Chapter

Fourth Industrial Revolution: Opportunities, Challenges, and Proposed Policies

Evanthia K. Zervoudi

Abstract

In this paper, key elements about the Fourth Industrial Revolution are set under examination. Concerns, challenges, and opportunities related to the Industry 4.0 are analyzed, and specific policies to deal with the challenges and take advantage from the opportunities are proposed. Other issues that are set under consideration in this paper are the rate at which the human labor is threatened by the technological achievements, the main factors that increase workers' exposure to the risk of automation, the jobs that are more at risk due to automation, and the basic factors that make political intervention necessary in order to deal with the unpredictable consequences of the technological progress such as the threat of a nuclear disaster and a possible income and social inequality gap widening. Finally, a special reference is done for the case of Greece.

Keywords: Fourth Industrial Revolution, industry 4.0, automation, technological progress, creative disaster, robots, artificial intelligence, STEM, true creativity, social intelligence

1. Introduction

In the last decades, the technological progress was remarkable. The fast and major technological changes offer the chance to improve human life, but they also create concerns about the future. One of the biggest fears related to the new technologies is that the robots and the artificial intelligence will replace the human factor in work leading to the "technological unemployment." This is not the first time that people face the technological progress as a threat for their jobs. In the nineteenth and twentieth centuries, when another major wave of technological progress took place, similar fears had arisen, but they had not been proven right; technological achievements of these centuries finally drove to the creation of new jobs that had fully compensated the consequences of the new job-saving technology adoption ("capitalization result").

However, in view of the Fourth Industrial Revolution that has already begun in Europe and in the United States, the fear that the automation and the digitization will drive to the "End of Work" [1] wakes up again. A great discussion about the possibility of human factor replacement by machines and robots and a probable "creative disaster" have been emerged in a series of studies. Frey and Osborne [2] in their study support that 47% of jobs in the United States may be at risk of automation in the near future (see **Figure 1**). Bowles [3] in his study concludes that the proportion of sensitive-in-automation jobs in Europe varies from 45–60%,

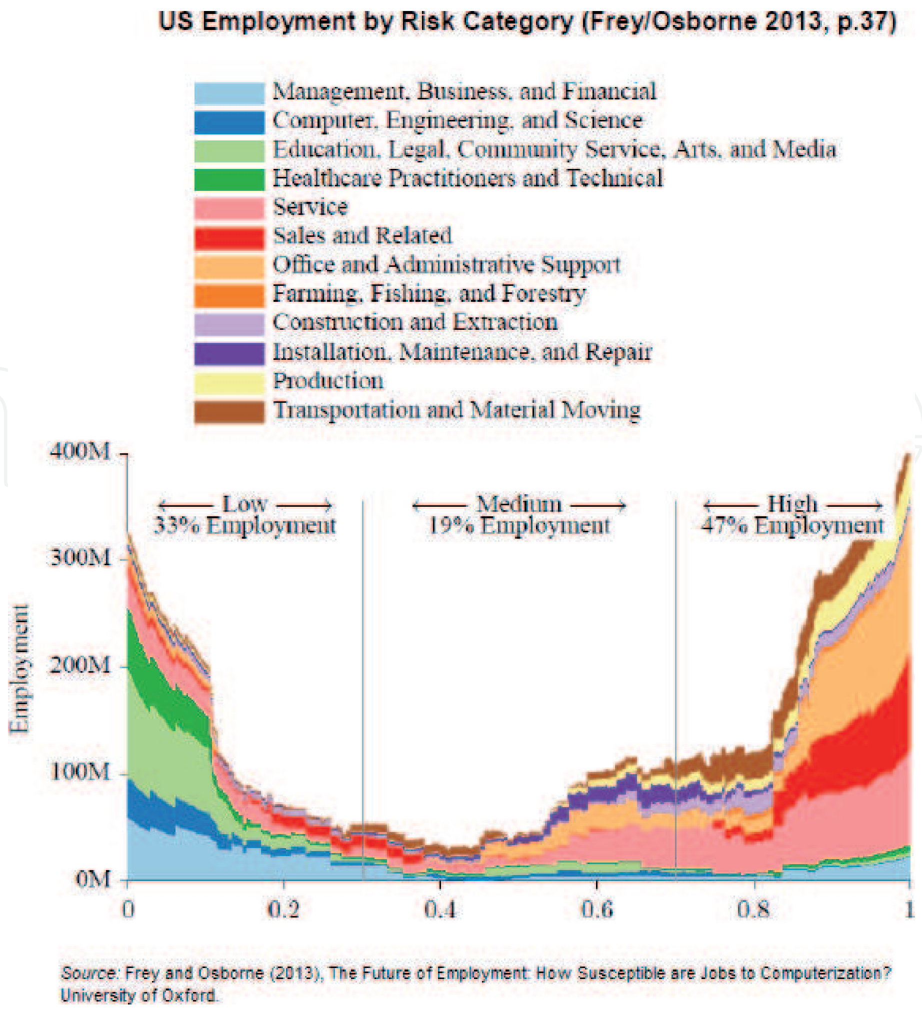


Figure 1.
Employment by risk category in US.

with Southern Europe being more exposed to a possible automation wave. The discussion about the consequences of the Industry 4.0 in World Economic Forum in Davos (2016) concluded that about 7 million jobs are at risk in the next 5 years with women being more affected.

There are various factors that could expose workers at the risk of automation. A low *work experience* is such a factor and mainly concerns young people who usually work as unskilled staff in routine positions that could be easily automated. *Low levels of education and training* is another crucial factor. Highly educated and highly specialized employees are less threatened by unemployment due to automation in contrast to low-skilled staff, whose tasks can be easily automated. The high percentages of people out of education, employment, or training (high NEET%) aggravates the situation since the difficulties of less-specialized workers to reenter into the labor market and get adapted to the new conditions will be great if they stay out of education, employment, or training for a long time. **Figure 2**[1] shows that there is a decreasing trend between educational level and the share of workers at high risk of automation; people with lower secondary education are the most exposed to the risk of automation, while highly educated employees with a Master's/PhD are the most protected against the risk of automation.

The *low degree of adaptation to automation* is maybe the most important among the risk factors of exposure to automation. Countries must acquire the mechanisms to help their citizens to be quickly and easily adapted to the new reality. In

[1] See [4].

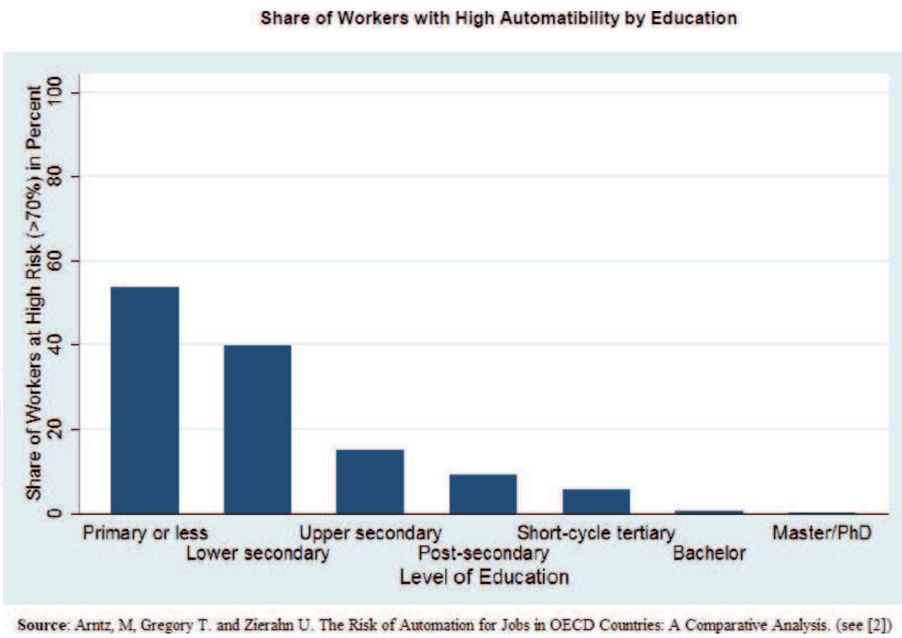


Figure 2.
Share of workers at high automation risk by education level.

technologically advanced countries such as Japan, South Korea, and Singapore, men are increasingly working with robots in order to be highly adapted to automation reducing in this way the unemployment risk in comparison with other countries where adaptation to automation is slower.

