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THE SIXTH WAVE OF INNOVATION: ARTIFICIAL INTELLIGENCE AND THE IMPACTS ON EMPLOYMENT

A sexta onda de inovação: inteligência artificial e impactos no emprego

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ABSTRACT

The beginning of the 21st century presents a scenario of profound transformations for human society. Technological innovations will enable significant advances in various areas and aspects of human society, such as health and longevity, energy efficiency and urban mobility. There will be economic prosperity within the logic of the process of creative destruction, with products and businesses being replaced by others. The sixth wave of technological innovation must severely impact the logic of interaction between technology, society and work. The new wave of innovation, based on digital and intelligence technologies that combine with information and communication technologies born in the second half of the 20th century, presents specific characteristics that differentiate it structurally from previous waves, such as high propagation velocity and maturation of technological innovations, convergence between several disruptive technologies and with high potential for the replacement of human labor.

Keywords: Artificial Intelligence, Industry 4.0, Technological Innovation, Labor and Employment.

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A SEXTA ONDA DE INOVAÇÃO: INTELIGÊNCIA ARTIFICIAL E IMPACTOS NO EMPREGO

The sixth wave of innovation: artificial intelligence and the Impacts on employment

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RESUMO

O início do século XXI apresenta um cenário de profundas transformações para a sociedade humana. As inovações tecnológicas permitirão avanços significativos em várias áreas e aspectos da sociedade humana, como saúde e longevidade, eficiência energética e mobilidade urbana. Haverá prosperidade econômica dentro da lógica do processo de destruição criativa, com produtos e negócios sendo substituídos por outros. A sexta onda de inovação tecnológica deve impactar severamente a lógica da interação entre tecnologia, sociedade e trabalho. A nova onda de inovação, baseada em tecnologias digitais e de inteligência combinadas às tecnologias de informação e comunicação nascidas na segunda metade do século 20, apresenta características específicas que a diferenciam estruturalmente das ondas anteriores, como alta velocidade de propagação e amadurecimento de inovações tecnológicas. , convergência entre várias tecnologias disruptivas e com alto potencial para a substituição do trabalho humano.

Palavras-chave: Inteligência Artificial, Indústria 4.0, Inovação Tecnológica, Trabalho e Emprego.

INTRODUCTION

The development of technology throughout the history of mankind has generated significant advances and its benefits are absolutely tangible, relevant and intrinsically linked to the own civilizational development (CASTELLS, 2006). Already in the field of human work, the fear of the potentially destructive effects of technology on jobs is symbolically represented by the Luddism movement in England in the early nineteenth century, where groups of workers used the destruction of machines as a means of pressing the employers against the precarious conditions to which they were subjected: exhaustive days, unhealthy working environments and low salaries. It was a historical period marked by economic turbulence, mass unemployment and hunger, in a scenario that was aggravated by the introduction of machines that caused layoffs and replaced more qualified and better remunerated functions by others with few technical demands and worse remunerated, generating conflicts between small producers (ROBSBAWM, 1952).

The emergence of a new technological revolution rekindles controversy with debates between opposing visions: those that envision a bright future, where technology releases humanity from the obligation of hard, repetitive and discouraging work, eliminates diseases, promotes longevity, comfort, allows new playful and sensory possibilities brought about by digital devices and environments and where older workers can work more and healthier - which would be a strategic possibility in the current demographic context, where several countries are facing a reduction of their workforce due to the aging and their deleterious effects on their economies (Vogler-Ludwig, Düll and Kriechel, 2016). In an antagonistic position, those who fear the potentially harmful consequences of the intense proliferation of technology by sensitive fields of human society, such as work, genetic medicine, control over information and reckless application in the military field. There is also a risk of the dehumanization of relations and human consciousness in a cybernetic post-humanism scenario (FUKUYAMA, 2002). Although computerization has historically been confined to routine tasks involving activities based on explicit rules, artificial intelligence and big data algorithms are now rapidly entering into patterns-dependent domains and can readily replace work in a wide range of cognitive tasks not routine. Adding to this, advanced robots are gaining enhanced senses and dexterity, which allows them to perform a wide variety of manual tasks. This will likely change the nature of work in companies and professions (BRYNJOLFSSON; MCAFEE, 2011). Some changes are already perceived: advances in user interfaces, for example, already allow computers to respond more efficiently to customer requests, reducing the need for human intervention in some service and service activities. With the expansion of computer capacity, tasks that were once considered too complex to be coded are being converted into well-defined problems treatable through digital solutions (OSBORNE and FREY, 2014). New high-performance applications in speech recognition and word processing allow simultaneous interpretation, automatic creation of complex standard texts, as well as analysis of large volumes of text for legal purposes. In medicine, intelligent image recognition software can significantly improve the diagnosis of many diseases and generate increased productive capacity for physicians and affect the class of general practitioners. In the area of health care, interactive systems are being tested that can promote the psychological and emotional well-being of the elderly, partially replacing the work of assistants and caregivers. In sum, whether in relation to industrial, service or knowledge work, digitization is changing the entire sociotechnical system of people, organization and technology (GRAGLIA, LAZZARESCHI, 2018). In its effects there are clearly positive aspects and others that inspire more reflection.

