The Challenges of the Industry 4.0

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***Abstract**: After the crisis EU has launched an ambitious reindustrialization policy to regain its competitive position and to stimulate its economic growth. Last year at the Davos Summit Klaus Schwab - WEF founder and executive president - promoted the concept and debates related to the fourth industrial revolution which involves rapid changes, many domains, great shifts and huge risks and will have a powerful economic and social impact.*

***Keywords**: industrial revolution, revolutionary technologies, deindustrialization, social impact, unemployment, education*

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1. Introduction

Klaus Schwab, WEF founder and executive president, has launched the concept of the fourth industrial revolution (Industry 4.0) which was much debated in Davos last year, and afterwards, with the contribution of many participants from business sector and civil society. For Klaus Schwab the first industrial revolution which started in 1784 was based on steam, water and mechanical production equipment, the second which started in 1870 on division of labour, electricity and mass production, the third which started in 1969 on electronics, IT, automated production and the fourth which is starting now is based on cyber-physical systems. *The current revolution has a high speed and is evolving at an exponential rather than a linear pace, is disrupting almost every industry in every country and is deeply transforming the systems of production, management, and governance.* Due to the artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing people may be connected and may interact very easy, while digital fabrication technologies are interacting with the biological world.

The Fourth Industrial Revolution may raise global income levels and improve the quality of life for many people worldwide. On demand side consumers will have access to the digital world and will benefit from new products and services with a higher economic efficiency provided by the new revolutionary technologies. On supply side long-term gains in efficiency and productivity are foreseen due to the drop of the costs of transportation, communication and trade and also due to more effective logistics and global supply chains, all providing an easier access to world markets.

But what are the potential risks and the social impact of the fourth industrial revolution? Authors like Erik Brynjolfsson and Andrew McAfee who published two interesting books on this matter, *Race Against the Machine* and *The Second Machine Age* were not the first to support the idea that new technologies may lead to higher unemployment also rising social inequality. John Maynard Keynes, the father of macroeconomics, used the term "technological unemployment" in the 1930s predicting that the displacement of workers by machines will lead to shorter workweeks and increased leisure. Some economists thought that globalization and technology progress could lead to the creation of "superstar" or "winner take all" labour markets. One cannot deny the strong impact of these revolutionary technologies on labour market and Klaus Schwab is right when he underlines *that automation substitutes labour across the entire economy on a large scale and the net displacement of workers by machines might exacerbate the gap between returns to capital and returns to labor.* Three essential aspects must be taken into account: the first is the need for a rapid reorientation of education systems from industrial skills to service needs, the second is related to the opportunities created by the new technologies for education and training while the third is related to the fact that talent, more than capital may represent the decisive factor of production thus on the job market low skills will be less paid while high skills will be much better paid, and this segregation may lead to an increase in social tensions.

The providers of intellectual and financial capital—the innovators, shareholders, and investors- are now in a much better position than the providers of labour force and that is why technological progress, deindustrialization and tax systems are the main culprits for the income stagnation in high-income countries where the demand for highly skilled workers has increased while the demand for workers with less education and lower skills has decreased. It is obvious the undermining of the middle class created by industrial revolution around the world which may lead to a serious weakening of the traditional democratic system.

Klaus Schwab sees four main effects of the Fourth Industrial Revolution based on combinations of technologies on business—on customer expectations, on product enhancement, on collaborative innovation and on organizational forms. While citizens are able to interact much more with their governments, the last ones will get new technological powers to increase their control over populations which means a setback for democracy. For more than two decades governments are under pressure from other actors involved in the governance process seeking to change and improve public policies. At the same time they are trying to improve policymaking and to diminish their central role, also redistributing and decentralizing their powers based on new technologies and on integration and globalization requirements. Due to rapid technological changes and their impacts brought by the Fourth Industrial Revolution legislators and regulators were facing great challenges but they were unable to cope with them successfully. Klaus Schwab points to the need of public *agile governance* after the example of private sector that was able to give quick and good responses to technological development and business evolution. For an adequate adaptation to the fast-changing environment governments and regulatory agencies must collaborate closely with business and civil society.

The Fourth Industrial Revolution will have a certain impact on the nature of national and international security, affecting both the probability, scale and nature of potential conflicts while recent advances in communication technologies have already created a great potential for terrorist activities but also for reducing the scale or impact of violence, through the development of greater precision in targeting.

The new technologies of the fourth industrial revolution may deeply affect people's life and profoundly change the economic, social, cultural, and human environments. Mankind is already facing a lot of crises and while traditional beliefs and values are strongly challenged the best parts of human nature—creativity, empathy, solidarity- must be preserved and protected in the face of the dehumanized forms brought by globalization and technological progress.