2. Professional sectors and jobs more exposed to automation

The Fourth Industrial Revolution does not seem to threaten the human work as a whole.[2] The heterogeneity of jobs even within the same professional sector is great. Employees are differently exposed to automation depending on the position they hold and on their tasks. *Routine jobs with a high volume of tasks* related to information exchange, sales, data management, manual work, product transfer and storage, constructions, and office work are more exposed to the risk of automation. *Construction and Manufacturing* and *Wholesale and Retail Trade* are the professional sectors that are expected to be highly automated until 2030, with an estimated automation of approximately 45 and 34%, respectively (for OECD[3] countries). On the other hand, the risk of automation is lower for *jobs with high educational requirements*, the tasks of which demand *high communicative and cognitive skills*. Such tasks cannot be defined in terms of codes and algorithms (Engineering Bottlenecks); they are more related to the perception, the ability to manage complex situations, multilevel activity and flexibility, and the *true creativity*, for example, any task that cannot be provided by a machine but requires critical thinking such as the ability to develop new theories, literature, or musical compositions. There are also tasks that require *social intelligence and comprehension* such as elderly care; for these tasks there is a strong social preference to be provided by human employees and not by robots. *Health and* education are the professional sectors with the lowest estimated rates of automation (around 8–9% for OECD countries). This is also clear in **Figure 3** according to which "Transportation and storage" and "Manufacturing" are the economic sectors that are more exposed to the risk of automation (up to 50%), while sectors such as "Human health and social

[2] See [5–7].

[3] Organization for Economic Co-operation and Development (OECD).

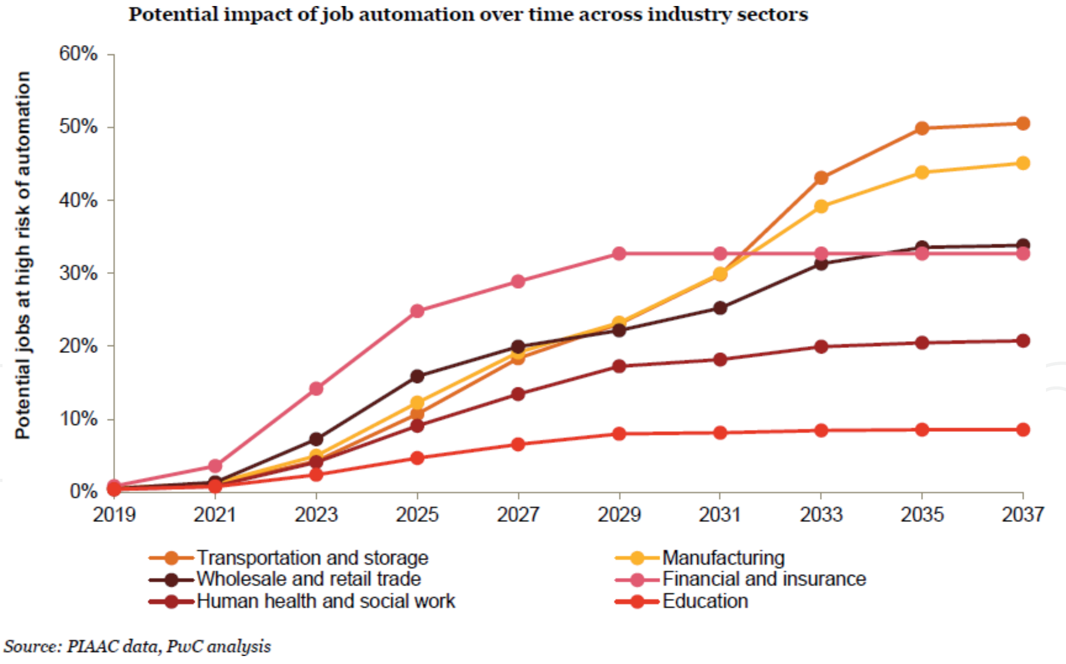


Figure 3.
Potential impact of job automation across industry sectors.

work" and "Education" are the most protected against the automation risk implying that there are tasks such as teaching and nursing that cannot be replaced by machines.

3. Challenges related to the Fourth Industrial Revolution and policies to deal with them

Major technological achievements may imply significant public policy issues. McKinsey [8] in its report underlines that the key for the successful adaption to the new technological conditions is the ability of governments to adopt the right policies. Governments that will not be able to follow the appropriate long-term policies will set their economies at risk, that is, when all the other economies will run with great speed, their inability to be adapted to the new reality will drive to the deterioration of their competitiveness, the reduction of their revenue, and the increase in their spending with the possibility of a bankruptcy to be increased. But it is not only the ability of governments to be adapted to the new conditions. There are also severe social problems that may get bigger due to the Fourth Industrial Revolution making policy intervention crucial. Political leaders must ensure that the technological progress will work for the benefit of the society and not against it. Some of the most significant challenges that may arise due to the Industry 4.0 and basic policies to deal with them are given below (see [4, 9, 10] among others). Given that the Industry 4.0 is directly related to socioeconomic growth, these policies must be in complete accordance to the Sustainable Development Goals (SGs) adopted by United Nations Member States in 2015.[4,5]

[4] https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

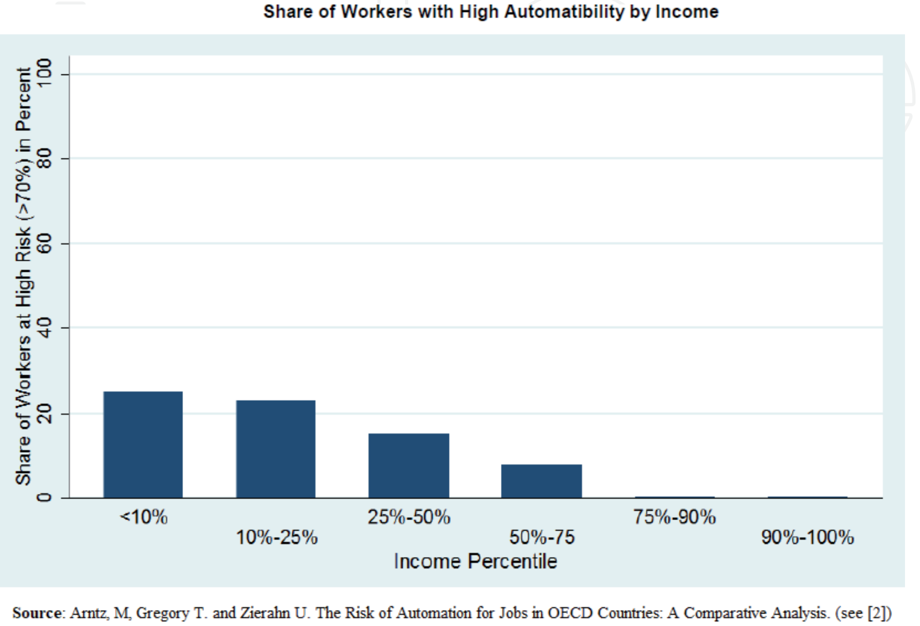
[5] **17 Sustainable Development Goals (SDGs):** No Poverty (SDG1), Zero Hunger (SDG2), Good Health and Well-being (SDG3), Quality Education (SDG4), Gender Equality (SDG5), Clean Water and Sanitation (SDG6), Affordable and Clean Energy (SDG7), Decent Work and Economic Growth (SDG8), Industry, Innovation and Infrastructure (SDG9), Reduced Inequality (SDG10), Sustainable Cities and Communities (SDG11), Responsible Consumption and Production (SDG12), Climate Action (SDG13), Life below Water (SDG14), Life on Land (SDG15), Peace and Justice Strong Institutions (SDG16), Partnerships to achieve the Goal (SDG17).

A major area on which governments should focus is that of work. The world of work becomes increasingly complex driving to loss of millions jobs. In the EU a significant decrease in the number of low and medium skilled jobs is already observed. The use of robots significantly reduces the labor cost and the likelihood of human error, while artificial intelligence begins to substitute the human factor even in jobs that require personal contact such as sales and customer service. The World Bank [10] estimates that the increase in automation will get at risk almost 57% of jobs in OECD countries, 47% of jobs in the United States, and 77% of jobs in China. Substantial differences concerning the impact of automation on jobs are also observed among countries, for example, the proportion of workers at high risk (due to automation) in Germany and in Austria is 12%, while in the technologically advanced Korea and Estonia is 6%. However, it is a common ascertainment that in all countries, the most educated and high-skilled workforce is able to be better adapted to the new technological requirements and enjoy higher real wages, while less educated and low-skilled workers are burdened by the cost of automation, being more exposed to income loss and unemployment.