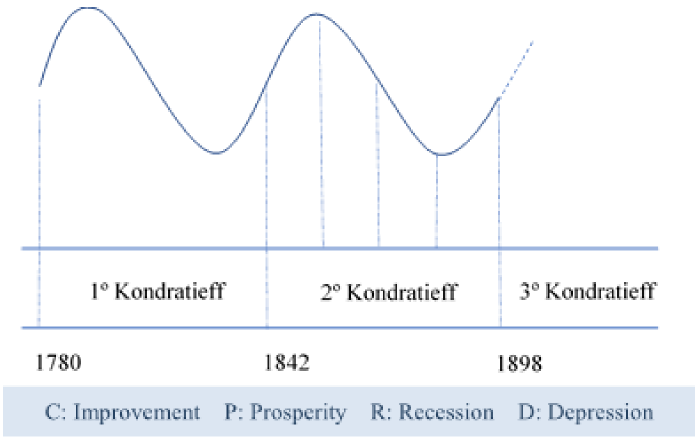
1. THE ECONOMIC CYCLES AND TECHNOLOGICAL INNOVATION

The cyclical behavior of the world economy, alternating moments of growth and crisis has been studied by several authors (HAYEK, 1933, KONDRATIEFF, 1935, MISES, 1953 and MODIS, 2017). Kondratieff

(1935) affirms the existence of long waves that are not originated by random causes, but by inherent causes to the essence of the capitalist economy. The mechanisms that explain the existence and behavior of long waves are derived from the emergence of major technical changes, wars, revolutions and assimilation of new countries within the world economy. The technical changes in production play an influential role in the development of capitalism, and the development of techniques is itself part of the longwave rhythm (KONDRATIEFF, 1935). Schumpeter (1939) argues that the disturbance motivating the beginning of a cycle is given by an innovation. According to his theory, there is a periodicity of long cycles, or long waves, of about fifty or sixty years. John Maynard Keynes (1883-1946) recognizes the existence of economic cycles, including the regularity of occurrence and duration, justifying it as the result of a cyclical variation in the marginal efficiency of capital. The marginal efficiency of capital (profit rate) is related to the expectation of an investor's return when acquiring a given capital asset, and the expected return will be the result of a flow of future incomes generated by the sale of the products. Keynes highlights the phenomenon of crisis as a typical feature of the economic cycle, where the inversion of an ascending to a descending phase usually occurs abruptly and violently - crisis - whereas the passage from a descending phase to an ascending one used to occur gradual and smooth. Therefore, both Keynes and Schumpeter believed that the understanding of the cyclical movements of the economy was in the fluctuation of the level of investment (LIMA, 2011). In his work Business Cycles, Schumpeter emphasized the importance of innovations as a determining factor of economic development. He also coined the term "Kondratieff cycle" and thus linked the name of the Russian economist to the phenomenon of long waves. For Schumpeter, the periods of economic expansion are related to the fact that the innovative entrepreneur, when creating new products, breaks certain economic inertia by establishing a new technological paradigm, which is followed by other entrepreneurs, who apply resources to produce goods similar to the one created by the first. Thus, a wave of capital investment leverages the economy, generating prosperity and expansion of production and employment levels. As technological innovations are absorbed by the market, the rate of economic growth slows and a recessive process begins, resulting from the reduction of investments and even consumption, affecting the level of employment. A new cycle depends on the occurrence of another wave of technological innovation. This alternation between prosperity and recession is seen as part of the larger process of economic development (Schumpeter, 1997).