2. General Considerations on Industrial Revolutions

Many authors and studies have analysed the multiple aspects of industrial revolution, which started in the second part of eighteenth century with the invention of the steam engine, but there were the first two phases or revolutions between 1800 and 1950 that allowed the transition from a farming and feudal society to an industrial and capitalist one. But only after the second World War a truly democratic and prosperous capitalist society or so called welfare state was built in the Western World based on a rapid industrial expansion and on the creation of the middle class. After 1980 we may speak about a transition era to the post-industrial or services society, where labour force is released from physical activity and is focused more on creativity and innovation. But this last process was accompanied by a deindustrialization process in the most developed countries followed by the erosion of the middle class and by a rapid industrialization process in Eastern Asia where a large part of labour intensive industries were transferred. In the table no.1 we tried to present the four phases or cycles of industrial revolution that were defined by specific literature as the first, second, third, fourth industrial revolution. All those industrial revolutions have certain characteristics related to the predominance of some energy resources, technical/technological achievements with major effects on the economy and on the public transport developed or improved in time.

Table no.1. Main characteristics of industrial revolutions

Period	Transition period	Energy resource	Main technical achievement	Main developed industries	Transport means
I.1760-1900	1860-1900	Coal	Steam engine	Textile, Steel	Train
II.1900-1960	1940-1960	Oil, Electricity	Internal combustion	Metallurgy, Auto, Machine	Train, Car

			engine	Building , Chemistry	
III.1960-2000	1980-2000	Nuclear Energy, Natural Gas	Computers, Robots	Auto, Petrochemicals, Pharma Industry	Car, Plane
IV.2000-	2000-2010	Green Energies	Internet, 3D Printer, Genetic Engineering	High Tech Industries	Electric Car, Ultra Fast Train

Source: Created by author based on specific literature

An author like Carlota Perez, professor of Technology and Development, Department of International Development, London School of Economics, has analysed the impact of technical changes and technological revolutions on society, business and the national and international economies and also the technological revolutions and techno-economic paradigm shifts and has identified 5 technological leaps, the last one, the fifth started in 1971 with microprocessor and we entered the information era. There are two phases for any leap, the first one is the **installation**-market entrance of technology and the second one is the **deployment** –penetration into economy. In the case of the fifth one there was created a stock bubble through massive investments between the two phases, followed by a collapse and a recession, and a period of transition. There were 2 bubbles, one in 2000 burst on Nasdaq of Dot.com and one in 2007/8, a financial one, both connected with innovations in high tech sectors and in financial derivatives. Now we are in the middle of the third bubble created by the governmental credit, or QE more precisely, targeting inflation level, these fund provided by central banks went more into financial assets than in the real economy. Perez thinks there is an overvaluation of stock assets that may bring severe corrections, we would be at a turning point in the deployment phase, the penetration of new innovations, as ICT and the financial innovations, into the world economy.

A well-known specialist in the field, Jeremy Rifkin, an adviser of the presidents of European Commission, published the book *The Third Industrial Revolution* in 2011 and he believes that the new phase or revolution is a true leap forward in the evolution of mankind, although it can also be seen as an extension of the second one. The third industrial revolution is conceived as a sustainable, post carbon economic era and has been endorsed by the European Union (by European Parliament in 2007) and by the United Nations and embraced by important world leaders. In Rifkin's vision the five pillars of the third industrial revolution are:

1) Passing from fossil fuels (carbon based) to renewable energies;
2) Conversion of the building stock of every continent into green micro-centrals to collect renewable energies onsite;
3) The use of hydrogen and other storage technologies in every building and entire infrastructure to store intermittent energy;
4) Using Internet technology to turn the electricity network on every continent into an Internet of Energy;
5) Moving to electric vehicles and fuel cells transport fleet, which may buy and sell green electricity on a smart and interactive grid at continental level.

Such an ambitious project could take place within some decades and it can be achieved only through a large international cooperation.

Banning Garrett, a well-known consultant and director of the Asia Program at the Atlantic Council of the United States and also director of the Strategic Foresight Initiative, working with the National Intelligence Council, analysed the features of the new industrial revolution that changes production mode, time and place of it, goods distribution; it is switching from mass production of standardized goods to specific products for personal needs; it drastically reduces the energy and raw materials consumption, also reducing the carbon footprint of production; but it affects social relations and people's relations to production. All these are possible thanks to recent strong development of information and communication technologies, artificial intelligence, 3D printing, genetic engineering, Internet of Things and synergy between technologies, machines and artificial intelligence. A striking dilemma is looming: there will be created more jobs and more prosperity, or it will increase the structural unemployment, the levels of income inequality and also social inequality?