Therefore, the basic policy that governments should follow in order to reduce the risk exposure of employees to automation is the investment in education and training for people of all ages so as to be able to be better adapted to new technologies and digitization. More specifically, a government should support (i) the practical training of professionals through job-related re-skilling and up-skilling programs so as to help people to get familiar with new technologies and become more competitive in labor market, (ii) the practical education and training of children and young people in new technologies so as to enter into the labor market having the appropriate skills and the necessary knowledge, (iii) the direct connection between education and labor market, (iv) the training in STEM (Science, Technology, Engineering, and Mathematics) subject areas and the active participation of young people in such programs as young people in South Korea, Japan, Singapore, India, and China do, (v) internships and practice for young people (up to 24 years old) in order to gain work experience during their studies, and (vi) adult learning and lifelong learning programs so as to help elder people to be smoothly adapted to new technologies and digitization. Another significant goal of governments must be the job creation. The investment in education and training can be effective only if the right jobs are available. The public investment in sectors such as infrastructure and housing could benefit the long-term productivity of the economy driving to the increase of demand and the job creation.

Another issue that may arise due to the Fourth Industrial Revolution is the income inequality gap widening. Nowadays, global income inequality is at very high levels with the richest 8% of the world's population to earn half of the world's total income and the remaining 92% of people the other half. The income inequality rises globally in a fast pace. Between 1990 and 2010, the income inequality in developing countries reached at 11%. The rapid technological progress and the introduction of new technologies in all sectors, in combination with factors such as the insufficiently regulated financial integration and the growing competition in product and service markets, may widen this income inequality gap. The most educated and highly qualified staff has the ability and the skills to be better adapted to automation, and thus they will be widely benefited by the technological achievements. Moreover, people whose income, skills, and wealth are already high will be further favored by the significant increase of their assets' value because of the technological progress. On the other hand, low-skilled workers will experience unemployment and constant downward pressure on their wages and their income. The workers that will be most affected by the Fourth Industrial Revolution will be those that may now feel invulnerable to competition with robots, that is, those whose jobs require moderate skills such as customer service that could be easily replaced by artificial intelligence. Many studies and reports underline that without the appropriate policies, the Fourth Industrial Revolution may contribute to the widening of the income inequality gap with unfavorable consequences for the society. **Figure 4** below depicts this decreasing trend between income percentile and the share of workers at high risk of automation; people with lower income percentile (less than 10%) are the most exposed to the risk of automation, while well-paid employees with income percentile more than 75% are the most protected against the risk of automation. The fact that the well-paid employees are usually highly educated people highlights once more the importance of the education as a shield against the risk of automation.

Studies that are referred to the relation between the Industry 4.0 and the income inequality are that of Acemoglu [11], Barro [12], Krueger [13], Krusell et al. [14], Hornstein et al. [15], Berman et al. [16], Card and DiNardo [17], Huber and Stephens [18], and Benioff [19], which argue that technological changes affect income distribution and deepen the gap between high and low-skilled workforce concluding that the income inequality gap expansion is due to the technological crises that can disproportionately increase the demand for capital and drive to a great job loss due to automation. Birdsall [20] in his study supports that the technological progress increases the "skill bonus" and replaces low-skill workers, deepening in this way the inequality. Papageorgiou et al. [21] conclude that variables such as technological development, access to education, sectorial employment rates, and national economic growth are deterministic for inequality in low- and high-income countries. In these variables, the International Labor Organization adds the technological change, the globalization, and the reduction of social welfare as key factors for widening income inequality. An alternative point of view is that of Goldin and Katz [22] according to which income inequality is mainly explained by changes in education rather than shifts in technology. In her study, A. Guscina [23] argues that during the period of pre-globalization (pre-IT period), technological progress enforced labor reducing the income inequality, while in the post-globalization period, technological progress enforced capital increasing in this way the inequality. According to the Deloitte Global report [24], the adoption of emerging technologies as artificial intelligence in countries such as India, South Africa, and China may drive to social turmoil and increase income inequality in the future. These countries



Source: Arntz, M, Gregory T. and Zierahn U. The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. (see [2])

Figure 4.
Share of workers at high automation risk by income level.

had significant economic and political changes that in some cases led to high growth, but at the same time unknown "social cracks" had been introduced creating greater sensitivity to future social and economic changes. Kuzmenko and Roienko [25] in their study support that the income inequality will rapidly grow (under the influence of the Fourth Industrial Revolution) not only in the emerging economies but also in the developed countries such as France, United Kingdom, and Spain. According to the report of the Swiss bank UBS [26], the Industry 4.0 will have less impact on developed economies such as Switzerland and Singapore, but in emerging markets and especially in countries of Latin America and India, the impact of the extended use of artificial intelligence and robots will be particularly unfavorable as it will reduce their competitive advantage of low-cost labor.

Another severe social problem that is possible to get bigger due to the Fourth Industrial Revolution is poverty that is growing rapidly. Today, 767 million people live below the poverty line (with $1.90 per day). The evolution of technology and the job loss may worsen this situation driving more people to the unemployment and the poverty. The problem may become deeper if one takes into account the massive urbanization that is observed internationally. By 2030, almost 60% of the world's population will be concentrated in urban areas. The rapid population growth and the non-sustainable urbanization may cause a great rising of poverty, conflicts, high waste of resources, and severe health and food security issues. In our days, one out of nine people worldwide (795 million) is malnourished.

Thus, a general conclusion is that the Fourth Industrial Revolution may contribute to the increase of poverty and hunger and to the widening of income and social inequality with rich and high-skilled people taking advantage from the technological progress and low-paid and less qualified employees suffering a greater reduction of their income. The widening of the income gap between rich and poor countries (but also within the countries) may also lead to an increase of illegal immigration which in turn may drive to serious cultural and political conflicts. Thus, the necessity of political intervention by authorities becomes crucial in order to reduce the inequalities and the negative social consequences.

Tax transformations could help in this direction. Governments may increase their tax revenue and social security contributions by workers whose earnings (income and wealth) will increase due to the Fourth Industrial Revolution such as the high-skilled people and apply a tax relief for workers whose income will be reduced. Tax revenue may be further increased by the reinforced productivity of the economy because of the use of new technologies. These increased tax revenue may finance investments in education, training, infrastructure and in stronger social security networks for those who have great difficulty to be adapted to new technologies such as elder people. Providing equal access to high-quality education and equal opportunities to people who do not have the financial ability for training and re-training, national authorities may drastically reduce the discriminations and the socioeconomic inequality. Other sensitive social policies are the extension of the existing social security benefits and the adoption of the universal basic income (UBI) in order to protect the income of people that are hit by unemployment. Finally, governments taking advantage from the opportunities that Industry 4.0 offers may also contribute to the reduction of the hunger worldwide by promoting the sustainable agricultural production and the "smart farming," organizing food quality improvement programs for all and especially for young people using digital technology and artificial intelligence and supporting innovative ways of recycling and food waste reduction.

The risk of a gender gap expansion is another social issue that requires authority attention. In the future, industrial workforce will be mainly male, with less than 10% of European programmers being women. According to the report of the

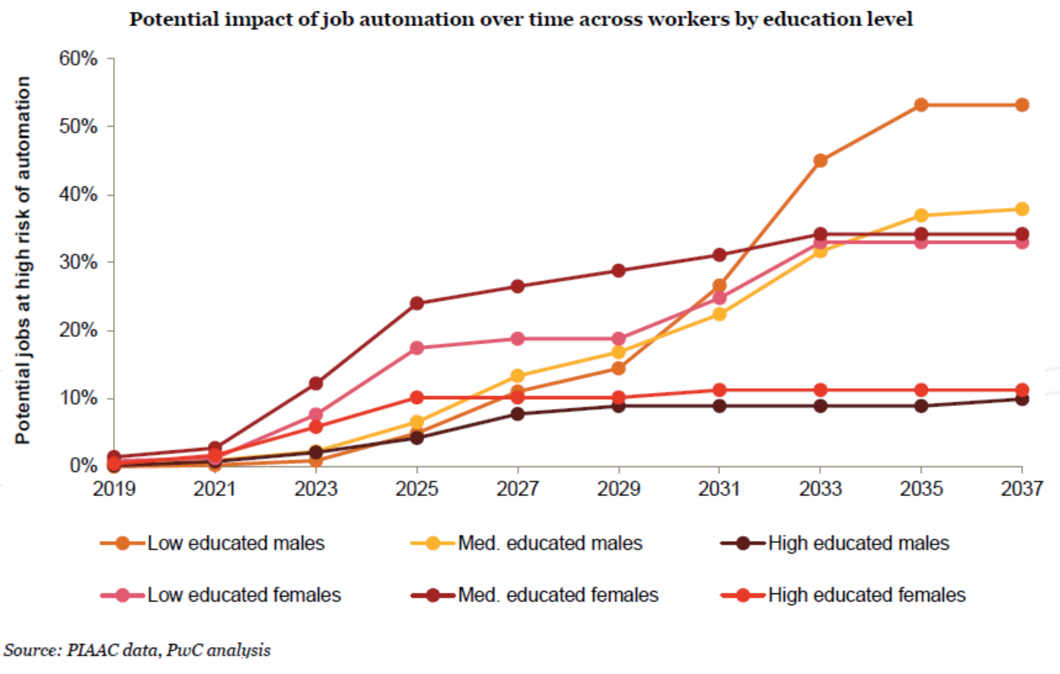


Figure 5.
Potential impact of job automation across workers by education level.

