Sauvy predicted in his "spillage" theory (Cohen 2012, 77).

Table 2. Employment in 'caring' vs. 'muscle power' occupations

	Share of Total employment	
	1871	2011
Caring	1.1%	12.2%
Muscle power	23.7%	8.3%

FIGURE 2. Employment in “caring” vs. “muscle power” (Adapted from Deloitte 2015b, 5)

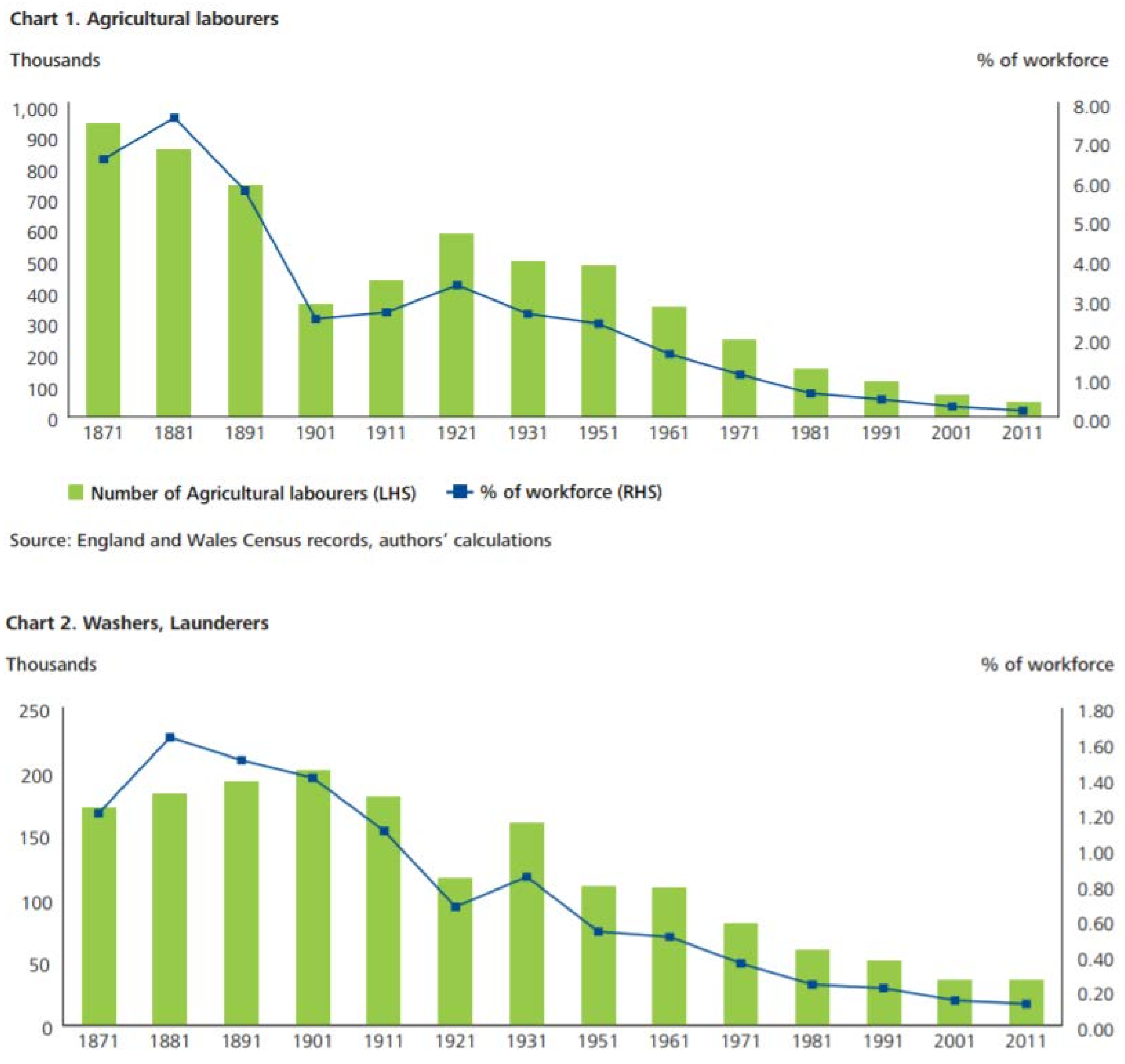

FIGURE 3. Reduction in laborious and repetitive jobs (Adapted from Deloitte 2015b, 6)

The first industrial revolution, which began in England in the mid-eighteenth century, gave rise to significant job transfers between the agriculture and manufacturing sectors. On the European continent, there is complementarity between cities and the countryside where people work for the industry. Rural labor is flexible and poorly paid. Small industrial cities appear.

In addition to setting up new inventions, particularly in the textile industry or the paper industry, which required the use of skilled workers according to a phenomenon of complementarity between technology and skills (Goldin & Katz 1996, 10).

2.2 Impact on production

The impact of automation of production on employment is the result of four effects: a substitution of the capital intended for labor work in a unit of production, leading to less employment if production remains at a constant level; an increase in production if the company has become more competitive and has gained share of the global market inducing an increase in employment (Acemoglu & Restrepo 2018, 5-6); creating skilled jobs in the field of design and manufacturing of robots, software and automata (which may be in other territories) and mainly local jobs related to installation, implementation and maintenance of robots (WEF 2016).

These effects vary greatly across sectors and contexts which explains the extreme dispersion and scattering of the analyzes and studies surrounding it, which goes from the certainty that "the robot kills employment" to the announcement of a new shared prosperity. Strong empirical observations, however, indicate a strong positive correlation between the rate of robotization of the industry and the growth of added industrial value (United Nations 2017, 39). Even if this growth is a little less profuse in jobs (per unit of value added), countries that have maintained strong industrial added value like Sweden (Goodman 2017) are those where the industry creates or maintains the most jobs.

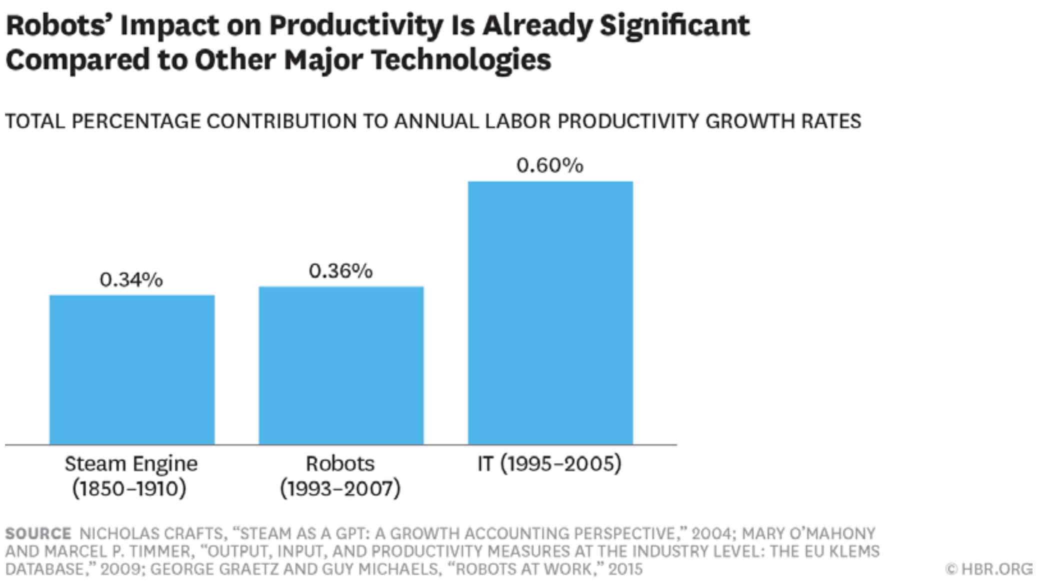

FIGURE 4. Robot's impact on productivity (Adapted from Muro 2015)

2.3 Impact on employment and the antiquated debate

The fear of "technological unemployment" is not new. This idea that technology would destroy more employment than it produces, on the basis of the luddite movement which took place at the beginning of Nineteenth century by Ned Ludd and his "companions", also called the luddites (Gruen 2017, 1). These English workers of the textile industry were worried about the appearance of weaving machines accused of replacing human labor. Nevertheless, concern about the impact of new technologies on labor remained strong throughout the 16th and 17th centuries. An illustrative example is that the inventor William Lee, who was invited by the queen to showcase his invention. Had the queen refused to issue a patent for fear that this invention would cause unemployment in the textile sector. Lee then promoted his invention in France, this time unsuccessfully, before returning to England and proposing his invention James I, The Successor of Elizabeth. But the claim was rejected again by the same reasons (Taylor 2019).

The "Luddites revolt" has had a strong resonance in many parts of northern England, where the destruction of machines multiplied at the beginning of years of 1810. The struggle of the members of this clandestine movement, called luddism, was characterized by them breaking and tea ring down machines. But the mechanization of these tasks eventually ended up destroying some trades, but others have been created since (Brynjolfsson & McAfee 2016, 82).

However, it remains difficult to quantify the impact of automation on employment in view of the complexity of the phenomenon, and the results diverge in a significant way. On one hand, several studies and reports are alarming. For example, it is estimated that, across all sectors, three million jobs could be destroyed by digitization on the horizon 2025 (conn 2016, 19). In another widely relayed study, another report estimates that 47% of US jobs have a strong risk of automation within 10 to 20 years (Frey & Osborne 2013, 48).

Among the most exposed trades are those of transport, logistics, production in industry but also services. The top of the ranking of activities most likely to be automated does not only include industrial or manual trades but also professions related to credit analysis, telemarketing, many insurance or legal profession. Factories will multiply their automation departments. Robots will go to the mines ... and supermarket aisles. Drones will do t he delivery jobs. Applying the same methodology to Europe, a study reveals that around half of the jobs presents a risk of automation (Bughin, Staun, Andersen, Martin, Aagaard & Enggaard 2017, 7).