From the work of Kondratieff, Schumpeter proposed in the 1930s that some important innovations were the root of the strong economic waves that began approximately in 1785. His hypothesis eventually led to an influential work in 1979 led by Gerhard Mensch. In the book Stalemate in Technology: Innovations Overcome the Depression, Mensch cataloged over one hundred innovations that made significant contributions to industrial society between 1750 and 1950. When he plotted the frequency of major innovations against the year in which they were invented, he discovered that a cluster of innovations arises once every fifty or sixty years, the same period observed in Kondratieff's work (POIRE, 2011). The fundamental impulse that keeps the capitalist machine in operation comes from the new consumer goods, the new methods of production or transportation, the new markets, and the new forms of productive organization created by the capitalist enterprise. It is a process that incessantly revolutionizes the economic structure from within, incessantly destroying the old and creating new elements, from discrete explosions, separated by periods of relative calm. The process as a whole is continuous, since there is always a revolution or the absorption of the results of a revolution, forming a new economic cycle. It is from this process that capitalism is constituted and that every capitalist enterprise must adapt itself to survive. There is inherent tendency in the capitalist system for self-destruction and the idea of creative destruction highlights the disruptive character that characterizes the interference of major technological innovations over economies and their role as a fundamental agent in the process of economic development. The motivation of this phenomenon is explained by the entrepreneur's view on the possibility of earning profits from innovation. Over time, with every wave of investment in technology, a wave of innovation is generated (Schumpeter, 1961).

Figure 1: Cycles of Kondratieff, according to Schumpeter.



Source: Schumpeter (1939). Adapted by the authors.

1.1 The first wave

The first wave is marked by the first phase of the Industrial Revolution, which was boosted by new technologies such as the invention of the steam engine in 1712 by Thomas Newcomem (1664 to 1729) and his improvement by James Watt (1736 to 1819). Watt, in addition to adding a separate condensation chamber that allowed to reduce energy loss and thus generate significant gains in efficiency, later incorporated other modifications, such as a mechanism derived from the crank-crank system invented by Matthew Wasbrough (1753 to 1781) and patented in 1780 that allowed to transform the alternating rectilinear movement of the piston of the machine to steam in a rotating movement, which contributed to the expansion of its application (TAVARES, 2008). The use of hydraulic energy expanded and the textile industry was one of the most representative economic sectors of this historical period.

1.2 The second wave

The second wave has as motivating technologies and determining industries the modern facilities of transport and communication (emphasizing the railway system, the telegraph, the steamship), Portland cement. The discovery of new steel processes, such as the Siemens Martin (1865), Bessemer (1870) and Thomas (1888) processes, enabled steel to be obtained on an industrial scale and gave impetus to a new era of development. As productivity increased, production costs and prices dropped dramatically. Between 1882 and 1885 the average production cost of one liter of kerosene fell by 70%, the cost of steel rails was reduced by 88% and the cost of aluminum was reduced by 96% by the electrolytic refining process invented in the 1990s. (Jensen, 1993).

1.3 The third wave

The third wave, characterized between the late nineteenth and the first half of the twentieth century, was a technological revolution that had among the main innovations the development of electricity, the internal combustion engine, chemical products and the first communication technologies, such as invention of the telephone and the radio and the diffusion of the telegraph. A set of macro inventions paved the way for the emergence of micro inventions in the fields of agriculture, industry and communications. A sudden and drastic increase in technological applications has transformed production and distribution processes, creating a flood of new products that has decisively changed the location of wealth and power, which has now been concentrated in the US and Germany (CASTELLS, 2006).

1.4 The fourth wave

The fourth wave, marked by the beginning of the second half of the twentieth century, is marked by the first computer, ENIAC, developed in 1946 by Mauchly and Eckert, the invention of the transistor by physicists Bardeen, Brattain and Shockley, Bell Laboratories, by the invention of the printed circuit in 1957 by Jack Kilby of Texas Instruments and the microprocessor in 1971 by Ted Hoff of the Intel Corporation. Significant changes in the speed of innovations can already be noticed. The so-called Moore's Law advocates that the number of transistors on a chip doubles every eighteen months, while maintaining the same cost. The set of these inventions paved the way for the emergence of personal computers, such as the Altair 8800 developed in 1975 by Ed Roberts, Apple 1 (1976) and Apple 2 (1977), PC - Personal Computer by IBM (1981). In 1984 Apple released the Macintosh. The development of optoelectronics (fiber optic and laser transmission) and digital packet transmission technology have promoted the expansion of transmission line capacity. This technology, combined with advanced switching and routing architectures such as ATM (asynchronous mode of transmission) and TCP / IP (transmission control protocol and interconnection protocol) formed the basis for the emergence of the Internet. (CASTELLS, 2006). Other innovations of this period include the control and development of nuclear power, the expansion of commercial aviation, the development of satellite production and the space race. Robotics is based on the development of microelectronics and is applied in industrial automation, initiating a new cycle of replacing human work in industries such as the automobile industry.