World Economic Forum, only 24% of the IT and communication sector workforce is female. McKinsey [8] in its report underlines that this fact constitutes a real business threat since companies with a higher percentage of women in managerial positions tend to perform better. Women's thinking encourages creativity and innovation and promotes the interaction between technology and society contributing to technological progress. Governments must work in the direction of addressing the gender gap by emphasizing to the female creative thinking and encouraging their active participation to the innovation processes through IT and STEM programs that will help them to become more competitive in labor market and will promote their social mobility. The protection of women's rights and the ensuring of equal opportunities for women in all countries, such as their unobstructed access to quality education, are prerequisites in order for the authorities to effectively deal with gender gap worldwide. **Figure 5**[6] captures the relation between both the educational level and the gender of employees with their exposure to the risk of automation. As it was previously highlighted, people with lower education are the most exposed to the risk of automation, while highly educated employees are the most protected ones. An interesting point in **Figure 5** is that as the automation replaces the manual work, low- and medium-educated men tend to be more exposed to automation than low- and medium-educated women, while highly educated women are constantly more exposed to automation than highly educated men but less exposed than people of low and medium education.

There are also severe legal reasons that oblige authorities to follow strict policies so as to reduce the negative consequences of Fourth Industrial Revolution for people. The transparency and the cyber security must be priorities for governments. The wide use of Internet and the increasing use of social media create the need for protection against internet bullying and personality insulting. Moreover, the great volume of personal data that is currently being collected by companies in return for providing zero-cost services obliges authorities to create strict laws and regulations that will prevent possible violations of citizens' personal data and their use in a malicious way and will protect individuals' personality. Concerning transparency,

[6] See [5, 7].

digital portals and accountability mechanisms for combating corruption may support governments' efforts and increase confidence in the governmental work. Another legal reason that requires governmental intervention is the use of new technologies for illegal activities, for example, the use of blockchain technologies for speculation purposes has been proven prone to failures and may drive to a great financial uncertainty. The use of models for secure and legal online payments and transactions and the use of new technologies for creating new, flexible, and secure service systems are crucial policies for ensuring the legality of online transactions and improving citizens' service in a safe and legal way.

The Fourth Industrial Revolution may also affect the nature of national and international security. Conflicts and wars in the new age will mainly become "hybrid" with the threat of a nuclear or chemical conflict being visible. The use of nuclear and chemical weapons in a conflict among countries requires special attention by national governments since it may cause mass destruction of populations and condemn next generations. States must proceed to strict agreements and apply the appropriate legislation in order to protect their people from the unpredictable consequences (and a probable irreversible damage) that a possible misuse of new technologies may cause on their lives and on ecosystems.

For all the above reasons, the need for cooperation among countries, at European and at international level, becomes crucial. Besides the security issues that demand the European and international collaboration in order to be addressed, such collaborations may also help countries to overcome financial and managerial difficulties that may arise at national level. The lack of interest for research and development projects by private sector (because of their great risk), the insufficient public and private funding for development projects with great social returns (because of the budget constraints), and the large funding gap in infrastructure with significant social and financial returns are important issues with which national governments may be called to deal. The coordination of national policies allows a more effective diffusion of knowledge and best practices and a more efficient use of digital innovations and country-specific business models. In this direction, governments could use new technologies to (i) promote organization and collaboration programs among businesses for information and practices' exchanging so as to increase their productivity, competitiveness, and exports, (ii) support the cooperation with European and International Institutions for funding research and development projects in all Member States, and (iii) promote the creation of forums and pan-European and international platforms so as to ensure that useful policy tools and best practices are identified, collected, exchanged, and disseminated to all countries.

Another major problem that may become more severe due to the Fourth Industrial Revolution is the climate change. Many studies have shown that the economic growth and the technological development contribute significantly to the climate change. The new species such as the drought-resistant vegetables and fruits and the new ecosystems that are created in order to deal with severe problems like hunger are up to a point helpful, but they may also affect humanity in an unpredictable and undesirable way. This fact in combination with the increasing extreme weather phenomena and the natural disasters that threaten human life (with the poorest areas to be more affected) obliges governments to take action in order to deal with climate change, sets limits in technological progress when this disturbs the environmental balance and threatens human life, and promotes the energy autonomy. In this direction, governments must use the new technologies as a tool in order to develop the appropriate policies, focusing on (i) programs and algorithms for prediction of extreme weather and climate phenomena, (ii) digital alert systems that improves the adaptability of countries to possible natural disasters, (iii) the adoption of new forms of affordable and "clean" energy such as the renewable sources of energy (wind, wave, solar) that may help countries to ensure their energy autonomy, (iv) sustainable industrialization and sustainable production infrastructure, (v) programs to promote the careful and sustainable use of terrestrial and marine ecosystems, (vi) the protection and sustainable use of forests, (vii) the protection and sustainable use of oceans and other water resources, (viii) the fight against desertification, and (ix) the protection of biodiversity.

4. The automation risk in Europe, the United States, and Asia

The estimated proportion of existing jobs at high risk of automation varies significantly by country.[7] Factors such as differences in labor market structure, education and skill levels, governmental policies on Industry 4.0, and differences in working way differentiate automation rates across countries. On the other hand, countries with similar economic structure and similar characteristics present similar potential rates of job automation (see [4, 7] among others). Four country groups that could be set under examination concerning their risk of automation are:

a. The **industrial economies**, that is, the economies where industrial production (that is easier to be automated), is still the dominant in total employment. Such economies are the **Eastern European economies** (Germany, Italy, etc.) that tend to have high shares of employment in industry sectors such as manufacturing and transport that will be easily automated until 2030s.

b. The **services-dominated economies** such as the **United States**, **United Kingdom**, and Netherlands, with relatively automatable jobs more concentrated in service sectors (that tend to be less automatable than industrial sectors) and low-skilled workers.

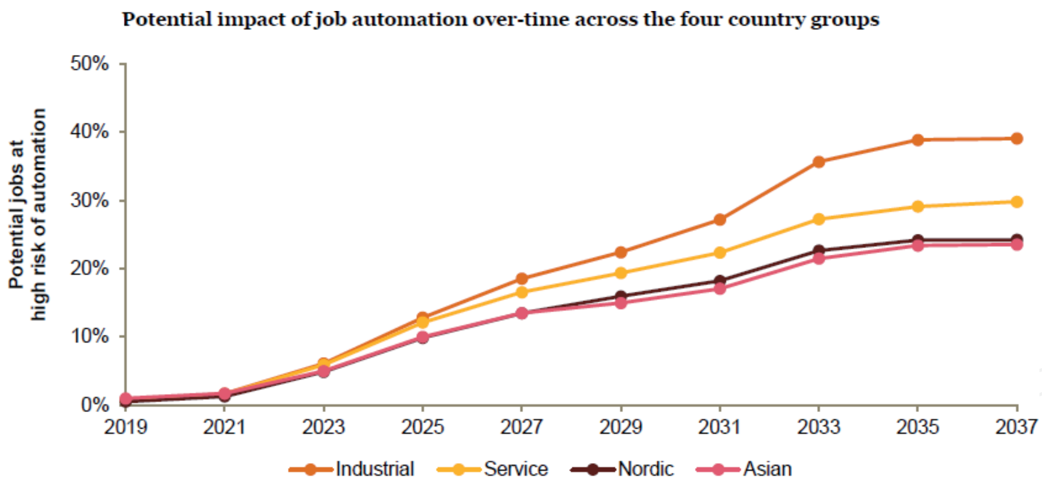
c. The **Nordic countries** such as Finland, Sweden, and Norway (in addition to New Zealand and Greece outside this region) with high employment rates, relatively less automatable jobs and high-skill workers.

d. The **Asian nations** (Japan, South Korea, Singapore, Russia, etc.) with high levels of technological advancement and education and relatively less automatable jobs but also with relatively high concentrations of employment in industrial sectors. *East Asian and Nordic economies* seem to be *less affected* by the automation (with an estimated range 20–25%), and *Eastern European economies* are *more affected* with higher potential automation rate range around to 40%, while *service-dominated countries such as the UK and US* present *intermediate levels* of potential automation. **Figures 6–8**[8] depict this potential impact of automatability across countries (individually) and across the four country groups and a range of estimates about the share of existing jobs that are at high risk of automation by the 2030s.