It was the former prime minister of Great Britain David Cameron who advocated for Rifkin's ideas and implicitly for the new industrial revolution and emphasized the role played by the Internet of Things, a means

by which any ordinary object may send and receive data from other devices or from individuals through the Internet. IT companies such as Cisco, IBM, Siemens, are already involved in the creation of intelligent infrastructure for the Internet of Things

Other revolutionary technological changes involved by the Industry 4.0 are:

a. 3D Printer or Additive Manufacturing, a fully automated process, compared to subtractive manufacturing, by which there are made important savings of raw materials and energy and are produced a lot of articles such as shoes, jewellery, mobile phones, auto parts and aircraft parts, medical implants and batteries.
b. Advanced Materials, like carbon fibres, Kevlar fibres, special ceramics, plasmatic, metamaterials-composites, which provide superior performances at low costs.
c. KET's, like photonics, nanotechnology, micro and nano-electronics, biotechnology, genetic engineering, which represent high tech sector and allow the manufacture of special products with exceptional qualities.
d. Modular Car Production that allows the delivery of all models on the same production line.

Yves Smith (Susan Webber) with *Naked Capitalism* blog calls on the lessons offered by history and it is better to learn from them and not to repeat the big mistakes made by humanity. She identified five pillars for a stable society: Food, Security, Health, Prosperity and Knowledge. There is a transitional period between two industrial revolutions (one can see this in the table no.1) and at the end of each transition Prosperity pillar is threatened, due to the high levels of unemployment, which may lead to a world war and this was seen after the first two industrial revolutions. Prosperity pillar of human society is in danger now that humanity is facing a potential food crisis as a result of global warming, a lot of health and safety issues, a serious increase in unemployment and the fall of Prosperity pillar will probably lead to a new industrial revolution. But we cannot predict the World War III, despite opinions saying that the war against terrorism would be such a phenomenon. Nowadays human society is trying to avoid such a horrible conflict and promote a new industrial revolution in order to ensure the objective of a sustainable economic development based on the Knowledge pillar, but global problems largely remain unresolved and their adverse consequences will persist over time.

3. Davos Presentations in 2016

3.1. Judith Magyar from SAP Community Networks presented the forecasts for 2025 from Technology and Societal Impact Tipping Points Report (September 2015), that foresee a major role played by the Internet through hyper-connectivity and Internet of Things, leading to a new cycle of global economic activity focused on sustainable solutions that can lead to a reduced dependence on fossil fuels.

3.2. Gary Coleman from Deloitte Consulting envisages that from 4.9 billion objects connected through the Internet of Things in 2015 one may reach around 25 billion in 2020 and leading technologies will double their value, over $ 85 billion in 2019. Capital investments in the field of robotics and artificial intelligence have increased with more than 70% per year after 2011. In 2020 in the US only 30% of its 1.4 million computer specialists will be covered with indigenous college graduates, on the one hand we will see increased unemployment for low and medium skilled workers, on the other hand we may have a scarcity of highly qualified employees

3.3. Mary Barra, CEO General Motors, insisted on the remarkable technical achievements recorded in automotive industry where in the next 10 years technological progress will be more spectacular than in the last 50 years. Interconnected cars, electronically controlled and powered by multiple energy sources, equipped with cameras, radars and sophisticated sensors will allow an increased security on several levels. Connectivity technologies, like OnStar System of General Motors, introduced in 1996, is meant to respond quickly to customer requests. GM is a pioneer in the field of 4G wireless connectivity (2 million vehicles). V2V System (vehicle to vehicle communication) will reduce by 80% the number of road accidents in the US. V2I System or Connectivity (vehicle to infrastructure communication).Automated (driverless) vehicles that can drive themselves, like Super Cruise (Cadillac) will widely proliferate.

3.4. Xavier Mesnard, partener at A.T. Kearney, showed that robots, artificial intelligence, 3D printer and other revolutionary technologies are threatening the jobs. He gives the example of Jeremy Rifkin and Martin Ford who predicted that automation will remove jobs. In US the share of employment in manufacturing industry has decreased from 25% in 1970 to 10% in 2014. The Future of Jobs Report covers 15 countries with 2/3 of the workforce level at world level in 2020. Robots will remove 7 million jobs (mostly in administration and offices) and only 2 million new jobs will be created, direct payments through Apple Pay will eliminate the cashiers, online services like LegalZoom may eliminate lawyers and notaries. Mesnard also mentioned the opinion of Carl Benedikt Frey and Michael A. Osborne who estimated that 47% of jobs in the US are in

massive distress because of the introduction of computers. Quick robotics implementation also threatens skilled workers jobs.