1.5 The fifth wave

The fifth wave, beginning in the 1990s, is heavily based on information and communication technologies - generating the expansion of digital cellular telephony, the explosion of digital social networks, the growth of the software industry, the development of the UHF (Ultra High Frequency) RFID (Radio Frequency Identification) by IBM, the development of geolocation technologies such as GPS (Global Positioning System), AGPS (Assisted Global Positioning System), GSM (Global System for Mobile Communications) and the emergence of new digital social media. This period was called by Manuel Castells (2006) of the Information Age, characterized by an informational, global and networked economy.

1.6 The sixth wave

Every wave of innovation lasts approximately until the profits generated by it fall back to the level of other older and more traditional sectors. It is a situation where technology, having reached its limits in terms of economic stimulus, needs to be replaced by another new technology in order to overcome those limits. Every wave converges, at its end, to a typical economic crisis and stagnation. The crisis in 2007-2010 is the end of the wave of the information technology and telecommunications revolution. The end of the fifth wave. Long cycles were originally described as having a frequency between 45 and 60 years. What some authors have pointed out is an apparent reduction in the interval between cycles due to the acceleration of scientific progress. In this new wave of innovation, the diffusion of digital technology has been driven mainly by two factors: the extraordinary pace of technical progress, expressed in Moore's Law (which deals with the exponential shrinkage of transistor sizes that can be applied to an integrated circuit and which can also be understood as a relation that deals with the continuous reduction of costs of these components and related equipment in relation to time) and the convergence of the marginal cost of information dissemination to zero. These factors have reduced hardware prices to an extraordinary degree. Intel co-founder Gordon Moore predicted in 1965 that the number of integrated circuits would double annually in relation to the cost of microprocessors over the next decade (Moore, 1998). This prediction, as a principle, proved to be correct. Supercomputer performance doubled every year between 1990 and 2012, disk efficiency increased 67% per year and the number of transistors in microchips increased 47% per year (BRYNJOLFSSON; MCAFEE, 2011). While Moore's Law provides for the annual doubling of memory capacity in electronic chips in relation to their cost and thus cutting hardware cost fast, the zero marginal cost hypothesis points to the decreasing cost of inputs and related services the information (RIFKIN, 2016). Even though these are not laws in the strict sense, they describe one of the key features of digital versus analog technology: not only is it better, faster, and cheaper, but it will also continue to become better, faster, and cheaper in the future. This explains the high growth rates of the digital economy and its ubiquity. The fall in prices of hardware, software and especially the approach to the marginal costs of obtaining information close to zero, is making the demand for information goods grow at exorbitant rates, while digital technology more and more replaces the traditional mode of information. production (VOGLER-LUDWIG; DÜLL; KRIECHEL, 2016). The acceleration of the process of developing new technologies and the speed of expansion of their application in the market and adoption by a larger number of consumers may not only depend on an assumption of the continuation of Moore's Law but on models which show that the changes exponentially and not linearly (KURZWEIL, 2001).