Eastern European countries such as Slovakia (44%) and Slovenia (42%) face relatively high potential automation rates, while Nordic countries such as Finland (22%) and Asian countries such as South Korea (22%) have relatively lower shares of existing jobs that are potentially automatable. It is important here to underline that existing jobs in some countries with low automation rates, such as *Japan and South Korea*, may face higher automation rates in the short term, given that

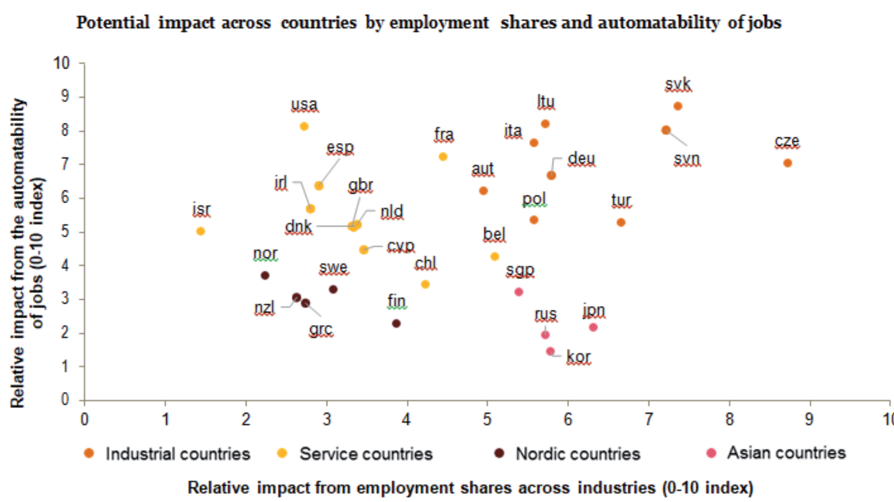
[7] See [4, 7].

[8] See [7].



Source: PIAAC data, PwC analysis

Figure 6.
Potential impact of job automation across the four country groups.



Source: PIAAC data, PwC analysis

Figure 7.
Potential impact across countries by employment shares and automatability of jobs.

algorithmic technologies are already widely used there, but in the long term (when the automation will displace manual jobs) will have lower automation rates than countries with lower average workers' skill levels and large manufacturing bases. On the other hand, countries such as Turkey may face a lower exposure in the short term but higher exposure to the later automation waves that will displace manual workers such drivers and construction workers.

Another interesting point in comparative analysis among these country groups (with an emphasis to the relation between **European and Asian countries**) is that European countries present strong negative correlations between the potential share of existing jobs at high risk of automation and the country education metrics such as government expenditure on education (as a % of GDP). This relationship is not so strong for Asian countries that present lower education spend. On the other hand, Asian countries achieve higher educational outcomes, especially in STEM subjects. Thus, the negative relationship between high education and low automatability holds for these countries as well, even with lower education spend. Furthermore, workforces in the more technologically advanced Asian countries such as Japan, South Korea, and Singapore have already adjusted to automation by *increasingly working with robots*, reducing in this way their future risk exposure

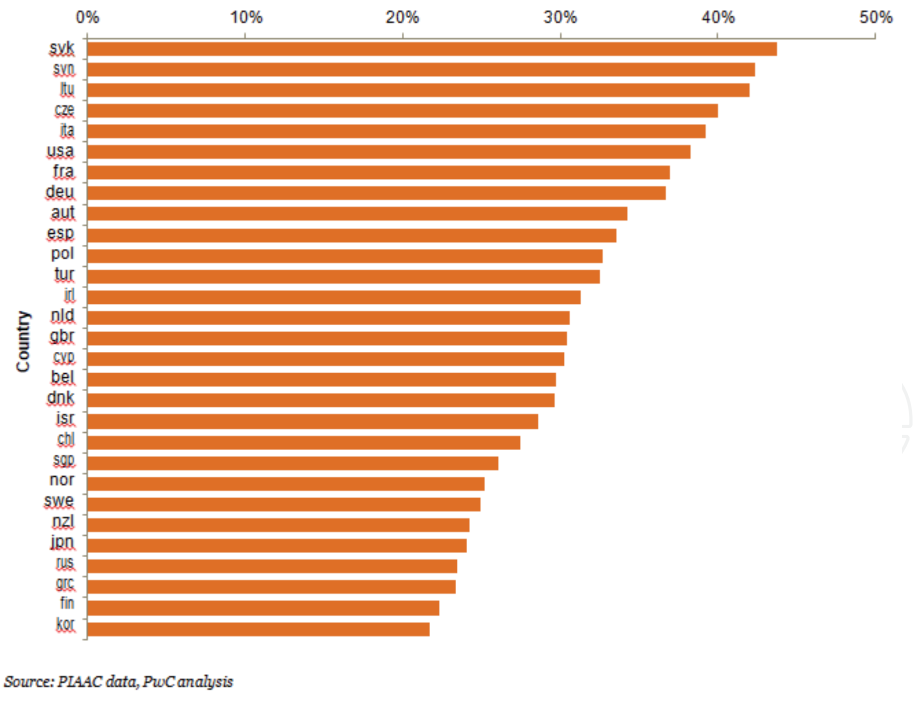


Figure 8.
Potential rates of job automation by country.

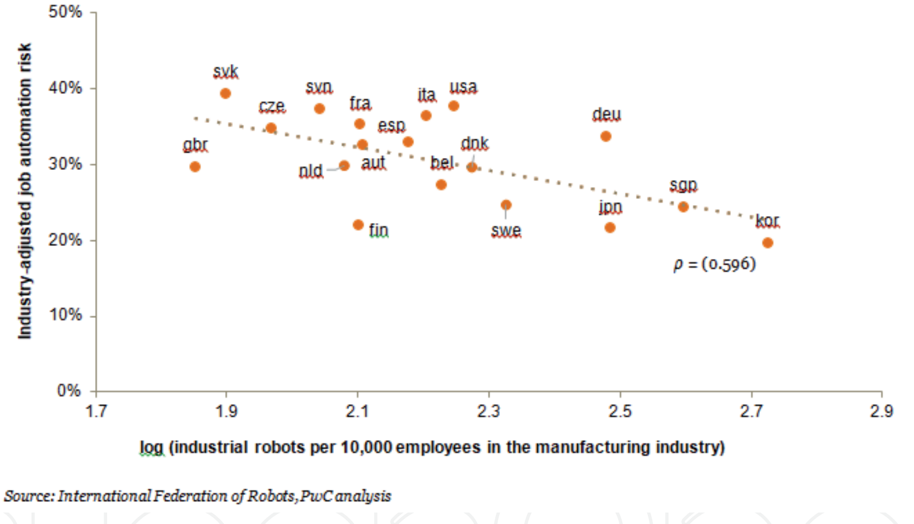


Figure 9.
Relationship between density of industrial robots and industry-adjusted job automation rates.

(they may also be benefited by automation in terms of higher productivity and real wages). **Figure 9**[9] shows this negative correlation between the potential jobs at high risk of automation and the density of industrial robots per country.

Concerning the United States, a great effort has been put to integrate into the manufacturing industry the latest developments in IT, Internet, and mechanical engineering so as to reduce the risk exposure of employees to automation and get benefit by the technological achievements of the Industry 4.0. However, as Brookings Institution [27] in its report underlines the Industry 4.0, and the wider notion of advanced industries has much in common with the advanced manufacturing sector in Europe, although it includes services (e.g., software) and energy as well that led the US economy (especially services); the United States is losing ground to other countries in advanced industry competitiveness since the

[9] See [7].

labor supply, the STEM occupations, the availability of skills, and the standards in comparison with other developed countries remain poor.