Mesnard was among the few speakers with a theoretical approach who raised the question of a challenging transition of Schumpeterian type (theory of creative destruction), as unlike other industrial revolutions that have created jobs the fourth industrial revolution does not show the same perspective, but the certainty that the professions will change in a way difficult to understand and accept. Many specialists do not take into account the exponential nature of digital technologies. The ubiquitous connection between people and machines, and data in real time, defining the fourth industrial revolution, would be governed by Moore's Law (doubling of performance/cost ratio at every 12-18 months). Impacts of the fourth industrial revolution are not limited to the manufacturing sector but may include all jobs related to knowledge and services, thereby inducing a much bigger challenge for society. The major risk is to face mass unemployment in a not too distant future for certain categories of workers, combined with lack of skills in other categories - and thus with major political and social implications of these imbalances.

3.5. **Anders Borg** - a Swedish economist and politician- insisted on the technological changes in the spheres of digital, connectivity, robotics and big data that may have a disruptive impact on the labour market and implicitly on tax revenues, tax labour income, VAT, public pension funds. Due to the negative impact on income distribution and on low income groups one must pay more attention to the education and re-education in order to avoid a high gap between incomes and pensions of high skill workers and low skill ones, and also between possibilities for providing an adequate healthcare for the poor and for the rich, for the young and for the old persons. Borg sees some serious challenges for the price stability and inflation rate due to the high impact of digitization on retail sales and also as a result of an evident trend for higher quality of goods and services. Borg thinks that the fourth industrial revolution would significantly rise the labour productivity which recorded a low increase after the crisis due to the low resource utilization and productivity may increase as a result of more capital and knowledge injected in the economy as there is a strong correlation between resource level and its utilization and productivity level, but one should take into account the situation of all resources.

3.6. Lisa De Propris, professor of Regional Economic Development, University of Birmingham, had a contribution to the debates with the article: *How the fourth industrial revolution is powering the rise of smart manufactures* published in June. She refers to Kondratiev's cycles based on the waves of technological change which radically revolutionise the techno-economic nature of economies. The four industrial revolutions may be associated with new technological waves, and one could see that old technologies cannot boost the economy and must be replaced by new technologies able to put forth new processes, new products and new services. Each technological wave imposes new resources and new ways of using them, modifies the organisation of production and creates new production sectors and new business opportunities.

Starting with the mid-1980s techno-economic system has changed under the impact of the new technologies like Internet, nanotechnology, bioscience, electronics, photonics, advanced materials and renewable energies which ensured a smart manufacturing and a symbiosis between traditional manufacturing and services, new producing sectors or upgraded old ones. Narrow market niches for personalised and customised products are developed based on customers' co-innovation or co-producing with the manufacturers. Small scale businesses depend now on digital communications and micro-factories are spreading everywhere with the support of 3D printing which permits to innovators and inventors to become producers and to connect directly with local and global markets. Smart manufacturing may redesign product supply chains by strategically integrating the local and the global joints. More sustainability is provided by reusing of resources, wastes, components, bio and natural products (circular economy).

3.7. Jennifer McNelly, executive director in the Manufacturing Institute, in an article published in July, sees a direct relation between innovation, competitiveness, increased income, a better quality of life and the progress of manufacturing sector, which instead of dying slowly in Western economies could still be the engine for the economic growth and for increasing the living standards. McNelly shows that for every dollar in final sales of manufactured products there is $1.33 in output of other sectors, manufacturing sector being the largest multiplier of any other related producing sector, because it contributes to the creation of jobs and growth in other industries. Supporting the manufacturing sector and also the whole economy in the context of the fourth industrial revolution implies three crucial factors: a focus on skills, continued innovation and technology, and more public-private partnerships. Under the research made by MI it was found that four years ago there was a deficit of 10 million highly skilled manufacturing jobs worldwide which could not be covered. Manufacturers have to train or recruit highly skilled workers and to pay more than the market rates for their skill and talent-driven innovation. Manufacturers must promote new technologies and sustain innovation and investments.

Public-private partnership may bring education system closer to industry standards and needs, so the policy makers should devise and implement education and job training policies that will strengthen and improve the manufacturing workforce.