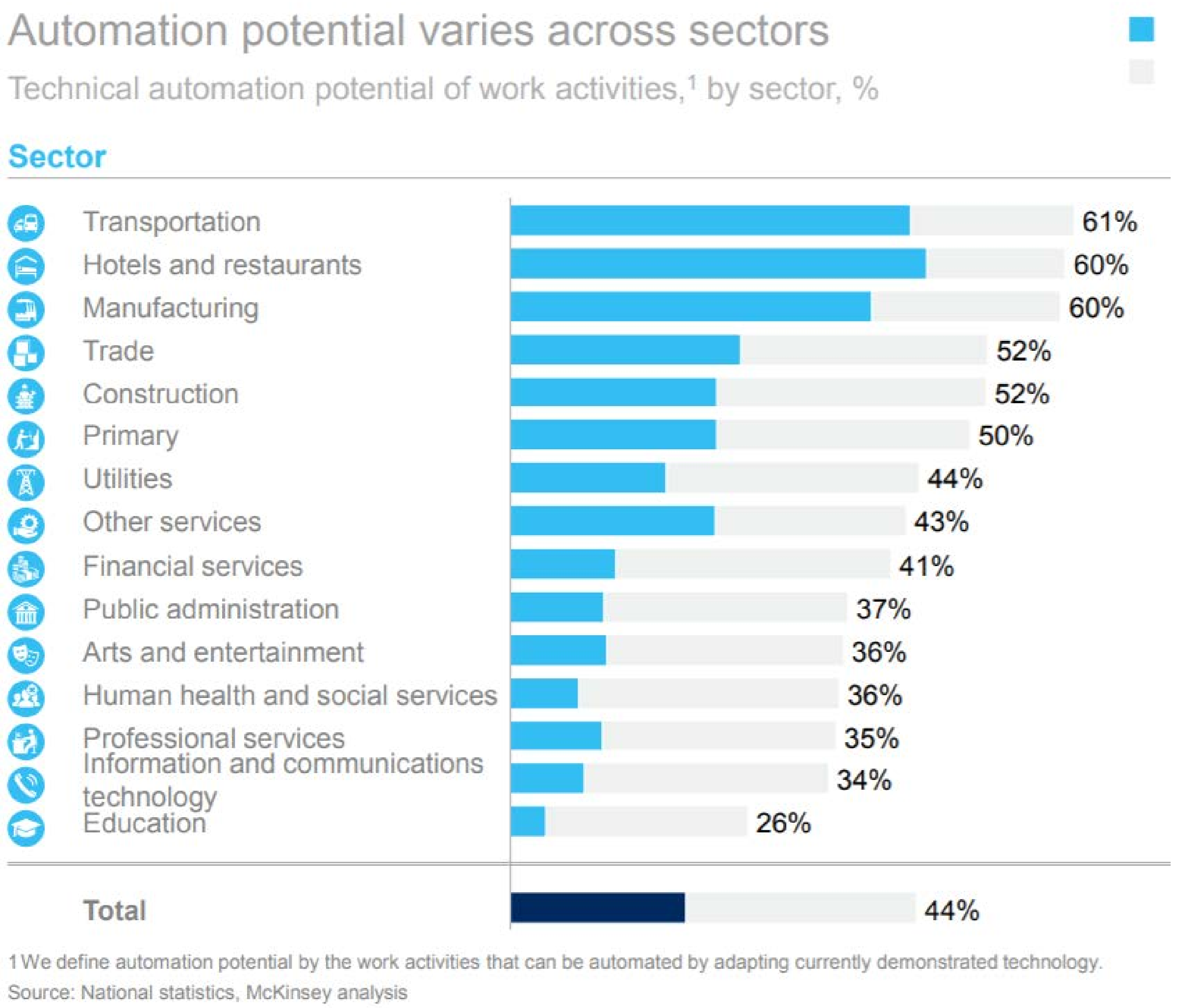

FIGURE 5. Automation potential variation across sectors (Adapted from Bughin, Staun, Andersen, Martin, Aagaard & Enggaard 2017, 32).

Moreover, automation sympathizer prefers to insist on wealth, value and new jobs created thanks to robots. In a study conducted Metra Artech (IFR 2013, 10), the International Federation of Robotics (IFR) defends the idea that between 2017 and 2020, 450 000 to 800 000 new jobs should be directly created globally through the robotics. By adding indirect jobs, it is up to two million jobs that could appear largely in agri-food industry, renewable energy, automotive or else, as electronics. A study by the American think tank, Pew Research Center, seems revealing concerning the doubts surrounding this subject. Between the new technology specialists interviewed on the issue, 52% believe that job creation will prevail while the other 48% expect the final balance to be negative (PewResearchCenter 2014, 5).

3 THE FACTORY OF THE FUTURE

With these trends, the factory of the future carries the hope of enriching industrial work, which is a factor of attractiveness for the sector. Indeed, many companies still struggle to recruit on for some positions, deemed and notorious for being arduous. Released or at least relieved by the robot in his work, the man in the factory will have skills inaccessible to machines. But this evolution will not happen naturally. As the right environment should be provided, an environment where autonomy and responsibility are nurtured.

New activities are emerging, favoring autonomy, responsibility, relationships. Others create a new environment of constraints. Robotics removes strenuous or dangerous tasks; elsewhere new risks appear. The factory of the future has become the favorite song of today's lobbyist, from industry bosses to government, to the media.

Viewed as the miracle solution to a chronic deindustrialization, this idea seems very vague. From advanced robotization to data digitization, from marketing etiquette to the true industrial revolution, a range of innovations and concepts exist, each claiming this famous "industry of the future". A homogeneous technical mutation perhaps. The International Monetary Fund sees it, as "a response to several simultaneous transitions: energetic, ecological, digital, organizational and societal" (Mühleisen 2018).

3.1 The importance of firm's internal strategies

The organization and the content of the work are particularly determined by the strategy pursued by the company. If it seeks essentially price competitiveness, there is chances it comes out of a logic of labor division or separation, in which the employee is considered a cost that must be minimized. Conversely, if a company builds its competitive edge on innovation and quality, it will be more attentive to exploit the specific skills of employees, while worrying about their involvement, to establish a work organization that favors autonomy, initiative and creativity (Burrus 2017).

The training of employees is therefore a major challenge for making this transition successful, robots do not replace trades but tasks (Gownder 2016). Affected employees by automating some of their tasks can be assigned to other functions provided they benefit from the required training. If they do not want to expose themselves to a significant loss in productivity, companies must seize the change and eventually be prepared to accompany their employees, to increase their skills so that they can perform these new functions (Coy 2018).

3.2 Limitation of Taylorism

The clear signs that Frederick Winslow Taylor system, also referred to as scientific management, which rely on heavy segmentation of tasks and which does only consider the employee only for his work force, shows its limits, as scientific management dehumanized the industry (Caldari 2007, 61). Taylorism is no longer suitable with the arrival of automation as the worker must be versatile today, additionally to emergence of new ways of thinking: listening, dialogue, cooperation, participation of all, appeal to the intelligence of employees (Caldari 2007, 72). The winds are sailing toward the transition into a more cognitive segmentation in which it is the capacity of workers to mobilize their knowledge to respond to unprecedented situations that will be decisive (Uddin & Hossain 2015).

In addition to the further automation of workshops, it's the introduction of cyber-physical systems which imposes a redefinition of the role of the man in the factory, the transmission of information becoming the key of the entire system. One can imagine that today prevailing approach to segment, prioritize, reduce complexity is getting obsolete. It will be hence the ability to solve problems in real time, the ability to converge the know-how of different trades, and to couple the real and virtual dimensions, is what will prevail (PwC 2017).

3.3 Possible effects on productivity and impacts on industrial employment

A methodical analysis must start from the fact that the volume of production and the overall quantity of work are not fixed in the economy. When a machine replaces a worker, numerous effects are induced in the goods and services sector resulting in simultaneous destruction and creation of jobs. This mechanics can lead, under certain conditions, to the seemingly paradoxical result of stronger growth and a higher employment. Since, as wealth creation increases as result of higher and stronger productivity, economic demand is growing, and new sectors are developing, such as recreation and entertainment.

Induced job creations can then offset the initial losses in jobs (Autor 2015, 1). Autor pointed out the importance of looking beyond the mechanisms of substitution and to take into consideration the interactions between the goods and services market and the labor market, eventually, to appreciate the impact of a technological change (Autor 2015, 5).

These mechanisms have been analyzed and debated for two centuries. that new techniques can create more jobs than they destroy. First, machines cannot not be manufactured without a large amount of work, which gives work to those which have been propelled out of their job. major innovation has reduced the need for workers as well as their level of qualification in a sector, but at the same time allowing the diffusion of knowledge with a positive impact on creating new activities and, subsequently, new jobs (OECD n.d). For his part, Karl Marx considers also according to his theory of surplus value, that technological change also allows the emergence of new productive sectors that constitute as many sources of employment (Mackenzie 1984, 487).

To the question "what is the impact of robotization on industrial employment? It may be tempting to answer with an intuitive reasoning: industrial employment declines as robots increases in factories. The reality is not so simple however, and several effects that occur at different scales and on different horizons should therefore be distinguished (Vermeulen & Kesselhut & pyka & Saviotti 2018, 7).

Obviously, a company invests in a machine because it expects its level of productivity to increase, that is to say to maintain the same level of production while reducing the resources it uses, so eventually, it does make sense that the number of employees dedicated to production will decrease (Miller & Atkinson 2013, 18). This is the first effect, which is direct and short term, which takes place in a company, or specifically in the production chain.

Behind the simple reasoning where the robots inevitably replace human work. First, it should be emphasized that automation is only considered a threat in a scenario where the productivity gains induced are greater than the increase in production. The amount of work needed to produce a unit will certainly be lower, but the total employment volume will be maintained or even increase if the production keeps increasing (Wilson 1960, 37).

Additionally, the productivity gains made by a company are necessarily reinvested in the economic circuit in one of following forms: higher profits, lower prices or higher wages for employees of the company (Miller & Atkinson 2013, 11). The first one allows to release investment capacities which contribute to the development of the company. The last two have the effect of stimulating economic activities by supporting the demand: this surplus of consumption helps to boost the economy as a whole (Miller & Atkinson 2013, 1), whether addressed to the company in question, its competitors or other sectors.

3.4 Robotization rate and the growth industrial employment

The relationship between the robotization rate and the growth of industrial employment is certainly positive but a lot less significant for added value. The phenomenon of spillage already described before translates two effects, the fact that total employment related to industrial production is found partly outside the field of industry; and the second fact that wealth created by industries leads to the development of other activities. These elements raise a thorny question: how to measure the good health of the industrial sector? More specifically, is manufacturing employment still a relevant indicator of a country's industrial performance? (Vonortas & Auger 2002, 28)

Once again, the phenomenon is more complex than it seems. This reasoning on the sectoral spill should not be dissociated from the question of defining the statistical parameter of the industry and the increasingly porous border between this sector and that of services. Some economists prefer the concept of "productive sphere" to that of "industrial sector", because it aggregates in addition to industrial activities, services which are related to them. The new professions created thanks to technological advancement are accounted for, although they may seem totally industry oriented. It is for example the case of robot integrators, consulting firms, or other specialized management firms, etc.

By this reasoning thus, the number of jobs leaving the productive sphere due to automation is much less important, as and according to Deloitte, who conducted a study on the on the UK labor force, suggested that technology helped created 3.5 million high skill jobs, after contributing the loss of 800 000 low skill jobs. Estimating that £140 billion pounds were injected in the economy in new wages (Deloitte 2015a, 4).

The most robotized countries in the world - Japan, South Korea or Germany are examples to this, and bear witness to this with low unemployment rates. Their performance is due to the automation of industrial sites which ensures a redeployment of the sector. It feeds a competitive, dynamic and job-generating activity (The economy journal 2019). With 143 jobs for every 100 job seekers and an unemployment rate of 2.8%, Japan is facing a labor shortage amid a demographic crisis. The strong growth of the number of robots in the Japanese archipelago is not enough to offset the scarcity of workers (The japan times 2017).

How to increase unemployment? This is a question that would not come to the attention of European governments, but one that is explicitly raised in Japan, where the drops in unemployment, which has fallen to the lowest level since June 1994 (The Japan Times 2017), is causing a shortage of labor in certain sectors of the economy.

In the Japanese archipelago, full employment, reached in 2014, coincides according to experts with an unemployment rate of 3.5%. In fact, there is in every economy a part of "incompressible unemployment" (also called "frictional") which concretely corresponds to the duration between the termination of one job and the beginning of another. In May 2019 the employment rate for Japan's college graduates reached a record high at 97.6% amid labor shortage (The Japan Times 2019).

3.5 Artificial intelligence

Even if the application of AI today is still weak, we are witnessing a breakthrough that will radically change our ways of producing and modifying our behavior in depth. The numbers speak for themselves. Between 2015 and 2018 alone, the introduction of AI in companies has increased by 270%, according to the latest Gartner study following a survey of 3,000 manufacturers in 89 countries (Conn. 2019).

According to Gartner, this increase can be explained in part by the fact that AI technologies have reached maturity. " If you are a CIO and your organization doesn’t use AI, chances are high that your competitors do and this should be a concern," said Chris Howard, vice president at Gartner (Conn. 2019). As for the filing of patents, it is the same trend: the report published by the World Intellectual Property Organization (WIPO) on technological trends 2019, dedicated to the AI, reveals that the number of "patents in intelligence artificial grew by 28% on average per year between 2012 and 2017” (WIPO 2019, 14).

In total, 55,660 patents were registered worldwide in 2017. 89% of the patents concern Machine Learning with an exponential progression of Deep Learning that works with clusters of artificial neurons. This growth is fueled by the profusion of existing digitized data and ever-changing computing power, with a potentially groundbreaking effect: by detecting targets among billions of seemingly unrelated data, AI can improve forecasts and allow to increase productivity and performance (WIPO 2019).

In addition, Deep Learning, which has enabled the development of visual recognition, differs from other Machine Learning techniques in the very short time between the time when scientific studies are published and when patents are filed. This period is usually 10 years for other machine learning techniques: for Deep Learning, there is almost no delay.