4.1 The Asian giant China

The leader among the Asian countries remains **China**. China's main ambition is to become a "strong" manufacturing nation within a decade, giving priority on *digitalization, modernization, and companies' maturity in Industry 4.0 terms*, including creativity, quality benefit, and integration of industrialization, information, and green development. Two main initiatives to achieve these goals are the *Internet Plus (IP)* and the *"Made in China"* (see [4] among others). *IP* is a plan aimed at upgrading traditional industries, searching for new technologies and spreading Internet applications into the public sector, increasing both quality and effectiveness of economic and social development. *Made in China 2025 plan* is strictly focused on five major projects among which new innovation centers, green and smart manufacturing, self-sufficiency in infrastructure, and indigenous R&D projects for high-value equipment, moving industrial companies up to the value chain. The main target of the *Made in China 2025 roadmap* is to develop a domestic innovation capacity that may be been seen as *China's equivalent to Industry 4.0*: "an effort to create a manufacturing revolution underpinned by smart technologies." Moreover, a study by Fraunhofer IAO[10] about *patents registered in China* in relation to the *Industry 4.0 technologies* shows that Chinese researchers have patented important inventions in the fields of wireless sensor networks, low-cost robots, and big data, concluding that *China will be leading the pack when it comes to production data in the future*. In terms of the number of patents filed for Industry 4.0 technologies, *China has far outperformed the United States and Germany* (which is considered as a pioneer among European countries). The energy-efficient technologies intended for reliable industrial networks to robotics are basic areas in which Chinese have registered key innovations.

But the most important field of innovation in which China is considered as a pioneer among Asian countries (and worldwide) is the field of **robotics**. The number of industrial robots, using by businesses to boost their productivity, increases rapidly. According to the International Federation of Robotics or IFR (2015), the worldwide stock of robots reached in 2014 (5 years ago!) at 1.5 million units. This pace of "robotization" grows very rapidly, while the cost of new robots continues to fall and their capabilities to go up. Moreover, with the robot density in most industries to be low, the IFR anticipates that the pace of yearly robot installations will continue to grow even faster in the following years. By 2018, global sales of industrial robots were growing on average by 15% per year, and the number of units sold was around 400,000 units (see **Figures 10** and **11**) [28]. "The automation witnessed by the automotive sector and the electrical/electronics industry comes out top here with a market share of 64 percent," said IFR President Arturo Baroncelli. "A new generation of robots is a strong echo of various demands — the 'Made in China 2025' plan, US re-industrialization, Japan's rejuvenation strategy and the EU's Industrial 4.0 all symbolize the new age of equipment's transformation and a changing production mode," said Dr. Daokui Qu, CEO of SIASUN Robot & Automation. The regional breakdown reveals that 70% of the global robot sales are going to five countries: China, Japan, the United States, South Korea, and Germany. *China remains the main driver of the growth overtime and the world's biggest industrial robots market*.

[10] https://www.fraunhofer.de/en/press/research-news/2014/march/security-tools.html.

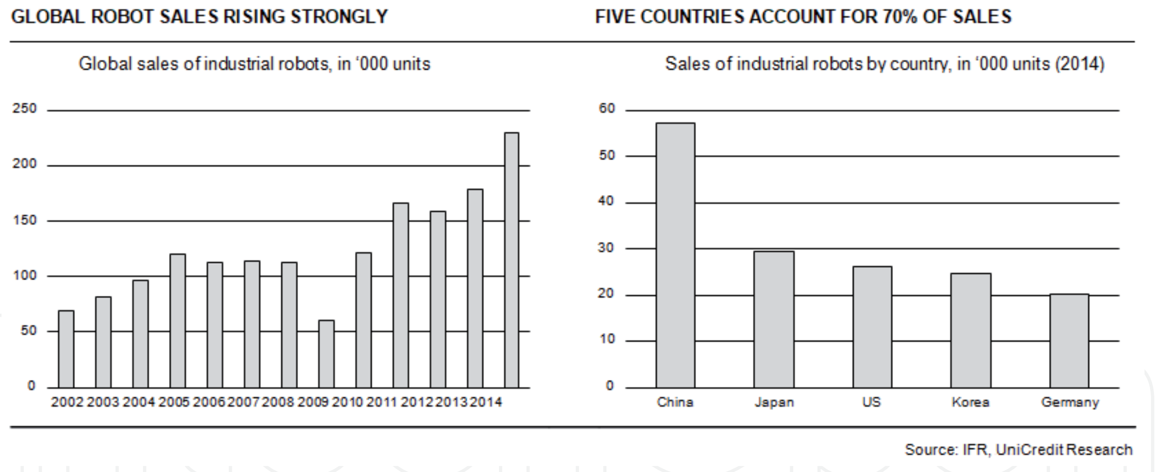


Figure 10.
Five countries account for 70% of the global robot sales that are strongly rising.

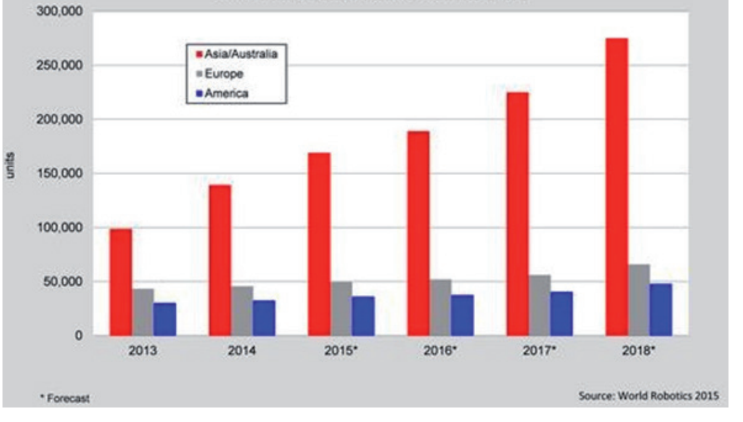


Figure 11.
Annual supply of industrial robots.

Chinese industries and country's administration have recognized the need for further automation. In 2014, sales volume reached about 57,000 units, amounted to a 1/4 of the total global sales. During 2009–2014, sales of industrial robots increased by an annual average of 59%. According to IFR "The potential remains enormous despite the recent economic downturn. Chinese production industries currently have a robotic density of 36 units per 10,000 employees. By comparison, South Korea deploys 478 industrial robots per 10,000 employees, followed by Japan (315 units) and Germany (292 units). Production industries in the United States deploy just 164 industrial robots per 10,000 employees." Statistics from the International Federation of Robotics show that China's demand for industrial robots has been growing at almost 25% per year. It is estimated that the market value in China will reach the 100 billion yuan, driving to a boom in Chinese robot manufacturers.[11] It is estimated that more than 1/3 of the global supply of industrial robots was installed in the Republic of China in 2018. China's rapid automation, says the IFR, represents a unique development in robotics history. As a result of this spectacular growth rate in robot sales, Asia, and **China** in particular, becomes the **largest and fastest growing robotics market in the world**. According to IFR, China including Japan, Korea, and other Asian countries is home to more than 60% of the robot stock in 2018, compared to 22% for Europe and 15% for the Americas.

[11] See [4].

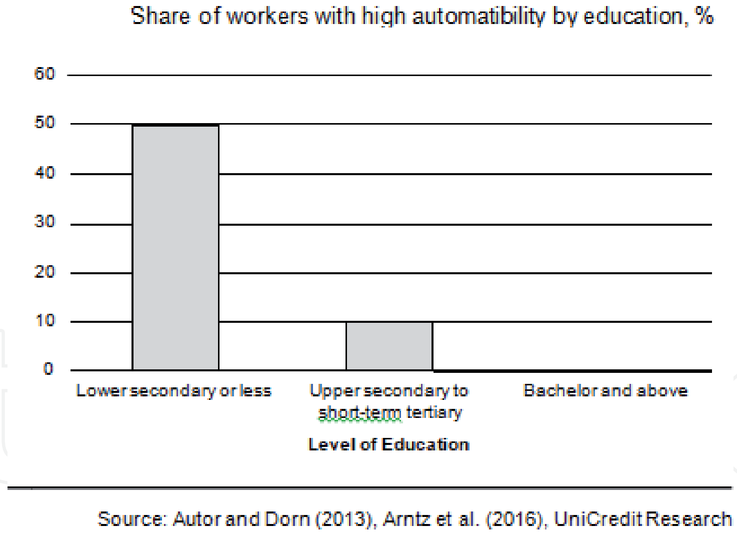


Figure 12.
Share of workers at high automatability by education.