The comparison between the times spent to reach 50 million users, used as a reference to evaluate the speed of propagation of a new technology, serves as indicative manifestation for the issue of acceleration. Comparatively speaking, while the phone needed seventy-five years, the radio thirty-eight years and television fourteen years to reach fifty million users, the phone needed five years, the internet four years, Skype two years, the mobile technology required only fifty days and it is estimated that new digital technologies need only thirty-five days to reach fifty million users (ERNEST & YOUNG, 2017). The report "Surfing the Sixth Wave: Exploring the Next 40 Years of Global Change" finds that the permanently high levels of commodity prices, as well as the worsening of environmental tensions, are indicative of the emergence of a new wave. The productivity of resources is the main driver of technological, economic and even social changes and part of the technologies that make up this new cluster that will impact the economy and society is already known. The sixth wave may have artificial intelligence, biomedicine, hydrogen engine and robots as conducting technologies (SHIMULA, 2009). Its effects will be leveraged by the digitalization and exponential increase of computational power, both legacies of the previous wave, which created favorable circumstances for the development of new products and services. The digitization will bring transformative possibilities in the field of virtual reality, which will be present in many common everyday situations. New business models will increase the flow of communication and interconnection between different groups and will provide the development of new forms of collaboration, business and social ecosystems. Robots will be able to do trivial things done by humans, from picking flowers to producing art. Information and communication technologies will continue to dramatically reduce transaction costs (KURK, 2012). The set of transformations driven by the application of new technologies have also been called the "Fourth Industrial Revolution" (WEF, 2017) or "Industry 4.0". From the technological point of view, it is not possible to explain the complexity of the current phenomenon considering only those technologies directly involved with the industry and its effects. In fact, no segmentation from economic sectors can broadly represent the technological, economic, and social phenomenon that is unfolding. The technologies themselves are being applied indiscriminately in all sectors of the economy, combining, reaching and transforming factories, banks, farms, builders, schools and governments. The terminology "Industry 4.0" seems more appropriate to identify the transformation that is occurring in the factories and in the industrial sector specifically, symbolized by the application of cyberphysical systems (KAGERMANN et al., 2013, MGI, 2015), which have the function of connecting the digital world with the physical world because they are mechanisms that associate information and communication technology with sensors, controllers, robots, etc. There is no doubt that, from a technical point of view, they are a very important part of the constitution and viability of Industry 4.0, and from a sociological point of view their function is discrete, since it is only a technological device among so many innovations and disruptive models. In the Sixth Wave, the new technological arrangement opens the expected possibility of economic expansion, but it exacerbates one of the fundamental aspects of capitalism: productivity will certainly make a leap from the integration of technological potentialities. This productivity gain will be obtained from the simultaneous action on the two components that define it. Productivity, as a concept, is the relation between value produced and value consumed for a given production. Taking intelligent factories as example: on the one hand, they are able to produce in large volumes and at greater speed by using a higher level of integration between systems, intelligent machines and artificial intelligence. On the other hand, the same systems, machines and new technologies will generate a huge reduction in the need for human labor (KAGERMANN et al., 2013). High productivity gains will increase the financial profits of many companies and investors, to the detriment of others that for some reason do not have access to new technologies, affecting competition and the economic logic of price regulation. If there are no changes in the tax system and in the policies of income distribution, there will be a deepening of the historical phenomenon of concentration of wealth and social inequality, especially with impacts on employment and labor. The history of job recovery, in the growth and prosperity phases of economic cycles, still fuels the hope of new jobs, in the logic of creative destruction (Schumpeter, 1961); however, such phenomena should not function as in previous cycles. One of the reasons is demographic: previous technological revolutions occurred at times of strong population growth, that is, the demand curve had a positive growth both by the increase of populations and by the insertion of gigantic parcels of people in the consumer market. Other differences should also be considered, such as the expressive amount of new technologies emerging in the same time window, combining, converging and generating other innovations at an exponential speed that cannot be followed by traditional institutions such as governments and universities and the potential impact in the the human labor market that some of the new technologies bring.