Francis Gurry, Director General of WIPO says about AI: "But there has been a quantum leap since about 2013, so we're dealing with what is happening right now in a very fast-moving field". The phenomenon is so profound, and even though many applications will be invisible, It will have enormous technological, economic, and social consequences and is going to transform the way we produce and distribute goods and services, as well as the way we work and live, according to Francis Gurry (WIPO magazine 2018).

In this frantic race for patenting, five large groups are at the top of the list. The first is IBM, which overflows the ranking with more than 8,000 patents all functions (WIPO, 2019). The US giant has announced that it will spend $ 2 billion to establish a new research center on the campus of the Suny Polytechnic Institute in Albany, New York (Suny 2019).

This new cluster will focus on research, development, prototyping, testing and simulation of computer chips based on AI. " Once established, the AI Hardware Center will be the nucleus of a new ecosystem of research and commercial partners, and further solidify the Capital Region's position as "Tech Valley". A global hub for innovative research and development." he said earlier this year in February 2019. Behind Big Blue, Microsoft is in second place with 5,930 patents filed by Toshiba, Samsung and NEC, respectively holders of 5,223, 5,102 and 4,406 patents (WIPO 2019).

This explosion of investments and patent filings is linked to the maturity of AI technologies. This is particularly the case of visual recognition in full deployment within companies. The first successful system called AlexNet was developed by Geoffrey Hinton (nicknamed the godfather of the AI) (Synced 2019) and his team at the University of Toronto in 2012. From this period, startups and manufacturers developed applications which more and more efficient.

A particular case is the one of Vinci Energies, via its branch Actemium, which has developed a system to inspect aircraft fuselage in Toulouse. Developed by Diota, a French start-up (augmented reality specialist) who designed its technologies with the Atomic Energy and Alternative Energy Commission (CEA), the solution is based on the use of an AGV (Automatic Guided Vehicle). The autonomous vehicle takes pictures of the aircraft which are then processed to measure the differences between the model and the reality (Agvinternational 2019).

The British astrophysicist Stephen Hawking, who died in March 2018, warned several times against the risk for humanity to see machines become much smarter than men: visual recognition is now one of the first areas in which the machine is able to replace the human (Jones 2014).

4 THE END OF WORK

The question of the impact of technical progress on employment and work is the subject of an abundance of literature combining both, optimism about the future of the setting of the human mankind, others, on the contrary, are marked by a certain pessimism. In his best-selling book "The End of Work", Jeremy Rifkin echoes the idea that the higher the level of productivity of the economy, the faster unemployment increases. Putting in it briefly, it means that if we continue to work in a way which is always more efficient, the amount of work that will remain to be achieved, will hence be less.

The Theory of spillage according to Alfred Sauvy (Cohen 2012, 77) and the mechanization of agriculture has led to a massive labor shift to the secondary sector (Cohen 2012, 76), then, productivity gains in the industry have led to the "tertiarization" of developed economies which have now came to an end, and as a result, we have entered today in a period of jobless growth. Another question is the diffusion of digital technology which is destroying more jobs in the industry and services (banking, insurance, distribution ...) than it would relatively create elsewhere. Here, human mankind stands before the fear of the total replacement of man by the machine. With no new sectors to pour in this workforce (Gauron 2009, 72), this surplus of working hands would inevitably increase the ranks of the unemployed.

4.1 Technophobia

The term "technological unemployment" appeared in economics literature to describe a situation of underemployment caused by the increase or replacement by technical tools. Today the expression became rather equivocal, given that the technological reality around it has accumulated, during its evolution, more variables than the original expression may have assumed. By referring to tooling science, nowadays, technology can have a broader range of meanings than it once had. So, one can talk about technology, either in the strict or original sense or in a broader context.

In the latter sense, technology does not only involve the use of the machine among the tools of production; it comprises, the scientific questions and issues, personnel management, the regularization of the stages of the production, storage and automation of office work (The reflective team 2019).

In short, all these means which do not directly affect the volume of manual employment and which, conversely, increase the return on working capital and intellectual capital refer in the strict sense, to the machinery or the general equipment used in the manufacture and distribution of the product. At the beginning of its terminology, technical progress referred to the substitution of manual labor by mechanical means, for special purposes, as increasing the productivity of labor, capital, or improve the quality of the product. In other words, the problem of technical progress has changed in size and the debates on "Technological unemployment" have gained momentum (Stettner 2018).

From the perspective of a technology understood in the strict sense, we have seen that automation is replacing a mechanical mechanism for many new categories of factory workers. What will be the consequences on the general economy? Such is the question. Some claim that the basic explanation of fluctuations in employment and unemployment, is particularly due to technology; others refuse to admit that there is a problem such as "technological unemployment" and that the expression is only a detour or a deceit to describe a situation accredited to other factors than technology. In this, as in everything, the reality does often fail to cope well with extremist points of view. But this does not mean however, that any pessimistic or categorical opinion should be disregarded or considered without a foundation (Lloyd, 2019). The opinion of Professor Norbert Wiener, for example, seems to be of this kind. Automation will engender an unemployment situation, which in comparison with, the 1930s depression will seem as a pleasantry (Wiener 1988, 162).

The myth of Prometheus as narrated by Hesiod (8th century BC) is perhaps the most famous narration among those who warn against the uncontrollable effects of technology: in retaliation against the theft of fire, Zeus decreed the end of the golden age, when men lived in carelessness, without having a need to work, exempted from any illness, suffering or aging (Cartwright 2013) .

Many historical examples can be cited, and way before the first Industrial Revolution started in the early nineteenth century, for example, the Cologne City Council decided in 1412 to ban a local textile craftsman from producing using the spinning wheel (Dorn 2015, 8), an innovation that appeared in Italy from the 13th century onwards. The spinning wheel purpose was to make the spinning job faster, This was because the board was concerned that many female spinners would lose their jobs if they allowed the use of this machine which considerably would increase the productivity of the process, similarly, Punitive measures were taken at the beginning of the Renaissance against artisans who derogated from the rules of production as set by corporations and public authorities (Molà 2000, 43-44).

4.2 Fallacy of labor scarcity

The Information Technology & Innovation Foundation (ITIF) has taken a stance opposite to Jeremy Rifkin reasoning, and severely criticizes what she calls the "fallacy of fixed workload" (lump of labor fallacy), according to which the rise in productivity would necessarily be a source of unemployment because the amount of work to be done would be limited. First because one of the effects of high productivity is to cut product prices, eventually freeing purchasing power that will be directed towards other types of consumption, considering the needs being (practically) infinite (Miller & Atkinson 2013, 2).

Additionally, ITIF points out that no link has yet been established between productivity gains and unemployment (FIGURE 6). Similarly, it recalls that an economy is a complex system, vast, with very different activities and as radical as technological innovations are, therefore changes are not to be expected overnight and their impact is highly variable across sectors.

Thus, although technological changes are accelerating, the pace of destruction and job creation has not increased in the United States in recent years, a sign that the phenomenon of creative destruction is still to be proved (Baldwin & Dunne 1998, 347-348).

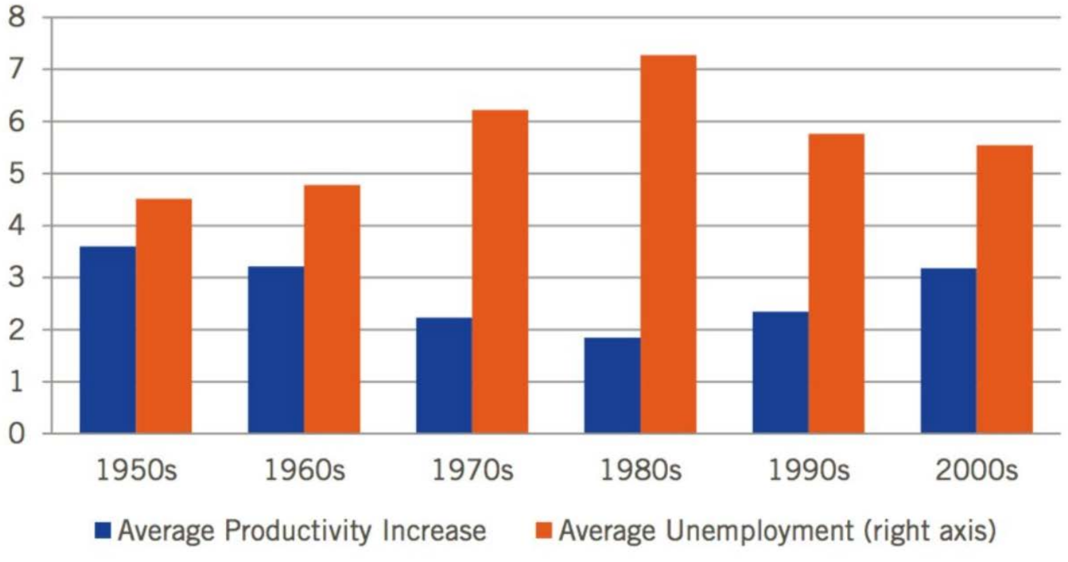

FIGURE 6. Productivity change and average unemployment rate by decade in percent (Adapted from Edwards 2015)

4.3 The techno-optimism and pessimism clash

For more than two centuries, successive waves of technological progress have raised concerns about employment and fears surrounding the emergence of sustainable technological unemployment. At the beginning of the 19th century, the revolt of English textile workers, who wanted to destroy the weaving machines to preserve their work, was one of these waves. John Maynard Keynes had anticipated that technological progress would lead to an uninterrupted growth in income per capita and massive unemployment as the workers are being replaced by machines (Tarascio 1971, 432). Wassily Leontief had expressed similar fears by stating in an interview that the work will become less and less important, more and more workers will be replaced by machines, going further to add that he do not see that the new industries can employ everyone who wants a job (Charlotte 1983).

Yet the various technological advances have so far not made the work obsolete (Autor 2015, 4). Nevertheless, this does not mean that it will always be this way and that the emergence of new automation processes cannot lead to the destruction of jobs in a large-scale, and yet the transformation in nature or location of the jobs performed. Today, a debate has opened in the economic literature between, on one hand, the techno-optimists for whom the economy is in the process of a radical digital metamorphosis, with potentially high productivity gains in addition to powerful trends of work capital substitution (Brynjolfsson & McAfee 2011), on the other hand, techno-pessimists who consider, conversely, that the consequences of recent innovations remain limited in comparison with the two first industrial revolutions (Gordon 2016, 566-577). For the latter, past innovations (steam engine, electricity, electrical engine, etc.) have transformed the economy in a much deeper way than the modern digital revolution. This would consequently result in a relentless slowdown in productivity gains.

4.4 The economic “Nirvana” and Finland experiment

The first predictable and typical reaction of each to the Basic income is often: "No one will work!" On closer inspection, it is possible to see that the basic income, on the contrary, is not against work, it promotes many theories that the current world order ignores. Would the basic income push us to spend our life on a chair?

Since the dawn of time, humans love to invent, create, challenge themselves, set up projects. Staying on a couch is especially tempting when one lives at a frantic pace and when one hates his work. When one has the opportunity to choose what he really wants to do with his life, the couch, be it, for a while at least. Universal Income, Negative Income Tax, Guaranteed Minimum Income, Universal Allowance; all these denominations point to the same principle. Everyone would be entitled to a monthly subsidy of a few hundred euros, regardless of their status or income, the poorest would then meet their basic needs (Carrie 2018).

In theory it would be more effortless to find a job while avoiding the stigmatizing paternalism of the welfare state. Administrative simplification, independence of each, restoration of one free will, fight against technological unemployment, the benefits would be many, and the idea has been emulated by many politicians, like Barack Obama and others (Bershidsky 2018), to prepare the society for a future when AI and robots will be replacing a huge number of humans.