3.8. Nouriel Roubini, professor at NYU's Stern School of Business and a well-known economist, published an article in Project Syndicate *Where are the gains from the golden era of innovation?* Roubini is quite annoyed as he hasn't seen a radical increase of productivity under the impact of new technologies, on the contrary after 2008 productivity growth in US, EU and Japan was very slow. Roubini has identified breakthrough innovations in 6 areas: ET (energy technologies), BT (biotechnologies), IT (information technologies: Web 2.0/3.0, social media, new apps, the Internet of Things, big data, cloud computing, artificial intelligence, and virtual reality devices), MT (manufacturing technologies: robotics, automation, 3D printing, and personalized manufacturing), FT (financial technologies), DT (defence technologies as drones and others). Roubini tries to explain why all these technologies have not led to a marked increase of productivity. Firstly, he mentioned the opinion of some technological pessimists that the recent innovations are much under the great innovations of the First and Second Industrial Revolutions, opinion which is highly questionable. Secondly, as new information-intensive goods and services are hard to measure and their output is difficult to commensurate, the productivity growth is not easy to calculate. Thirdly, there is always a lag between innovation and productivity growth, the first Internet revolution impacted upon productivity of the whole economy after many years. Fourthly, one may blame aging population in USA, EU, Japan, Russia, China coupled with lower investments in physical capital for the low economic growth and productivity. Roubini offers maybe the best explanation: *persistent cyclical downturn or weak recovery may reduce potential growth because workers remained unemployed for too long, losing their skills and thus depreciating human capital and because technological innovation is embedded in new capital goods, low investments leading to permanently lower productivity growth.* We may add the impact of liquidity trap upon investments, due to reduced demand and due to the lack of trust on behalf of investors, consumers, markets. Roubini recognizes the difficulty of finding plausible explanations for the slow productivity growth and condemns recent populist tirades against free trade, globalization, migration, and market-oriented policies.

4. Conclusions

Eduardo Porter, a New York Times journalist, published an article with the title *The Mirage of a Return to Manufacturing Greatness.* Research and technological modernization, which have increased more the productivity and reduced the labour force, came into collision with the interests of the unions and professional bodies because productivity growth has far exceeded the growth in demand for processed products. The dramatic consequences in terms of unemployment led to silly political reactions: Donald Trump wants high tariffs on imports, Hillary Clinton wants limitations for investments of US corporations outside US, but no such measure will bring recovery in the US manufacturing sector, on the contrary, this may become less competitive. The share of the workforce in this sector fell almost 3 times since 1950. Agriculture + manufacturing sectors hold together around 12% of the workforce in USA.

Restraining the labour force and the share of manufacturing sector in GDP is an issue at global level. Japan's stagnation for over two decades is explained by the excessive dependence of this country on manufacturing sector and on exports to foreign markets. Deindustrialization has also been associated with the development of some services with well-paid labour force, like those of recreation, health, Internet. In US it has forced many workers to enter low paid jobs, such as those in retail and services poorly paid, but what will happen in India where income is only 1/25 of US and where industry has already come at its peak. Dani Rodrik, an expert in global economy at Harvard's Kennedy School, argues that developing countries, including China, are undergoing a premature deindustrialization, at low income levels and with a middle class still passing through a consolidation process.

Deindustrialization is a painful blow for the poor countries from Asia, Africa and Latin America. Manufacturing sector could quickly hire unskilled workers and export a large part of production, but many poor countries export only raw materials, with low added value, subject to high price fluctuations. They have neither developed manufacturing and financial services nor well paid Internet services, instead remained focused on domestic services, retail sales (crafts) and other services that cannot remove poverty persisting in these states. In Western World it took place the transition from agriculture to industry in the first half of the twentieth century. The current transition initiated in the 80s from manufacturing sector to services is more problematic. Low wages for workers coupled with large corporate profits for most services accentuated income inequality,

hence the nostalgia for industry, which has brought prosperity and endorsed the creation of the middle class, but whose rebirth seems quite impossible.

Reindustrialization must be thought in terms of qualitative not quantitative development but it cannot solve just it the job crisis. In EU reindustrialization is based on promoting KET's such as advanced materials, nanotechnology, micro and nano-electronics, biotechnology, photonics, advanced production systems, on the existence of complete industrial eco-systems based on strict and intelligence specialization, on clusters (supported also on the research and technological innovation centers, universities, business incubators), on the industrial parks and innovative hubs, on the Europeanization of value chains. In USA the focus is put on education, research and innovation, medical sector, green energy. In Japan are required significant changes in industrial structures (keiretsu) and in practices of corporate governance, SME's are excessively oriented within keiretsu structures, start-ups have a small role in business activities, competition is too high in some sectors, the government adopted after 2000 some laws and strategies to revitalize the industry.

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