2. SCIENCE, EMPLOYMENT AND WORK

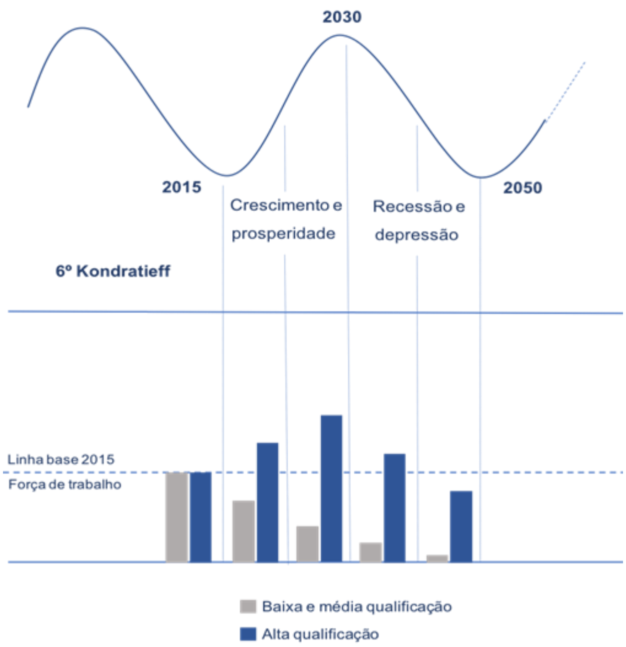
In the twentieth century, mechanization affected manual and repetitive labor, triggering a cycle of substitution of human labor in factories around the world. On the other hand, it collaborated for economic development and opened space for the growth of the services sector, which expanded to the point where it currently represents the largest share of the gross domestic product of the main developed and developing nations (BLS, 2017, IBGE, 2018; DW, 2018). The service sector, in this way, has become the largest generator of jobs and income for the populations of these countries. However, even intellectual services, such as those performed by engineers, teachers and researchers, tend to be affected by new emerging technologies, especially with regard to replacing human work with systems and software (OSBORNE and FREY, 2013). According to World Trade Organization studies, 80% of job losses in advanced economies are linked to technological innovation. This phenomenon tends to be even stronger in developing countries, causing structural unemployment crises (WORLD TRADE ORGANIZATION, 2017). Employment lost during short-term economic crises is partly reestablished in later periods of economic growth. It is clear that this reestablishment, even if partial, occurs in an uncontrolled and random manner: there is no guarantee that a resumption of growth will reverse a certain unemployment rate that was generated on a region, country or individuals. This job, because of the mobility of capital and labor, can migrate from country or continent, in search of greater efficiency and advantage. Structural unemployment, so called by its characteristic of irreversibility, is the result of productivity gains obtained by companies from the application of technology in their processes, whether those generating physical goods or services. The influence of technology on productivity and the consequent substitution of employment has been accelerating with the evolution of digital technologies. Digital innovation changes more radically the way the economic pie is distributed and accentuates the concentration of wealth, while destroying jobs for middle-class workers. New jobs generated in this context require more sophisticated skills that are not accessible to most workers (BRYNJOLFSSON; MCAFEE, 2011; OSBORNE; FREY, 2013). Developing competencies through training strategies does not guarantee the insertion of the worker in the labor market, either because of the shortage of labor, or because the training programs often fail to sufficiently develop the necessary skills, generating an "apparent" training. The advancement of digital technology over these functions can repeat the effect that automation, mechanization and robotization have generated on industrial jobs. Despite fears about these possibilities, what is certain is that artificial intelligence and other technologies such as synthetic biology, computer science, nanotechnology, quantum computing, additive manufacturing, autonomous vehicles and robotics will have fundamental impacts on the structure of work, on the economy and society in the coming decades. One of the critical points in the discussion about the expansion of the use of the new technologies in their diverse applications by individuals and organizations is the urgency of a deep restructuring of the policies, structures and mechanisms of social protection, of stimulating the generation of work and income and the systems educational, to support the transformations that are already taking place and that in a few years will reach new heights of complexity and power. Such restructuring also depends on an exceptional collaborative effort and enormous capacity for political articulation to involve countless actors, in many cases with distinct and contradictory interests. Even countries structurally well-prepared and organized to cope with this transformation depend on a combination of complex factors to succeed. If socioeconomic systems do not fit into a scenario of technological acceleration, integration and digitized globalization, then much of the global mass of workers may be unemployed by 2050 (GLENN, FLORESCU, 2015). The possibilities of generating new jobs from new functions and professions that emerge must be viewed with caution, since they can demand levels of impediment of competences for workers from functions of low complexity. What's more, they tend to be in insufficient numbers to accommodate the mass of affected workers. Consultant McKinsey estimates that the career transition needs will be enormous - considering where it is feasible - and will involve at least 375 million workers who will need to develop new skills - in case of success in the rapid adoption of the digitization by the countries. If the transition is slow, unemployment will increase and still cause depreciation of wage values (MGI, 2017). The emergence of new businesses will also occur, but with higher levels of productivity and less need for human labor (RANDER, 2016). The new business models will demand a lesser relation between the necessary labor and their productive capacity, whether of manufactured goods or services. The growth of companies that become automated will also occur in a lower standard of job creation. Personnel costs are usually significant for most companies; thus, the technology will be used to reduce personnel, with the objective of increasing operating margins and financial results. According to Osborne and Frey (2013), 47% of jobs fall into the high risk category, ie jobs that can be automated in a relatively short period of time over the next decade or two decades, including jobs in numerous service sector activities, whether of an administrative or knowledge nature. In Germany, the services sector accounts for about 70% of GDP and in Brazil for about 75%, where it also accounts for most jobs. In Germany it comprises 72% of jobs and in the United States 80.1% (BLS, 2017, IBGE, 2018, DW, 2018). The adoption of process automation robots, electronic document recognition technologies and artificial intelligence opens up many optimization possibilities (VOGLER-LUDWIG; DÜLL; KRIECHEL, 2016). Various occupations of the service sector will be impacted, involving transportation and logistics activities, office workers and administrative support, as analysts. Also factory workers will be affected (OSBORNE; FREY, 2013) and the digitization will significantly affect the public service. Reduction forecasts are already consolidated in some countries, such as Germany and the United States, where a reduction of 15% of occupations is expected in federal public services only until 2024 (BLS, 2017). The automation of knowledge work is being done from a new approach, which involves not only the question of information but also all the theory and modes of reasoning necessary to perform a task or task. Emerging solutions deal with large-scale knowledge bases, complex forms of situation assessment, sophisticated modes of reasoning based on values, and autonomous system behaviors. Some law firms, for example, are already using computers that can examine thousands of clarifications and legal precedents to aid in the preliminary research work that may involve hundreds or thousands of hours of work. Symantec's Clearwell system uses language analysis to identify general concepts in documents and present the results graphically and is able to analyze and classify more than 570,000 documents in two days. In financial services, artificial intelligence has played an important role in the analysis and financial transaction processes for some time. Banks are using machine learning to detect scams and identify situations like charges or claims outside the normal behavior of a person buying. Even services like Future Advisor use artificial intelligence to offer customized financial advice in a cost-effective and scalable way. It is estimated that by 2025, productivity gains of 45-55% can be achieved for 25 million knowledge workers in this sector, which would lead to the economic impact of $ 600- $ 800 billion per year (MGI 2013). Even in the field of programming services, the use of artificial intelligence applied to self-repair codes reduces the need for human programmers. Voice-enabled systems and ever-increasing personalization are expected to drastically reduce the demand for Call Centers to which India has become famous. About 69% of jobs in India are at risk of displacement due to artificial intelligence and automation. In India's top five IT service companies, job growth is down by as much as 40 percent, and the country faces huge challenges from the ongoing technology revolution: if nothing is done, about 69 percent of jobs will be lost for automation (SINGH, 2017). The negative effects on employment also arise for medical health professionals, especially nursing and laboratory professions (VOGLER-LUDWIG; DÜLL; KRIECHEL, 2016). The automation of knowledge work can have important effects on health care services. Oncologists at Memorial Sloan-Kettering Cancer Center in New York are using IBM's Watson Artificial Intelligence system to provide diagnoses of chronic treatment and cancer treatment by accessing the knowledge of 600,000 reports of medical evidence, two million pages of scientific literature from 42 medical journals and 1.5 million patient registries and clinical trials in the field of oncology, plus clinical and genetic data for each patient. With this, the AI system compares individual patient symptoms, vital signs, family history, medications used, genetic structure, diet and exercise routine to diagnose and recommend a treatment that is most likely to be successful. Wellpoint has adopted this technology to support decision-making and accelerate the process of approving medical applications, which took days before and are now completed in a matter of seconds. This was only possible because the system was trained with 25,000 historical cases, to which techniques of hypothesis generation and evidence-based learning are applied, to generate recommendations that aid in decision making. Cognitive computing in health can also help reduce costs and increase the efficiency of organizations by crossing data that allows for more efficient management (IBM, 2017). The benefits that such technologies can bring are undeniable, however, their side effect on jobs needs to be considered.