To see if this works in practice, the Finnish government decided to try the experiment for a year on a group of 2,000 randomly selected unemployed. They received each 560 euros per month over the period 2017-2018. According to Olli Kangas, the experimental coordinator, the preliminary study of the results shows, as for February 2019, that the universal income did not lead to an increase in the employment of the beneficiaries compared to the control group. But on the other hand, and among the beneficiaries, more people reported a higher level of relative well-being (Kela 2019).

4.5.1 A distorted good idea to fight unemployment

If the idea of universal income may seem attractive at first glance, it is clear that it has not managed to get out this test population of dependence. This system is criticized by many economists for its deterrent effect for maintaining part of the population under financial assistance, for others, they think that those who would bear the burden of financing by their taxes this basic income would be less encouraged to develop their own productive activities (Annunziata 2018).

Let's take a fictional person “A”, a wealthy pensioner, and “B”, an unemployed person with no income.

- First possibility, the universal income: The State takes 600 euros from “A” to give them to “B”. But the latter has an income, but only for a month, he is kept under financial assistance, because he is always unemployed. “A” got nothing in return. It is a zero-sum game, even negative if you consider the cost of bureaucracy.

- Second possibility, the investment: “A” invests these 600 euros in a productive activity. This capital makes it possible to create a company that will produce new wealth. For this, the company will need labor and will be able to hire “B”. It's a positive-sum game, “B” creates value and earns a salary,” A” creates value and earns a return on investment, and we don’t forget about the consumer who also benefits. Everyone wins, it is the fundamental principle of the market economy.

Universal income does not help “B” out of his financial dependence, which the Finnish experience confirms. A common objection used by basic income supporters, is that mass unemployment is now inevitable because of the robotization and computerization of our societies. Universal income would then be an answer for all those who have no hope of finding a job.

This widespread fear does not, however, stand up to Schumpeter's economic concept of creative destruction, also referred to as Schumpeter's gale. Robots and artificial intelligence do not create unemployment in the countries that make the most use of them (Goodman 2017). The productivity gains associated with these technologies free up resources that can be reinvested in new job-creating activities.

In Finland, the relatively high unemployment rate of 7.4% as for 2018 is mainly due to a deficient training system (Opetushallitus 2018), unemployment compensations, which are often considered too generous, and a labor market which is highly regulated and inflexible (Böckerman, Kosonen, Maczulskij & Keränen 2017, 44) which also creates fences to the entry of foreign high and low skilled workers.

4.5.2 Immorality of morality of the concept

While the basic income can relieve some short-term economic constraints, it keeps the poorest in the poverty trap of long-term financial assistance. It creates a self-sustaining cycle of dependency, just like the failures of all redistribution policies in collectivist countries. Social progress is a matter of incentives that only a competitive and innovative market economy can achieve. The labor market must remain inclusive, while Finland can be considered a top performer amongst EU countries, it is still lagging behind other Nordics (WEF 2018, 3) with Norway scoring the best as the most inclusive and advanced economy in the world, followed by Iceland, it is therefore urgent to restore a regime of free labor competition and freedom of contract, and fair hiring practices, an area where Finland can still do better (Ministry of employment and the economy 2012).

Beyond an announced economic failure, the universal income opens the door to a dangerous collectivist drift. This moral right allows the state to take charge of each individual from the cradle to the grave and creates unlimited dependence on the system. Otto Von Bismarck, the initiator of the welfare state in Germany saw in it a very good way to control the population: "I will consider it a great advantage when we have 700,000 pensioners drawing their annuities from the state, especially if they belong to those classes which otherwise do not have much to lose in an uprising. " (Van Kersbergen & Vis 2013, 39 [Rimlinger 1971]).

The political excesses of such a system should not be difficult to suppose, starting with electoral increase of the amount of the basic income, introduction of progressivity, financing by debt (thus by the future generations). Furthermore, and according to the study made by the Leibniz Information Centre for Economics, a transition to the universal basic income is unlikely to induce any benefit overall (Fabre & Pallage, & Zimmermann 2014, 14). For certain the Universal income is also considered a trojan horse, not only concealing a moral fault, which suggests that the mere fact of existing gives the right to enjoy the work and earnings of others without their consent. But for dismantling the extravagant welfare state (Ervasti 2019, 8), antisocialists see in it a way for destroying therefore the foundation of civilization, “responsibility”, while calling this destruction "liberation. The analogy of comparing socialism to a mouse trap borrowed from the idiom “The only “free” cheese is in the mousetrap” may, or not, be considered a representation of reality, although, it may be effortless, to suppose that the results of an UBI would be, lower investments, productivity, and wages.

FIGURE 7. Universal basic income caricature (Adapted from Spencer 2017).

5 METHODOLOGY AND LIMITATIONS

The impact of new technologies on the evolution of employment is mainly analyzed through the empirical literature available. To evaluate the effects of the diffusion of technologies on employment, the research can be approached in two ways, from a retrospective point of view and prospective one.

In a retrospective approach, it is necessary to observe the effect that the use of technologies by companies and their diffusion in the economy, and this by mobilizing past data and by drawing conclusions from the available literature.

While in a prospective approach, it is a question of anticipating the effect that the current and future deployment of technological advancement can have on employment from the available literature. This approach tends to be subject of many difficulties because it is based on the great uncertainty surrounding the shift in the technological frontier, as understanding the future effects on employment, under the light of today technological frontier, without knowing how it will spread and combine tomorrow to affect employment may be uncertain in nature.

While perfectly isolating the effects of technology on employment may seems as an impossible exercise, some of the empirical literature studied the effects of technology on employment, by testing for the most part the validity of their model by the introduction of alternative explanatory variables.

5.1 Impacts on the volume of employment: The existing studies

The debate on the impact of automation on employment has recently been focusing, particularly since the publication of the study by Frey and Osborne (2013), on the question of the volume of employment and the jobs which are the most exposed to the risk of automation. More specifically, the debate tends to focus on a single prospective approach to estimate the share of jobs potentially threatened by disappearance due to advances in automation (Frey & Osborne 2013).

On one hand, many empirical studies have sought to evaluate the effects of technological innovations on the volume of employment over the last thirty years: they tend to converge, despite differences in approach and method, to conclude that these effects have been generally favorable.

On the other hand, even if this can be considered a part of a prospective approach, it is also necessary to seek a kind of appreciation toward the job creation potential (direct and indirect) inherent to these new technologies. Finally, the existing prospective studies deserve to be supplemented by an approach aimed at taking into consideration not only the jobs at risk, but also the existing jobs that can be profoundly transformed.

5.2 Limitations of the available literature

The use and diffusion of technologies is not the only factor influencing the volume, structure or location of employment. Other factors, such as globalization (which is largely linked to the diffusion of technical progress) and the financialization of the economy, socio-demographic changes (aging, female activity and contribution to labor, rising education levels, etc.) can also have an influence.

In addition, labor market regulations and institutions, organizational changes in the way companies operate (some of which may be directly linked to technical progress, others to changes in management methods) may also play a role. An important issue is that the literature available was unable to isolate the effects of technologies from all of these other factors.

Another fundamental issue to consider is the temporality of the effects of technology on employment. Prospective studies often consider a time horizon of 10 to 20 years: this is particularly the case of studies by Frey and Osborne (2013) and Arntz, Gregory and Zierahn (2016). They are essentially based on the assumption that this is the most likely duration for the automation potential existing at time t to spread widely to the productive sphere and can then play at full capacity.

This time horizon is not necessarily the most convincing. First, because it ignores the speed of movement of the technological frontier, which can vary according to the technology involved and the combination of technologies. Second, because these prospective studies seek to measure only one effect of technology: the risk of human substitution by the machine. They therefore ignore the compensation mechanisms that have their own rhythm, respectively, new machines, lower prices, new investments and lower wages (Vivarelli 2012).

5.3 Qualitative research

Qualitative research methods are scientific methods of data analysis used in social science (ex, sociology, management, economics). They allow to acquire a deep knowledge of a social phenomenon, thanks to the analysis of texts (and words, rather than numbers). Therefore, a qualitative research is characterized by a comprehensive aim, which aims to understand the problem in a context or situation. Its objectivity is based on "multiple sources of evidence" (Yin 2012, 10). Namely, direct observations, interviews, archival records, documents, participant-observation and physical artifacts, but in our contemporary world, the term “source of evidence” take a broader meaning, including various sources as journals, research reports, books, even information collected and analyzed from the internet. It is in particular the heterogeneity of the empirical sources in a qualitative research which guarantees their objectivity, Qualitative research is characterized by an approach that aims to describe and analyse, Therefore, it insists on the complete or "holistic" knowledge of the social context in which the research is carried out (Collins 1992).

Reliability refers to a tool for evaluating the quality of the measurement procedure utilized to collect data, therefore, all information collected must be assessed in terms of its relevance to the subject and the objectives of the work to be performed and in terms of its reliability and quality, especially when it comes from the Internet. First a relevance analysis must take place to make sure that the documents matches the subject concerned, the documents used for this thesis are mainly academic reports an journals highly relevant to the matter, and the scientific level of the documents corresponds to the expected level of reliability, as the documents must be reliable in order to consider that the results of researches and studies are valid (Cronbach 1947).

Validity is used to determine that researches truly measures what it was intended to measure. many research ways and styles have their own ways to examines reliability and validity established into their basic methodologies and procedures. The validity of the information (credibility) makes it possible to verify the seriousness of a source, of an author, his competence and notoriety to treat a subject. To evaluate the validity of information, knowledge of the disciplinary context or domain is desirable (Cronbach 2012).

Qualitative data are information which can be retrieved, and which are not considered measurable data. The common attribute point of qualitative data is that the verbal, audio, textual, and visual material acknowledge the interpretations and statements and does not concentrate on measurements. (Eriksson & Kovalainen 2016, 82-83.)

Documentary analysis is a form of qualitative research methods (Research Rundowns 2009). Documentary analysis aim to gather data from existent documents excluding having to inquire people by using surveys, interviews or by using observations and collection of data. Documents are considered a tangible source of information's, which represents recorded ideas or facts. Generally, people consider evidences, the materials which are produced or written on paper, for instance, newspapers and articles, brochures and conference proceedings.

Materials in other forms can also account for the object of a documentary analysis, including movies, music, photos and websites as well. Documents can reveal and communicate notably concerning the people or organization that made them and the social context in which they come into sight (Skillsyouneed 2017)

5.4 Data collection

For this research, the author searched for academic reports related to technological unemployment and used them as the data. Basically, their contents were closely related to technological unemployment and its effect on the creation of employment. After the data collection, the articles were classified according to their contents and analyzed for research.

All articles were written in English and are highly related to the subject of technological unemployment. The following chart display the articles chosen, the authors names, their titles, the retrieving sources, and their original sources. While the articles for the most part originally come from economics journals, in contrast with some few exemptions, as discussion papers and books. And for the sake of convenience and simplicity, they were mostly retrieved by the author from online databases. Such as, Econpapers, ScienceDirect, and other miscellaneous sources. EconPapers for instance, provides access to RePEc, the world's largest collection of on-line Economics working papers, journal articles and software.

TABLE 1. Articles table

Author	The source of article	Retrieving source	Article title
Hölzl Werner	Small Business Economics, 2009, vol. 33, issue 1, 59-75	Econpapers	Is the R&D behavior of fast-growing SMEs different? Evidence from CIS III data for 16 countries
Francesco Bogliacino, Mariacristina Piva and Marco Vivarelli (2012)	Economics Letters Volume 116, Issue 1, July 2012, Pages 56-59	ScienceDirect	R&D and employment: An application of the LSDVC estimator using European microdata
Alex Coad and Rekha Rao-Nicholson (2011)	Journal of Evolutionary Economics 21, pp.255-283	Econpapers	The firm-level employment effects of innovations in high-tech US manufacturing industries.
Vincent Van Roy, Daniel Vertesy and Marco Vivarelli (2015)	IZA Discussion Paper No. 9147	IZA institute of labor economics website	Innovation and employment in patenting firms: Empirical evidence from Europe.
Stefan Lachenmaier and Horst Rottmann (2011)	International Journal of Industrial Organization 29, pp.210-220	ScienceDirect	Effects of innovation on employment: A dynamic panel Analysis.
Rinaldo Evangelista and Antonio Vezzani (2011)	Industrial and Corporate Change 21, pp.871-899	Econpapers	The impact of technological and organizational innovations on employment in European firms.
Harrison Rupert, Jaumandreu Jordi, Mairesse Jacques & Peters Bettina (2014)	International Journal of Industrial Organization 35, pp.29-43	ScienceDirect	Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries.