4.1.1 The role of robotics in society

Previously in this chapter, it was analyzed the role of robots in labor market and in industry. The use of robots in industry may have both positive and negative consequences for human people jobs and lives. On the negative side, robots may be considered as a *threat for human labor* in the sense that the use of robots significantly reduces the labor costs and the likelihood of human error, and thus they may be preferred by international industries in order to reduce their costs, increase their output and their productivity, and improve their efficiency and their reliability in manufacturing by removing human errors. Moreover, job positions that were hard to be replaced by machines, such as customer services, are now easily replaced by artificial intelligence. It was also underlined that the greatest risk due to automation (including robots) is faced by low- and medium-skilled workers. The technological change overtime has been biased toward *replacing labor in routine tasks* that tended to decrease demand for low and middle-skilled occupations and increase the demand for high-educated workers rising in this way the inequality in advanced economies. *Rising inequality and slow productivity* may be the main economic challenges of the twenty-first century,[12] and the increased use of robots may affect both of these developments. There are also studies which support that robots may lift productivity, wages, and total labor demand but mostly for benefit of higher-skilled workers. In this chapter, the **great importance of education** was emphasized. As it is clear from **Figure 12** (and **Figure 2**), the risk of automation declines significantly with the level of education. Education may help people to "protect" their jobs and finally get benefit from this technological progress. Since robots are capable of taking over a great number of tasks, humans have to exploit their comparative advantages such as their cognitive skills and their capability to think out of the box in order to manage complex situations, capabilities that may be significantly strengthened by education.

On the positive side, automation may help workers to become *more efficient in their jobs* using robots as assistants/tools and entire industries and economies to become *more productive*. The productivity impact of robots is comparable to the contribution of steam engines in humanity (see [29] among others). Besides the improvement of efficiency and productivity, the use of robots in a workplace may also involve safety improvements for both employers and employees. Human workers are keeping away from dangers and risks that manual works often contain

[12] https://blogs.worldbank.org/jobs/economic-and-social-consequences-robotization.

(high risk of industrial accident) and prevent employers from potentially facing expensive medical bills and lawsuits that are always more expensive than the repair bill for a robot. Moreover, in countries where men are increasingly working with robots, their adaption to automation is easier and higher (reducing in this way their unemployment risk) in comparison with other countries where adaptation to automation is slower. Besides their impact on purely industrial activities, robots may also offer important opportunities for AI in public services such as health and social care. Smart digital assistants and intelligent robots are already valuable tools in doctors' hands in order to perform complex surgical procedures saving human lives. Robotics and AI may help to transform the whole medical ecosystem, including early detection, diagnosis, decision-making, treatment, and life care (see [7] among others). In general, there are many sectors and works where robots could be useful tools in order to facilitate people's lives and help science and humanity to go one step further. The question is whether humans are prepared for the fundamental transformation brought by artificial intelligence and automation (including robots) and whether this fundamental transformation makes social and economic sense.

In the past, radical innovations have transformed the way in which humans live together; for example, cities acquire a less nomadic character with a higher population density. More recently, the invention of technologies such as the telephone and the internet revolutionized how people store and communicate information. However, these innovations did not change the fundamental aspects of human behavior such as love, friendship, cooperation, that remain remarkably consistent throughout the world. On the other hand, the artificial intelligence and the robots' invention in our everyday life may become more disruptive. Nowadays, robots start to look and act like humans, live in our houses as personal assistants, become part of our lives, and have direct interactions with people and between each other.

The "machine behavior" is a field that does not see robots only as human-made objects but as a new class of social actors. The aspects of AI machines that should concern us are those that affect the core aspects of human social life. In 1940s, when the interaction between humans and artificial intelligence starts to seem not a distant prospect, Isaac Asimov posited his famous Three Laws of Robotics, with a main goal to keep robots from hurting people. Such a rule was "a robot may not injure a human being or, through inaction, allow a human being to come to harm." In 1985, Isaac Asimov added another law of robotics to his list: "A robot should never do anything that could harm humanity. But he struggled with how to assess such harm." "A human being is a concrete object," he wrote later. "Injury to a person can be estimated and judged. Humanity is an abstraction".

Dr. Christakis in his lab at Yale conducted some experiments in order to explore the effects of the interaction between people and robots [30]. The results were ambiguous. In some experiments, the interaction of robots with humans made people more productive and improve the way humans relate to one another, but in other experiments, the presence of robots in a social environment made people to behave less productively and less ethically. More specifically, in an experiment designed to explore how AI might affect the "tragedy of the commons," that is, "the notion that individuals' self-centered actions may collectively damage their common interests," robots converted a group of generous people into selfish persons that care only for themselves. Cooperation, trust, and generosity are key features for human social life. The fact that AI may significantly reduce people's ability to work together is extremely concerning.

There are various social effects of the use of AI in our everyday life. Many parents have noted that their children develop close relationships with AI robots and that multiple times they behave rudely to those digital assistants, that is, they give them orders in a rude way. These facts made parents to worry that this rude behavior will not be limited only to robots, but it may be expanded to the way that their kids will treat people and/or that their kids will have socialization problems in the sense that they will prefer to have relationships with AI machines instead of people. Additionally, Judith Shulevitz pointed out that as digital assistants become part of our lives, people start to treat machines as confidants or even as friends and therapists. People start to feel more comfortable to talk to devices whose responses make them feel better than to people that may hurt them. So, which is the future of human relationships? As AI become part of our lives, it seems possible for human emotions to become "something" ridiculous and the deep human relationships to be transformed into "something" superficial and narcissistic. Kathleen Richardson, anthropologist at De Montfort University in the United Kingdom and director of the Campaign "Against Sex Robots," pointed out that even love and sex will be dehumanized; the users of sex robots may pass from treating robots as instruments for sexual gratification to treat other people in the same way. Of course, there is also the opposite opinion such that of David Levy who defends in his book "Love and Sex with Robots" the positive implications of "romantically attractive and sexually desirable robots." He suggests that some people will come to prefer robot mates to human ones in sex, and this must be seen as ethical and expected since robots will not be susceptible to sexually transmitted diseases or unwanted pregnancies, while someone may easier fulfill his sexual fantasies with a robot.

Since robots are actively involved in human workplace, it would be interesting to set under consideration, besides the economic effects, the effects that such a coexistence (human workers and robots) may have on workers' psychology [31]. Of course, the overall employee psychology is affected by the robots' presence in their workplace both positively and negatively, basically depending on how the employer chooses to incorporate robots into the business. If the majority of the job positions in a workplace become automated, employees will feel insecure, unmotivated, unappreciated, and quite unhappy for the robots' presence in their workplace. On the other hand, if the robots are incorporated into the business as assistants to the current workforce, workers will feel secure and satisfied by the robots' presence in their workplace since employees will have a precious assistant to accomplish dangerous and uninteresting tasks while they will have the chance to work on more interesting and mentally stimulating tasks becoming more productive, shifting into more skilled positions and increasing their earning potential in the future.

The general conclusion is that robots and machines are already part of our everyday life, and this is a new reality that must be accepted by everyone. People must try to be adapted to this new reality in order to have a smooth transition from the old to the new world. The key is the way that people face this new reality. As it was underlined in this chapter, there are tasks such as teaching and nursing, for which there is a strong social preference to be provided by human employees and not by robots. However, robots are already used as personal assistants for elderly care with a very positive impact, for personal and domestic use and for many more categories that seem to be on the way. Based on the results of his experiments, Dr. Christakis underlined that "in what I call "hybrid systems"—where people and robots interact socially—the right kind of AI can improve the way humans relate to one another." Based on the findings of this chapter, a key word for a harmonic coexistence of robots and human people is "the right kind of AI" and the way that people treat those AI robots and machines. AI must not replace humans but they may help people to become better. AI must not be treated by humans as family members or as friends but as digital assistants that make their lives easier. In this way, people will get benefited by these technological achievements, the human feelings and the human relationships will be protected, and the genetically inherited capacities for love, friendship, cooperation, and teaching that helped people to live together peacefully and effectively across the time will not be set in danger by the AI robots and machines present in their lives.