The retail sector is one of the great generators of employment, both because of its size in the world economy and because of its labor-intensive character. In the United States, it is the 4th largest generator of jobs, accounting for about 15 million eight hundred and twenty thousand jobs in 2016. Retail has a complex cost structure, based on two main factors: cost of goods sold and cost of the hand of work. The challenges and investments needed to improve the customer experience will entail automating tasks and processes that have remained unchanged for decades. By applying technologies such as AI and robotics, retailers want to use intelligent process automation to identify, optimize, and automate intensive, repetitive activities. Many retailers are already applying the automatic checkout process in their stores (GARTNER, 2017a) and others are experimenting with robotic solutions with virtual assistants for customer service. The retail sector in the US has already presented a reduction of 3% in its annual jobs as a result of the digitization. (VOGLER-LUDWIG; DÜLL; KRIECHEL, 2016). It is estimated that by 2020 the top 10 retailers will apply advanced algorithms that will cut up to one-third of merchandising teams and digital chat and answering applications that will process 50% of customer service requests, impacting on the need for professionals for these activities (GARTNER, 2017b). Another aspect that deserves attention when assessing the phenomenon of the threat of structural unemployment in the services sector is that this sector - historically - has absorbed a large part of the labor force that has been eliminated from the agricultural and industrial sectors, due to its own automation and increased efficiency. Because it encompasses a variety of activities that require low qualification, the services sector has generated job and income opportunities for industry and rural unemployeds (OSBORNE, FREY, 2013). The possibilities of migration of workers from the industrial and agricultural sectors to sectors of greater aggregate knowledge do not seem so possible with the new technological revolution.