Mastrostefano Valeria and Mario Pianta (2009)	Economics of Innovation and New Technology 18, pp.729-741	Econpapers	Technology and jobs.
Matthias Buerger, Tom Broekel and Alex Coad (2012)	Regional studies 46, pp.565-582	Tandfonline	Regional dynamics of innovation: Investigating the coevolution of patents, research and development (R&D), and employment.
Mario Pianta, Matteo Lucchese (2012)	Comparative Economic Studies 54, pp.341-359	Springer website	Innovation and employment in economic cycles.
Vincenzo Spiezia, Michael Polder and Giorgio Presidente (2016)	OECD (Unclassified)	OECD Ilibrary	ICTs and Jobs: complements or substitutes? The effects of ICT investment on labor market demand by skills and by industry in selected OECD countries.
Roberto Simonetti, Karl Taylor, Marco Vivarelli (2000)	The Employment Impact of Innovation: Evidence and Policy, pp.26-43	The book	Modelling the Employment Impact Innovation
Georg Graetz & Guy Michaels (2018)	LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE	Author's personal upload	Robots at Work
Terry Gregory, Anna Salomons and Ulrich Zierahn (2016)	discussion paper No.16-053.	ZEW – Leibniz Centre for European Economic Research official website	Racing with or against the machine? Evidence from Europe.

6 ANALYSIS OF RETROSPECTIVE STUDIES

A new wave of studies has sought to evaluate the risk of substitution of jobs by machines or software. These studies are most often part of a purely retrospective approach: they seek to quantify the jobs likely to be destroyed because of automation-related progress.

However, the economic literature has long been interested in the links between technology, innovation and employment. Economic theory struggling to provide an indisputable and definitive answer as to the effects of technologies on employment, many empirical studies have investigated the effects of innovations induced by the emergence of new technologies on the volume of employment. Their results vary according to the methodological choices: on one hand, the effects of technological progress variable (such as expenditure in R & D, patents filed, investments in new equipment or software, introduction of product or process innovation) and on the other hand, the level of analysis (Micro, sectoral or aggregate). The literature is currently unable to quantify precisely the respective weight of technology and trade on changes in the volume of employment, but still these ex-post evaluations of the impacts of technology over the last thirty years on employment from a quantitative point of view can enlighten to a certain extent the debate on the future impacts of new technologies on the volume of employment.

In the study conducted by Hölzl (2009), Hölzl compared the R&D behaviour of fast-growing SMEs, specifically in 16 country between the period of 1998 to 2000, specifically the growth in employment and R&D, the author concluded from the data collected, respectively CIS 3, a positive effect for high-growth companies in countries near the technological frontier.

Another study conducted by Bogliacino et al (2012), a similar dependent variable to the one used by Hölzl (2009) was used, namely the growth in employment and R&D, the study concerned 700 enterprise in Europe between the period 1990 to 2008, the authors concluded a positive effect in services and high-tech industries.

Coad and Nicholson (2011) study used somehow a different dependent variable, namely the growth in employment R&D and patents, the study concerned the United States between the period of 1963 to 1997, they concluded from the data collected, namely from Compustat and NBER innovation program, a positive effect for high-growth companies in the high-tech sector. While Van Roy et al compared the growth in employment and patents by analysing a unique panel dataset covering around 20,000 patenting companies, the study covered Europe over the interval 2003-2012, eventually the authors deduced a positive effect but only in high-tech companies, it is estimated that when a company doubles the number of patents filed, the demand for labour increases by 5%.

In another study by Lachenmaier and Rottman (2011), the authors used the growth in employment and process innovations as a dependent variable, the study was conducted on Germany between the interval 1982 and 2002, the authors concluded from the data collected from the Ifo innovation survey, a positive effect in general, especially concerning process innovation, which was superior as compared to product innovation.

Evangelista and Vezzani (2011) conducted a study on 6 European countries between the period of 2002 and 2004, by using growth in employment, process innovations, and product and organization as a dependant variable, they deduced from the CIS 4 data's a positive effect concerning process and product innovations in industries and services, while a negative effect was noticed regarding process innovation when combined with organizational innovation.

Harrison et al. (2014) studied the growth in employment, process and product innovation in the following countries, Spain, Germany, the United Kingdom and France, between the period 1998 and 2000, they concluded from the community innovation survey CIS 3 a negative effect of constant production process innovation, in contrast a positive effect was observed for product innovation.

In a study conducted by Mastrostefano and Pianta (2009), the authors compared the growth in employment and demand, wages, diffusion of technology and product innovation in 10 European countries in the interval 1994-2001. And with the help of data from the community innovation survey CIS 2 and 3, and the OECD STAN, they concluded a positive effect for demand, no effect through wages, little effect for technology diffusion.

In the study by Buerger et al. (2012), the authors used the growth in employment, R&D and patents as variables. The study concerned Germany between 1999 and 2005. Finally, and from the regional data's collected from the four sectors examined, they concluded, a positive effects in electrical, electronic and medical device industry, meanwhile, a null effect was observed for the chemical industry and for the transportation equipment industry.

Lucchese and Pianta (2012) study compared employment growth, product and process innovation in the following countries, Germany, France, Italy and UK. They concluded from the data collected between the period of 1995 to 2007, namely the community innovation survey 2,3 and 4, and the OECD STAN. A positive effect for product innovation during periods of growth, while a negative effect concerning process innovation during economic slowdown.

Simonetti, Taylor and Vivarelli (2000) studied employment and patents growth in the following countries. The United states, France, Italy and Japan, they observed from the data collected between the interval of 1965-1993 from the Organisation for Economic Co-operation and Development OECD and the international labour organization ILO, a negative effect on employment concerning process innovation, which was eventually compensated by the compensation mechanisms of lowering prices and increasing revenues. Meanwhile, product innovation had an overall positive impact on employment, but only for the United States and France. Taking into consideration their proximity to the technological frontier.

Spiezia, Polder, Presidente (2016) used the estimated demand for work and lower cost of ICT capital employment and process innovations as dependent variables. The study was conducted on Germany between 1982 and 2002. The authors concluded from the data collected from OECD productivity database, the STAN Structural Analysis Database survey, national annual accounts, and the OECD EAG indicators (Education at a Glance), a null long term effect on employment.

Another study by Graetz and Michaels (2018) was conducted on 17 countries between the period of 1993 and 2007, by using growth in employment, and the density of industrial robots in the economy (NB: the indicator measures the effect of a single type of technology, namely industrial robots), they used data’s from the International Federation of Robotics and EU KLEMS, they concluded a positive effect on employment.

In a study labelled “The Risk of Automation for Jobs in OECD Countries”, Gregory, Salomons and Zierahn (2016) Studied the local growth in employment and intensity index in routine jobs (NB: once again, the indicator chosen here is intended to represent technological progress unfavourable to routine work). The study was conducted on 27 countries between 1999 and 2010, by using data’s from the European Labour Force Survey (Eurostat), and STAN, the Database for Structural Analysis from the OECD. The authors concluded from their studies a positive effect on employment.

6.1 Recapitulation of the results

The following table summarize the results, according the study, and the effects concluded afterwards, the effects were categorized either as positive, negative, compensated or null.

TABLE 2. Recapitulation of the results

Study	Results
Hölzl (2009)	**Positive** effect for high-growth companies in countries near the technological frontier
Bogliacino et al. (2012)	**Positive** effect in services and high-tech industries
Coad and Nicholson (2011)	**Positive** effect for high-growth companies in high-tech
Van Roy et al. (2015)	**Positive** effect but only in high-tech companies. It is estimated that when a company doubles the number of patents filed, the demand for labor increases by 5%.
Lachenmaier and Rottman (2011)	**Positive** effect of process innovation, superior to the effect of product innovation
Evangelista and Vezzani (2011)	**Positive** effect of process and product innovations in industry and services. **Negative** effect of process innovation when combined with organizational innovation
Harrison et al. (2014)	**Negative** effect of constant production process innovation. **Positive** effect of product innovation. The quantified results are detailed below.
Mastrostefano and Pianta (2009)	**Positive** effect on demand no effect through wages, little effect of technology diffusion. **Positive** effect of product innovation but only for innovative sectors

Buerger et al. (2012)	Of the four sectors examined, the effects are **positive** in electrical / electronic and medical instruments but **null** for the chemical industry and for the transportation equipment industry
Lucchese and Pianta (2012)	In periods of growth, **positive** effect of product innovation; **negative** effect of process innovation during economic slowdown
Simonetti, Taylor and Vivarelli (2000)	**Negative** effect of process innovation But **compensated** by the compensation mechanisms by lowering prices and increasing revenues **Positive** effect of product innovation but only for France and the United States (proximity to the technological frontier)
Spiezia, Polder, Presidente, (2016)	**Null** Long-term effect on employment
Graetz, Michaels (2016)	**Positive** effect on employment
Gregory, Salomons, Zierahn, (2016)	**Positive** effect on employment

We can observe that the study's results converge despite differences on the level of analysis (aggregated, sectoral or Micro) and the methodological choices made, concluding a generally positive effect.

6.2 The past effects of solely digital or robotic technologies on employment

If we now focus on the impact on the volume of employment of only digital and robotic technologies, some recent studies have sought to evaluate ex post facto the effects of some of the technologies of the digital and robotic revolution on the volume employment. These analyzes use new indicators of technological progress and show that, at aggregate level, the effects on employment are, in the medium-long term, null or positive.

In 2016, the OECD conducted a study on the effects of investment in information and communication technologies, namely ICT, on employment at the macroeconomic and sectoral levels. 18 OECD countries are studied over the period 1990-2012.

The authors start from the observation that between 1990 and 2012, the cost of ICT capital has steadily declined in all the countries studied and then seek to evaluate the effects of the fall in the cost of ICT capital on the distribution of factors of production within companies.

Based on a very restrictive assumption (the authors estimate that, in the long term, labor and capital are easily replaceable) and using as an indicator the fall in the annual cost of using ICT capital, the model shows when investments touch the medium term, ICTs have no negative effect on employment at the aggregate level in the countries observed over the period 1990-2012, given the compensation mechanisms: the effect of direct substitution of labor by capital is compensated by the increase in demand (the mechanism of falling prices and rising incomes) (Spiezia, Polder & Presidente 2016)

Another study by Graetz and Michaels (2018) sought to evaluate the impact of the spread of industrial robots on different economic variables including employment. It covers 17 countries over the period 1993 to 2007. They conclude that densification of industrial robots in the economies studied between 1993 and 2007 did not have a negative effect on the number of hours worked except for the less qualified. However, during the concerned period, industrial robots were used on average in only one third of the economy, the authors stress that the effects to come could potentially be more powerful.

A recent study by Gregory, Salomons and Zierahn in 2016 analyzes the theoretical and empirical effects of technological progress that is unfavorable to routine work on the volume of employment. Data from 238 regions in 27 European countries are analyzed over the period 1999-2010. According to them, three effects of technological progress can affect the volume of employment.

The first is the substitution effect: when the cost of capital falls, companies have tendency to become more cost-effective, the effect is negative. Then there is the effect of lower prices and therefore the increase in demand that is favorable to employment. Finally, there is the mechanism of increasing available income that can support local consumption for new products and services - the effect is positive.

The balance between these three theoretical effects empirically determines the effects on employment. The authors conclude that, according to their estimates, the RRTC (for routine replacing technical change) created around 11.6 million jobs in Europe, i.e. half of the jobs created over the period 1999-2010. Recent technologies would therefore create jobs. These three retrospective studies, especially, shows that technological innovations can temporarily destroy jobs but also create jobs directly and indirectly. Depending on the nature of the technologies and the institutional context, new technologies may be unfavorable to employment during a period of adjustment. Recent empirical results, however, show that over the last thirty years, the innovations that emerged with the digital wave have allowed companies to be more productive and have initiated mechanisms that have driven growth in output and employment while at the same time creating new sectors that have supported labor demand.

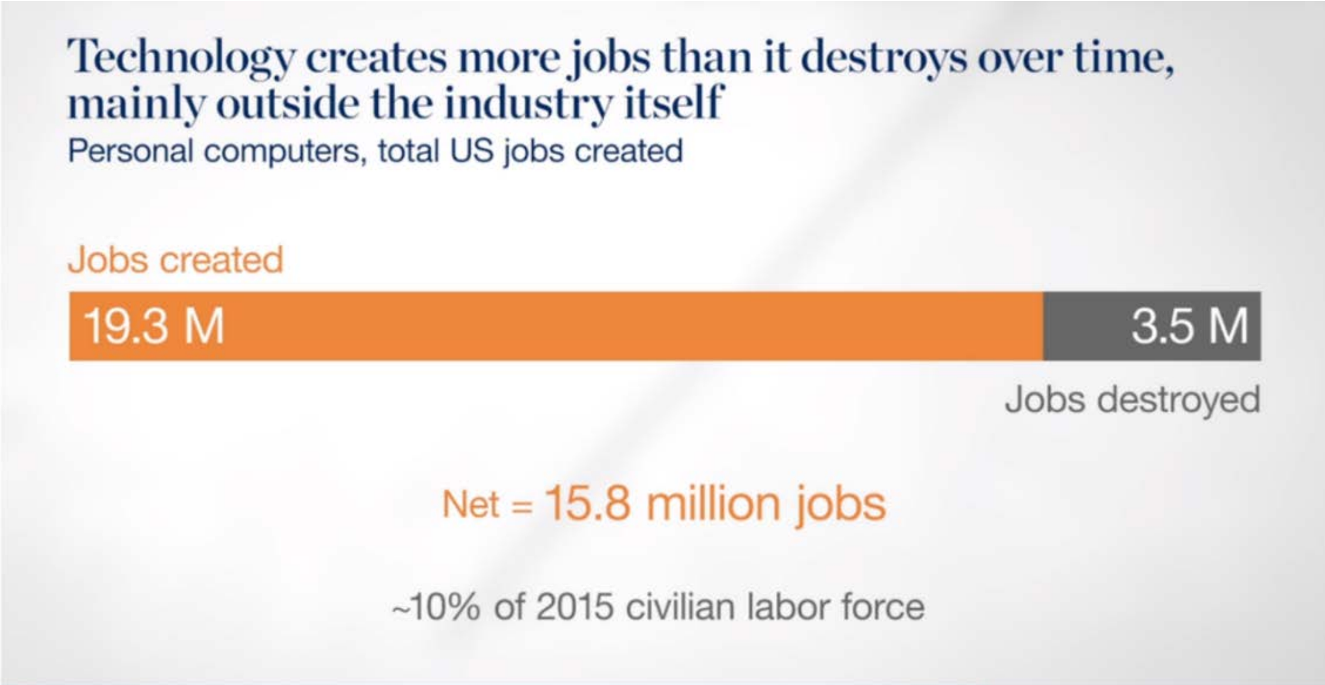

FIGURE 8. Personal computers / total US jobs created. (Adapted from McKinsey 2019)

7 ANALYSIS OF PROSPECTIVE STUDIES

In recent years, in parallel with the new changes brought by automation - and more recently by the digitization and advances of big data, many prospective economic studies have sought to quantify the risk of substitution of labor by automation possibilities. By attempting to quantify potentially substitutable jobs, these studies focus only on the risk of job destruction associated with automation and digitization. They do not consider either the induced effects or the potential for job creation. And unlike the retrospective studies which tend to converge, the results of these studies are far from converging.

In fact, depending on the methodological approach adopted, and the existing prospective studies. very disparate results in terms of number of jobs at high risk of automation are deducted, while Frey & Osborne concluded that 47% of professions are at risk, Arntz et al (2016) results were less alarming, at 9%, while McKinsey & company found that automation potential varies greatly across sectors (FIGURE 5).

7.1 The study by Frey and Osborne

The starting point of the analysis by Frey and Osborne (2013) remains the matrix of Autor David H, Levy Frank & Murnane Richard J (2003), which distinguishes within the tasks performed by the workers, the manual / cognitive tasks and the routine / non-routine tasks. The two theoretical frameworks diverge, however, when it comes to determining the tasks that can be automated: in fact, Frey and Osborne (2013) estimate that several non-routine tasks can now be automated in the light of new technological advances (machine learning, artificial intelligence, big data, etc.).

The criterion used to determine which tasks are automatable is then based on the "bottlenecks of the technological frontier" (manual perception and dexterity, creative and social intelligence). Autor and his coauthors labeled them as routine and non-routine manual tasks, and routine and non-routine cognitive tasks, while cognitive require a lot of cognitive activities such as decision-making, problem-solving, memory, attention and judgement, manual task on the other hand does not require much cognition when performed, manual task can take form and can involve tasks as using the human body to lift, lower, push, pull, carry or otherwise move, hold or restrain any person, animal or object.

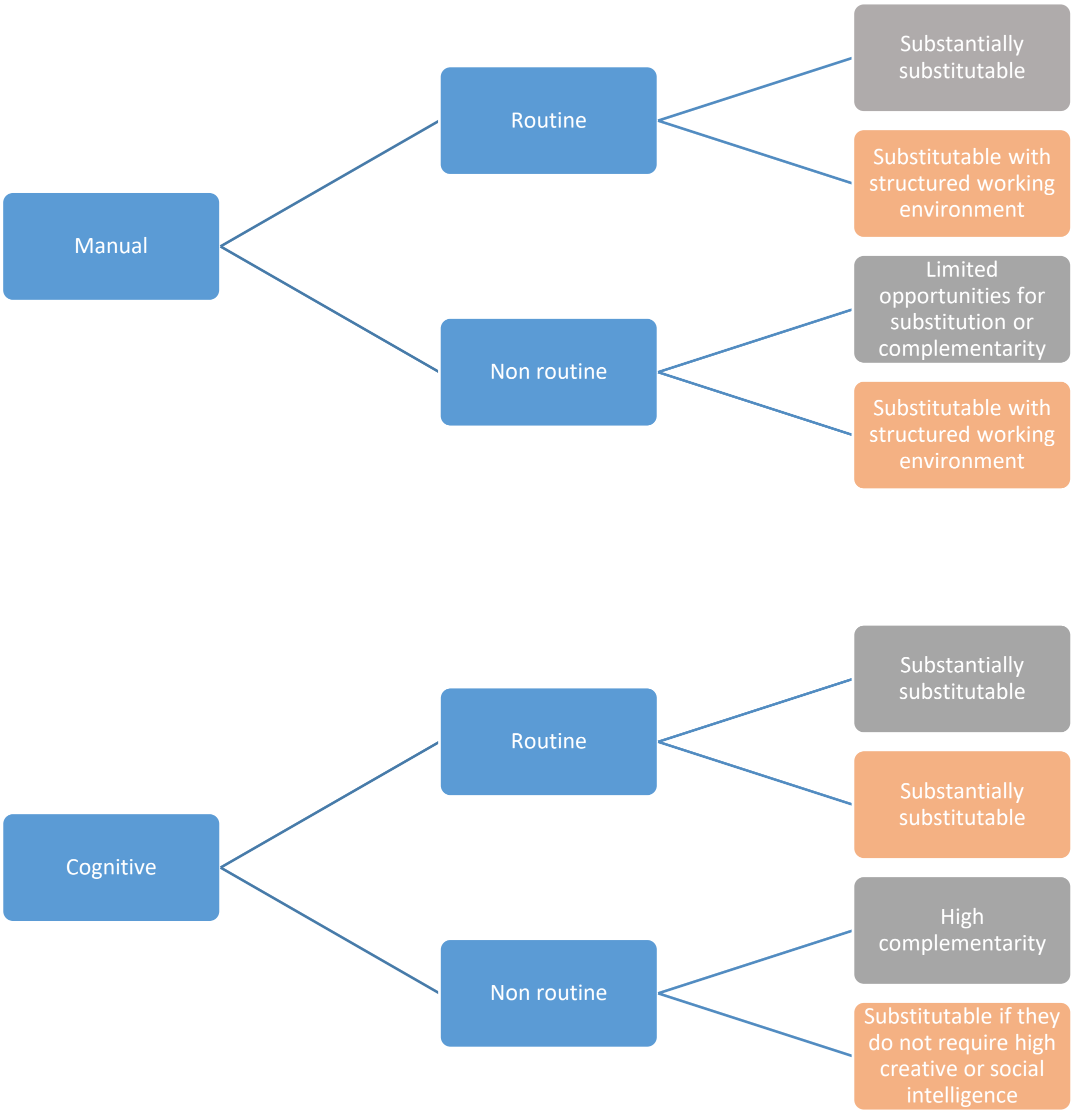

FIGURE 9. Comparison of complementarity / substitution characteristics of tasks (Autor, Levy & Murnane (2003); Frey, Osborne (2013))

It is in this broader context, presupposing an increased possibility of substitution of labor by capital, that the analyzes of this study are based on the future impact of automation on the volume of employment. The figures from their analysis appear significant: 47% of jobs in the United States and 35% in the United Kingdom would thus have a high probability of automation over a period of twenty years.

These methodological choices have therefore strong implications in the analysis of these projections. Specifically, Frey and Osborne (2013) approach have thus led to consider that not only do all workers in the same occupation carry out the same tasks and activities, but also that when the tasks performed by workers in the same trade are considered to be automatable, all jobs in this occupation will disappear.

This have led the author of this thesis to consider that the 15 main occupations (those occupying the most workers) among those considered to be automatable, they alone accounted for 20,69 % of the US jobs in 2016 (FIGURE 8). Believing that 47% of jobs will disappear in the United States (Frey & Osborne 2013, 38), it is therefore believed that there will be no seller, cashier or office worker in the next 20 years.

15 MAIN TRADES THAT CAN BE AUTOMATED BY NUMBER OF EMPLOYEES	NUMBERS
Sellers (retail salespersons)	4 602 500
Cashiers	3 555 500
Office clerks	3 117 700
Fast food and counter workers	3 957 500
Waiters and waitresses	2 600 500
Stock clerks and order fillers	2 008 600
Secretaries and administrative assistants	2 536 500
Bookkeeping, accounting and auditing clerks	1 730 500
Accountants and auditors	1 397 700
Heavy and tractor-trailer truck drivers	1 871 700
Sales representatives, wholesale and manufacturing, except technical and scientific products	1 469 900
Executive secretaries and executive administrative assistants	682 300
Financial managers	580 400
Security guards	1 123 300
Receptionists and information clerks	1 053 700
All 15 professions	32 288 300
All occupations	156 063 600
Share of the 15 occupations on total employment	20,69%

FIGURE 10. 15 most automatable occupations according to Frey and Osborne (2013)
And their share of the labor market according to US Department of Labor (2016)

With the results they get, Frey and Osborne draw 3 risk categories for occupations, respectively high, medium and low risk of automation, as we can see in the graph below (FIGURE 10). But in a very bilateral analysis: trades placed in the medium category are rare, and the essential is at the ends of the model. The main businesses largely spared are those corresponding to management, business, finance, computer science, engineering, science, education, legal, arts, media and health care. At the other end of the spectrum, that of the high risk of automation, we find the transportation, production, a share in construction and extraction, as well as sales-related occupations, as well as massive parts in office-related jobs, administrative support and services.

The trades that escape automation are above all intellectual and dynamic. Those professions linked to advanced physical dexterity certainly seem protected against automation, but Frey and Osborne ultimately consider that the inherent qualities of these trades are more easily overcome by technology than those related to certain intellectual professions.

The latter have in common the ability to cope with complex or technical situations thanks to a strong social intelligence and creativity. The high qualities they highlight in these professions are in fact the artistic talent, the originality, the capacity to negotiate and persuade, the talent for social perception as well as the ability to assist and take care of others.