3. ESSAY ON THE SIXTH WAVE OF INNOVATION AND WORK

Schumpeter (1961) dealt with the concept of creative destruction, highlighting the disruptive and revolutionary character that characterizes the interference of technological revolutions in the economic structure: from within, intensely destroying the old and creating the conditions for the new. As technological innovations have emerged, from time to time, the investment of entrepreneurs in entrepreneurial actions have caused waves of economic growth. The sixth wave, or the sixth Kondratieff, is beginning, and like any great wave of technological innovation, it will last approximately until the profits of the new innovation fall to the level of other older and more traditional sectors, reaching its limits in terms of stimulus economic. In addition to entrepreneurs investments, the new wave is also receiving stimulus from governments, which have been making huge investments to support initiatives that prepare the infrastructure of their industries and economies for the oncoming digital transformation, as has been happening in the US with the creation of advanced manufacturing institutes - Manufacturing USA - and in Germany, with the Industries 4.0 program (HOLDREN; LANDER, 2011; VOGLER-LUDWIG; DÜLL; KRIECHEL, 2016; BMAS, 2017). Typically, waves of innovation are composed of four phases. The first phase is growth, when investments are boosted and innovations begin to impact on the economy and the labor market. The second phase is prosperity, when the degree of utilization of the innovations brings marked gains in productivity and causes wealth growth. The third and fourth phases are movements of economic decay: recession and depression (Schumpeter, 1961). The behavior of the labor market and employment used to follow this cycle, progressing in the phases of growth and prosperity and falling in the phases of recession and depression. However, the new wave suggests a behavior different from the previous ones. In the initial stages the employment will grow, but only the one based on higher qualification and for certain occupations. The employment of medium and low qualification, for the most part, may already decline in the first phase. Even high-skilled jobs tend to regress after the apex - which is characterized by the depletion of the effects of the high levels of investment that have driven the economy and the full adoption of innovations by companies. From the available studies and forecasts (SHIMULA, 2009; HOLDREN, LANDER, 2011; BLS 2017; BMAS, 2017) we can suggest a temporal configuration for the sixth wave of innovation and a trend in terms of the evolution of the workforce. Figure 26 represents this assay and suggests a setup for the sixth innovation wave.

Figure 2: The 6th wave of innovation and the evolution of the workforce.



Source: Prepared by the author. Dates are just references. The charts suggest trends.

CONCLUSION

New technologies will enable significant advances in various areas and aspects of human society, such as health and longevity, energy efficiency, reduction of environmental impacts and risks, food production, mobility in major cities, reduction of traffic accident rates and loss of life, new learning systems. There will be economic prosperity within the logic of the process of creative destruction, with products and businesses being replaced by others. The impacts that new technologies can generate on the 21st century workforce are of an order of magnitude similar to the great changes brought about by earlier waves of innovation. The changes that have taken place have not resulted in long-term mass unemployment because they have been accompanied by the creation of new types of work. However, we can not say with any certainty that this historical relationship between economic growth and employment and job creation will be maintained. The sixth wave of technological innovation has determinant characteristics that differentiate it structurally from previous ones. The speed with which transformation is occurring, the accelerated scalability of new technologies, the number of disruptive technologies emerging or maturing simultaneously, the massive potential for replacing human labor, the relevant impact that will occur in service sector jobs, and the different demand for qualification for workers - which favors some occupations as it excludes others - are some of the differences from the past that will dramatically affect the structure and the labor market. Imagining the future perspectives of work without considering these differences would be a misnomer. There will be an imbalance in the generation of jobs in terms of the functions of higher and lower qualification, being the second category impacted from the beginning of the process, in the phases of growth and prosperity of the new wave of technological innovation. After 2030, approximately, the decline of part of the most qualified workforce necessary for the operation of companies and organizations will also begin. The second phase of the sixth wave of innovation, with its typical stages of recession and depression, may be particularly critical for combining the degradation of economic conditions and the reduction of jobs in a society whose transformation to a new model of income generation and way of life has not yet is fully consolidated, given the speed with which all change must occur. The wealth that will be generated by economic growth in the prosperity stage of the sixth wave can be captured in a concentrated way by a few countries, corporations and individuals, accentuating inequality conditions.

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