Finally, and in an article entitled “Computerization Threatens One-Third of Finnish and Norwegian Employment ”, Pajarinen Mika, Rouvinen, Petri & Ekeland, Anders of the Research institute of Finnish economy tried to analyze the effects of computerization on jobs in Norway and Finland, and this by replicating Frey and Osborne study.

The choice of Norway and Finland was primarily for availability of consistent data’s, this exercise resulted in a 14-16% points less than the 47% estimated for the USA in Frey and Osborne study (2013), more precisely 33% for Norway and 35% for Finland (Pajarinen et al. 2015, 5). The jobs threatened in Norway were to a certain extents also quite similar to the US one, namely, accountant and bookkeepers, Salespersons, contact sellers, and office clerks, and similarly enough, jobs related to teaching, engineering and managerial tasks were shielded.

The authors did also emphasize on the limitations of Frey and Osborne method, especially the non-specific character of the task descriptions given by them. As and concerning the authors findings, they suggest that indeed a major change in the job market is to be expected, while it can be difficult for economies to adjust in the short term, a mass unemployment tragedy is unlikely to take place (Pajarinen et al. 2015, 6-7).

7.2 The study by Arntz, Gregory and Zierahn

This study is positioned as an alternative to the projections by Frey and Osborne. Indeed, their "occupation" based approach was not able to consider the heterogeneity of the tasks that compose them: professions considered as "at risk" by Frey and Osborne also include tasks that are difficult to automate, for example, and according to their study, watch repairers are at 98% risk of automation while they accounted for dexterous fingers as an obstacle for automation (Gittins 2017), they also considered accountants, tax agents and other marketing professions automatable, while the demands on such professions is projected to grow faster than average, the complex structure of these type of jobs is limiting the risk of outright disappearance of these jobs as a whole. In addition, individuals who do the same job do not necessarily perform the same tasks (and are not exposed to the same "risk").

This article therefore relies on a strictly task-based approach for estimating the share of risky jobs in 21 OECD countries. By exploiting the PIAAC survey, they can therefore consider both the heterogeneity of the tasks of the workers who do the same job, and the differences in terms of tasks carried out within the same profession between countries.

They find that only 9% of jobs in the United States have a high risk of disappearing due to automation compared to the 47% by Frey and Osborne. 9% is also the average for the 21 OECD countries selected for analysis.

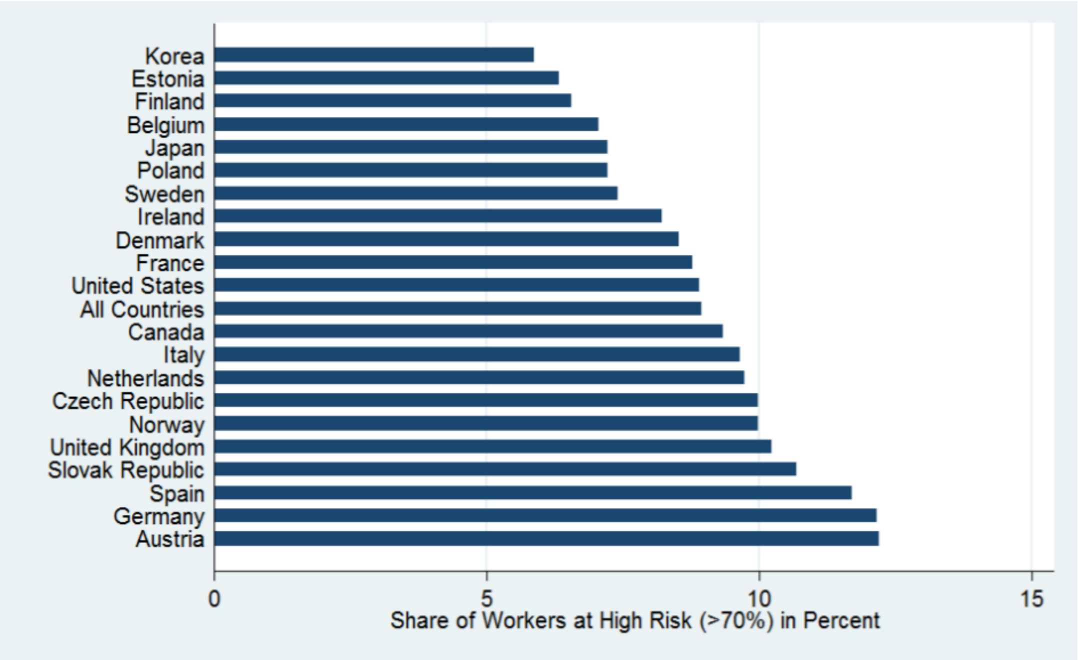

FIGURE 11. Share of Workers with High Automatability by OECD Countries (Adapted from Arntz, Gregory & Zierahn 2016)

This study presents results only at the aggregated national level and does not enter into the details of the occupations in question. Even though these projections are already less worrying than those of Frey and

Osborne (2013), the authors point out that these figures will not necessarily translate into an actual loss of jobs, for at least three reasons: Technology adoption and diffusion is a slow process, slowed down by economic, legal and social obstacles, so this technological substitution often does not take place as planned.

The workers have the ability to adapt so that they can change the content in tasks in their occupations and work with technologies. Innovation can also on one hand create new sectors and thus employment, and on the other hand increase competitiveness and thereby support demand. In short, as Dr. Ulrich Zierahn pointed, according to the conclusions of this article, automation and digitization will mean, first and foremost, the transformation of existing jobs rather than their disappearance.

7.3 Low skilled jobs mostly at risk

Most of the prospective studies that have sought to quantify the number of jobs at risk of automation in the light of current and future technological advances have focused on the effects of new technologies on the structure of employment. Regardless of the method used, the least skilled jobs are those who are most at risk of being replaced by robots or computer programs within 10 to 15 years.

This is the conclusion, for the American case, of the study by Frey and Osborne (2013) which establishes a strong negative relationship between the level of education or salary level and the risk of automation. If this happens, then, at least in the case of the United States, there will be a deep breach within the polarization of employment similar to the one observed since the 1980s (Autor 2010, 3).

While simple reasoning may push one to think that rather than helping to reduce the demand for intermediate skills, technologies would lead instead to a reduction in the demand for low-skilled work and an increase in the demand for highly skilled work. Figure 10 shows a strong polarization in labour demands and a linearity in skills relatively to employment during the period 1979-1989, namely, a decline in the share of low skilled workers, and an increase in the share of high skilled workers. While the following period, namely 1989-1999, shows an increase in the share of low and high skilled workers, relatively to the previous period. Finally, the last and most recent period of 1999-2007 shows a decline in the share of high skilled workers and a rise in the share of low skilled workers. Technology can rather have an opposing effect on jobs by creating a spillage in jobs, leading to the creation of new types of low skilled jobs (Gibbs 2017).

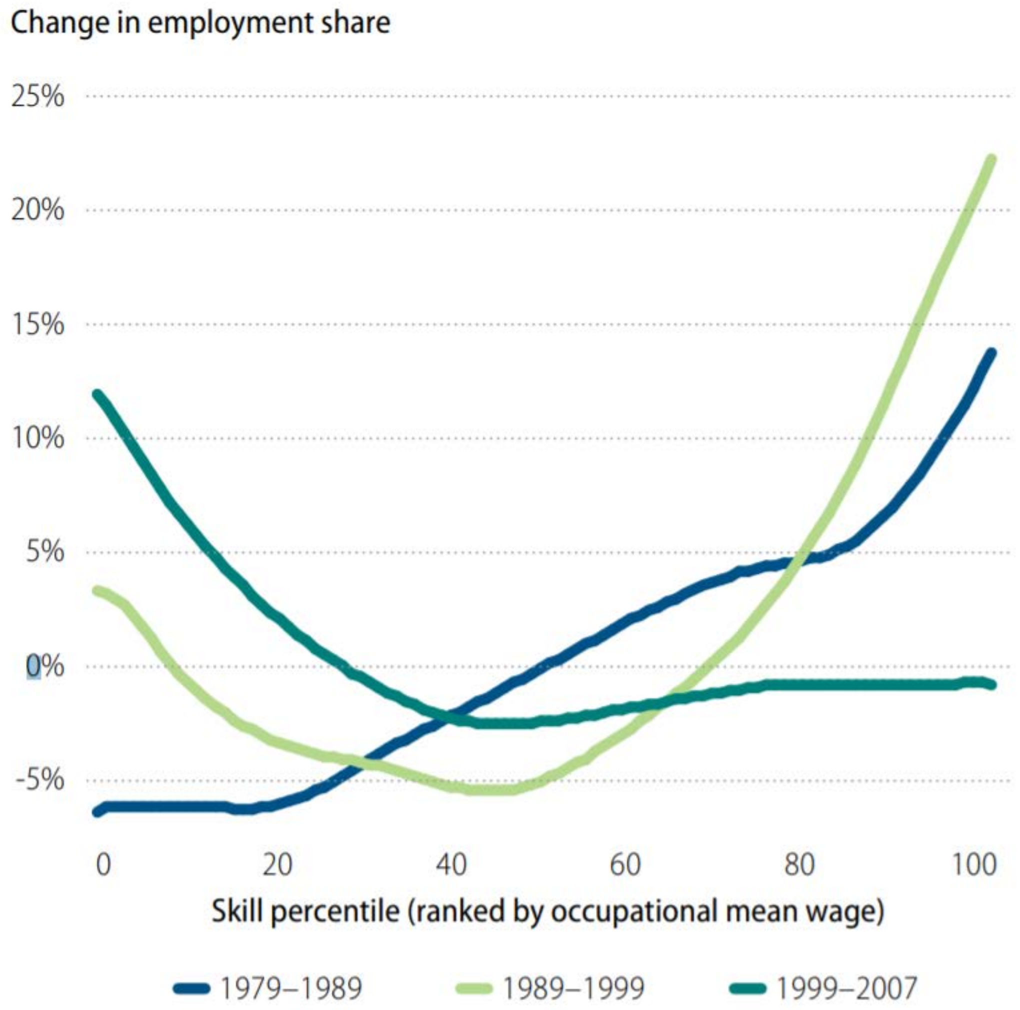

FIGURE 12. Correlation between skills and change in employment during different periods in the U.S (Adapted from Autor 2010, 3)

When looking at the risk of automation by occupational groups, salespersons, support and administrative functions as well as services account for most of the volume of jobs most at risk (FIGURE 11). The transport and logistics and production trades are also anticipated in this context as being at high risk of automation.

While it may be counterintuitive to find among the most at-risk occupational groups, occupations in services or sales, these developments are, however, consistent with current and future technological advances. With regard to services, this result may appear consistent with the observed increase in the personal and domestic robots' market (IFR 2016).

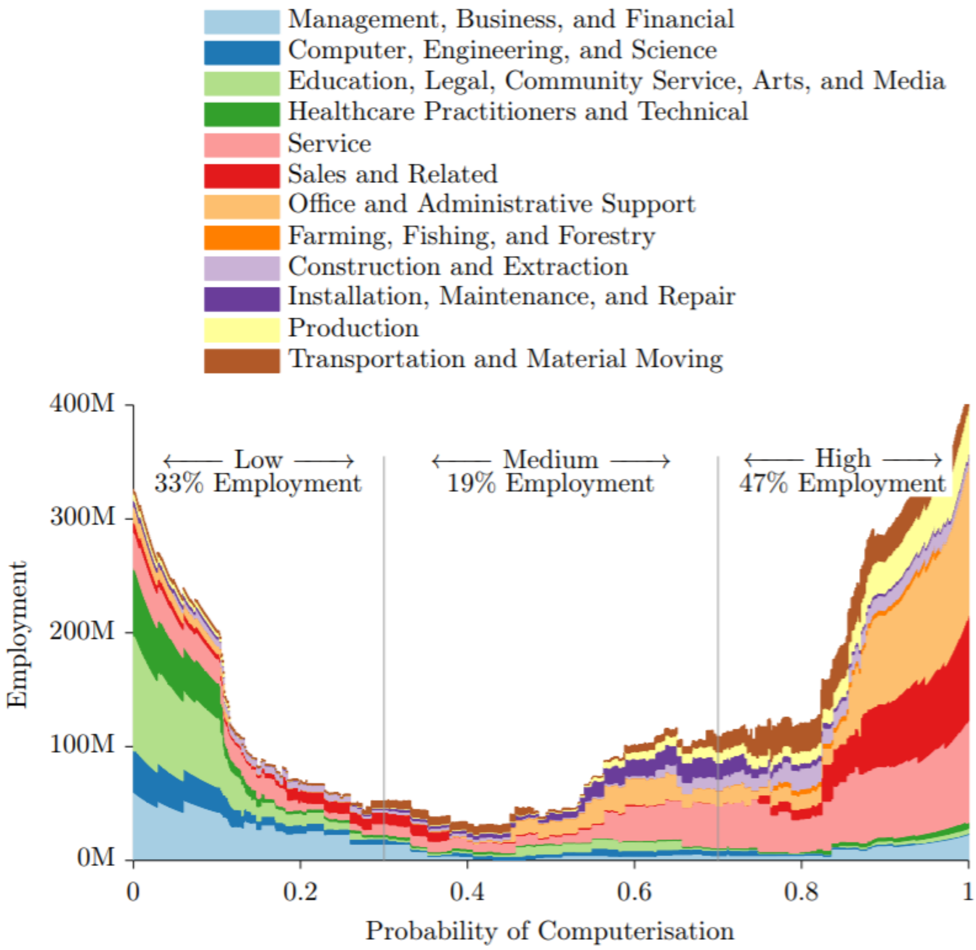

FIGURE 13. Classification of total employment by field and by risk of automation (Adapted from Frey & Osborne 2013, 40)

There is also a gradual decline in the comparative advantage of men over machines in performing tasks that require mobility and dexterity. With respect to sales, this occupational group includes cashiers, telemarketers, or counter employees. Although these trades involve interactive tasks, they do not require in all cases a high degree of adaptation related to social interactions. For the authors, the model on which their analysis is based seems to be very capable of distinguishing the specificities of the different trades included in a professional group. If the least skilled jobs are the most at risk, the progress expected in the areas of artificial intelligence in particular are also likely to push the limits of the automation of non-routine tasks.

Advances in sub-domains of artificial intelligence such as machine learning must make it possible to transform more and more complex tasks into more clearly defined problems. If the volumes of jobs concerned remain the same, jobs considered qualified can thus also be part of high-risk jobs of automation.

7.4 A further comparison between the two studies

The study by Arntz et al. (2016), published on behalf of the OECD opts for an approach that contrasts with the methodology of Frey & Osborne. This study does indeed require an analysis according to tasks rather than occupations, leading to conclusions much less alarmist, albeit still substantial, with an average of 9% risk studied for the US case (Arntz, Gregory & Zierahn 2016, 14), about 5 times less than that estimated by Frey and Osborne. These downward results are explained by an increasing number of occupations which, although represented as at high-risk by Frey & Osborne, seem to carry unachievable tasks (Arntz, Gregory & Zierahn 2016, 8).

These authors advocate for greater precision through the Program for the International Assessment of Adult Competencies (PIAAC) database, which collects data that is supposed to be more precise about the tasks actually performed in the professions (Arntz, Gregory & Zierahn 2016, 12). In the American case, they reach conclusions that opposes the polarized vision of Frey and Osborne. The latter classified the trades according to two poles, conceiving them as either fully automated, or fully protected from this risk, and this by subjectively labeling the 70 occupations studied, by assigning a value 1 if automatable or 0 if not (Frey & Osborne 2013, 30).

The study by Arntz et al. (2016) For its part shows much more contrasting forecasts, with a majority of occupations, some of which tasks would be replaced by the machine, but without ending the existence of the profession. The purely automated trades would thus be rarer, just like those unaltered by the progress of technologies (FIGURE 12).

The figure below, materializes the substantial differences between Frey and Osborne's findings and Arntz et al. (2016) The line "Task-Based Approach" refers to the method put forward by Arntz et al, while the line "Occupation-Based Approach" is deduced from the method used in the study by Frey and Osborne. It should be noted that to achieve this result, Arntz and his colleagues converted the data according to the PIAAC, but either by tasks or by occupations, and this in order to allow comparison between approaches, in other words, they had to match all values from Frey & Osborne study to each individual in the US-PIAAC Data. The x-axis represents the estimated percentage of automation, which percentage will be reported on the y-axis, which is representing a smoothed estimate of the density of current occupations in the United States.

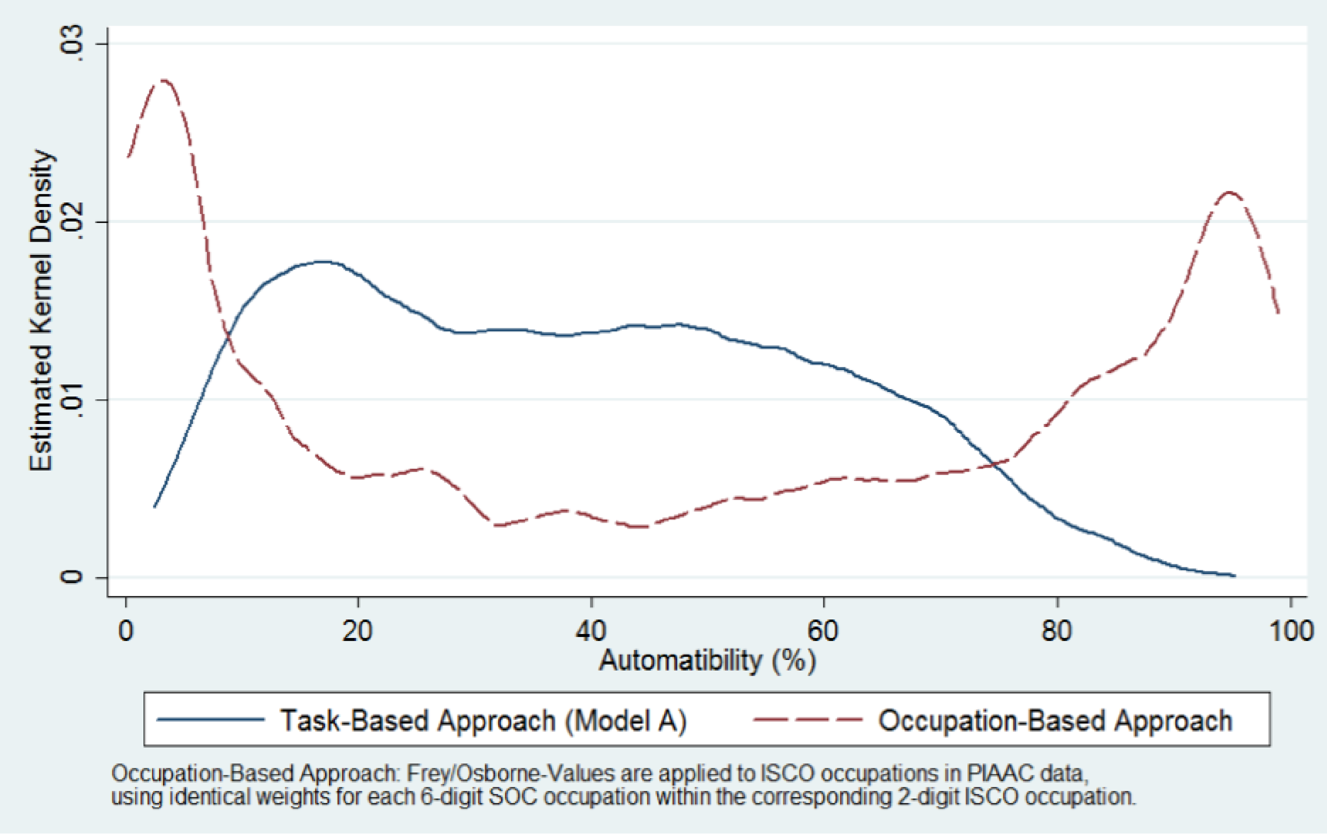

FIGURE 14. Arntz et al calculation based on the Survey of Adult Skills (PIAAC) (2012) (Adapted from Arntz, Gregory & Zierahn 2016)

To conclude, the curves thus represent for each approach the share of trades estimated in relation to the total according to the degree of automation they will face in the future. And indeed, as these researchers point out, the result obtained according to the Occupation-Based Approach is very similar to the one obtained by Frey and Osborne (FIGURE 11), in contrast by using data information's on task-usage at the individual level (PIAAC), the results are significantly less alarming, which is because, and as stated before, not taking into account the variation of tasks performed within a profession affect the final estimations to a large extent. Lastly and despite the disparities in the methods and variables used in the multitude of studies, we can conclude that, and as for today, the effect of technology on employment remain generally positive.

8 CONCLUSION

The lessons of the recent economic analysis invite to consider, beyond the speed of displacement of the technological frontier, the challenges of temporality. Indeed, the introduction of new technologies does not only translate into the substitution of man by the machine, by producing more with less. The productivity gains associated with "process innovations" that allow producing with less labor are also likely to promote market share gains, especially in export. Alongside these "process innovations", "product innovations" may appear, with positive effects on employment. In addition, in the short or long term, compensation mechanisms contribute to the increase of employment, directly - via the employment necessary for the implementation of new technologies - or indirectly - particularly via the increase in demand. Two mains issues are therefore critical: to ensure that these compensation mechanisms can intervene in the best conditions and as quickly as possible and managing well the transition period.

Also, and too often, the analyzes are partial, which can distort the conclusions. Sometimes they are interested in job destruction only, where job creations should also be taken into consideration, which are, of course, more difficult to quantify. Sometimes the studies consider the question from a purely quantitative point of view by omitting the qualitative dimension: the transformation of the content of jobs and work. As on one hand, all individuals within the same "occupation" do not perform the same tasks, on the other hand the content in tasks of the same profession can evolve with, in particular, technological progress.

To conclude, an economy cannot abstain or even stand aside temporarily from technological progress at the risk of be left behind: technological progress is not an option and the speed of adaptation is also a criterion of success in a context of globalization. The economic history shows that over the last two centuries, employment, although it has changed a lot, has continued to increase over the course of technological revolutions. The rather favorable link between employment and new technologies has also been confirmed over the last three decades. We can have the opinion we want about automation; but one should, and as much as possible, try to situate one's own opinion in the array of points of view that motivate a multitude of other opinions.

But these points of view usually depend on the situation that everyone occupies in the hierarchy that our industrial society has built. Small owner of a small manufacture; plant manager in an industry; director or manager of an industrial group overlaying with the entire economy; public administrator, or politician. The policy must consider not only the economic efficiency of a system but also its social effectiveness, this progress must not be feared, and depicted as the "End of work", but this should encourage even more measures that will help a large number of employees to acquire the knowledge and skills needed to work hand in hand with these new technologies.

The threat of technological unemployment has sometimes been used by free market economists as justification for supply-side reforms to make it easier to revoke and hire workers, and by other economists to increase worker protection, aka Basic income. But Michael Spence warns that responding to the future impact of technology will require a detailed understanding of the global forces and movements that technology has set in motion. Adaptation for it will require a change of mindset, policies and investments (especially in human capital).

Since the publication of the book “Race Against the Machine”, the authors, Andrew McAfee and Erik Brynjolfsson's professors at Massachusetts Institute of Technology, they became today, important voices in the debate over technological unemployment. Both remain relatively optimistic, starting by saying that "the key to winning the race is not to compete" against "machines, but" with "machines".

The objective of the thesis was to prove that technological advancement, especially during the last three decades, did not affect employment negatively, and that technologies and new machines should not be considered and regarded as labor displacers. Ultimately the goal of the thesis was reached, as the studies and researches around the topic concluded that technology create more job than it displaces, and that this upward trend, is expected to continue.

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