5. Opportunities related to the Fourth Industrial Revolution

Besides the problems that may arise or get bigger during the Fourth Industrial Revolution, there are also significant economic and social opportunities that may contribute to a sustainable socioeconomic growth (see [32, 33] among others). Concerning entrepreneurship, new technologies must not be treated as a threat for human work but as a valuable tool/assistant for employees to increase their productivity and facilitate their decision-making and for entrepreneurs to boost their business competitiveness and productivity. Governments could also support entrepreneurship, focusing on the following:

i. Providing know-hows to start-ups and small- and medium-sized enterprises (SMEs) about next-generation technologies and digitalization in order to increase their revenue and reduce their production costs.

ii. Supporting co-operations among enterprises, businesses and research institutes, enterprises and people who have great market experience as business angels, businesses, and public and regional authorities.

iii. Promoting funding measures for start-ups and small- and medium-sized enterprises (SMEs) in order to help them participating in technological development processes, for example, facilitation of their access to public funding and guarantees (and to private borrowing), support of co-financing by industry and market players, and use of innovative and close-to-market financing instruments such as business loans and tax incentives.

iv. Facilitating the access to multilevel platforms that offer digital transformation programs for businesses in order to reduce information asymmetry and help businesses to remain updated and sustainable.

v. Reducing bureaucracy and barriers for business to be expanded in new markets and diversify their activities.

These policies may benefit both businesses and governments; entrepreneurs will be smoothly adapted to the new technological conditions and the digitalization having the appropriate support, and governments will increase their tax revenue due to the higher labor income and the increased business gains (due to the use of new technologies that improves businesses' effectiveness). This additional tax revenue may finance higher public spending on health and education and support additional jobs in these areas.

The new IT systems may also give to entrepreneurs the chance to participate in new supply chains for small- and medium-sized enterprises and have access to new product and service markets that under other conditions would be difficult and costly. The development of new markets with greater quantity and variety of products and services, and eventual lower prices, in combination with the improvement of the existing jobs' efficiency and the improvement of customer service, will benefit consumers driving to a demand increase and consequently to a labor demand increase. New technologies may further increase the labor demand by creating new, stable, and well-paid jobs in innovative technological sectors that will reduce the potential job loss due to automation and will substantially contribute to the fight against poverty worldwide. A characteristic example is the information and communication technology (ICT) sector that has been a key driver of economic growth in OECD countries and led to a 22% increase in jobs in 2013. Briefly, new technologies may contribute to the reduction of unemployment, to the fight against poverty and to the improvement of the quality and the prices of products and services offered to people improving in this way the quality of their lives.

In the direction of human life quality improvement, significant steps have also been done in the health sector. The broad technological innovation in the field of medicine, involving nanotechnology and genetic engineering, allow the treatment of devastating diseases and illnesses increasing the life expectancy. Moreover, smart digital assistants and intelligent robots are able to perform complex surgical procedures that under different circumstances would be impossible to be done. Except the physical health, the opportunity for more flexible forms of work due to the technological progress improves the mental health of people as well; workers have the possibility to distribute their time according to their needs, to create family and acquire a healthy social life having a better work-life balance.

Digital technology also facilitates the access of all people (in developing and developed countries) to education giving them the chance to improve their knowledge and their skills by attending educational and training programs by distance. In this way, the barriers in access to quality education for all are reduced, and the fight against inequalities and discrimination among countries and social classes becomes more effective. Moreover, the improvement of their skills enforces the self-confidence and the competiveness of individuals in labor market, helps them to be smoothly and quickly adapted to the new conditions, gives them the incentives to live and work in their country (and not to immigrate), and helps them to efficiently deal with their economic problems by becoming more productive in their work. In this way, labor income increases contributing to the reduction of poverty and hunger.

The *fight against poverty and hunger* is also supported by the technological progress in the field of sustainable agricultural production and the "smart farming," using new effective "smart" cultivation systems that may help people not only to have food for a specific period but also to learn how to easily and effectively cultivate the land in order to ensure their food forever. In this direction, the varieties of drought-resistant vegetables and fruits that may ensure food to people who live in countries that are strongly affected by drought like many countries in Africa also contribute. The technological innovations in recycling for industry and households such as the innovative composting methods may also help in the direction of food waste reduction contributing further to the fight against hunger.

6. Case study: Greece

An interesting case study is that of Greece. It is about a country that does not belong to heavy industrial economies, such that of Germany, Slovakia, and Italy which have relatively inelastic labor markets and large tertiary service sectors that may be strongly affected by the Fourth Industrial Revolution. Jobs in Greece are more related to tasks that require the involvement of human factor such as teaching and elderly care and less to routine tasks.

In general, the automation process involves three overlapping waves: (i) an *Algorithm wave* that mainly focuses on automating simple computational tasks such as structured data analysis and mathematical calculations, and it is expected to reach its full maturity by 2020, (ii) an *Augmentation wave* that focuses on the automation of repeating tasks such as communication and information exchange and statistical analysis of unstructured data that is in progress, and (iii) an *Autonomy wave* that focuses on the physical and manual work automation, such as manufacturing and transporting, that is likely to reach its full maturity by 2030.

Based on international studies' results (see [5–7], among others), less than 5% of the jobs in Greece is exposed to the automation risk due to the Algorithm wave, 10% is exposed due to the Augmentation wave and 10% of the jobs is exposed due to of the Autonomy wave, completing a percentage of about 25% of jobs in Greece that is exposed to the automation risk. This is the fourth lowest percentage of exposure to the automation risk among other OECD economies, along with some technologically advanced countries in East Asia and Scandinavia (20–25%).

Moving to an in-depth analysis of the data about the long-term impact of automation in Greece and making a separation by gender, age, educational level, and industry, one may firstly observe that the proportion of men exposed to the risk of automation (27%) is higher than that of women (18%). This is basically related to the nature of the tasks that men undertake, for example, manual work and tasks that require muscle strength and can be easily automated. Additionally, PISA scores show that women in Europe achieve better educational results than men, which may further explain the lower rate of exposure to automation risk for women. It is noteworthy that the percentage of women exposed to the risk of automation in Greece is among the lowest in Europe.

Focusing on the age groups, the highest rate of exposure (25%) is observed for the *middle-aged group (40–50 years)* and the lowest (19%) for the age group of young people with elderly people to follow with 20%. In the most European countries, the highest rate of exposure is observed for the age group of elderly people. This is mainly explained by the difficulty of elder people to be adapted to the new conditions and by the low participation rates of elderly people in labor market and in re-training programs that could help them to be adapted to the new reality. The high rates of "Not in Education, Employment, or Training" middle-aged people in Greece and their very low participation in re-skilling and up-skilling programs in order to get familiar with new technologies and become more competitive in labor market may offer an explanation for the high rate of exposure to the risk of automation for the middle-aged group in Greece.

Concerning educational level, the lowest rate of exposure to automation is observed for highly educated people (10%), the highest (30%) for people who have medium educational level, while people with low educational level present a rate of exposure of about 24%. It is about an expected result since highly qualified and educated people are at lower automation risk than medium- or low-qualified workers because of the nature of the tasks they undertake that is more complex and demanding and thus more difficult to be automated. The fact that the highest rate of exposure to automation is observed for people with medium educational level is in accordance to the results of several studies, such that of UBS [26], according to which the greatest impact of the Fourth Industrial Revolution will be experienced by the medium-skilled employees in jobs such as the customer service that although require communication skills and personal contact with the clients can be easily replaced by artificial intelligence.

The industry that appears to be most exposed to automation in Greece is the manufacturing sector with 35% rate of exposure (the 4th lowest percentage among other OECD countries). The second most exposed industry is the construction sector with 25% rate of exposure (second lowest), followed by retail trade with 23% (third lowest), social protection and health industry with 20%, and the education sector with the lowest rate of exposure of 3%. Humanitarian activities such as social protection and care services, education, and teaching require high social and cognitive skills, personal contact, and communication skills and exhibit low exposure rates to automation in comparison with the manufacturing and the construction sectors. This is in accordance to the previous findings for the Fourth Industrial Revolution concerning the sectors that are more exposed to automation. In general, the rates of exposure to automation for all professional sectors in Greece are among the lowest in Europe; especially the risk of automation of the educational sector in Greece is lower than the average of all countries worldwide, emphasizing the anthropocentric nature of the Greek educational system that makes quite difficult the total replacement of human factor by machines and robots in the long run.

7. Conclusion

Major waves of technological progress such that of Fourth Industrial Revolution always create concerns about the future of human labor and the possibility of substitution of the human factor by machines and robots. The main findings of this paper show that the Industry 4.0 does not seem to threaten the human labor under the conditions that employees are able to be quickly adapted to the new reality and governments follow the appropriate policies to protect people from the unpredictable and undesirable consequences of technological progress. The jobs that are most exposed to automation are the routine jobs with a high volume of tasks that do not require high communicative and cognitive skills such as office work, constructions and manufacturing, and wholesale and retail trade. On the other hand, jobs such as teaching, nursing, and elderly care that are multitask and require flexibility, true creativity, and social intelligence are difficult to be automated. Therefore, the complete substitution of human workforce by robots in labor market is extremely unlikely to happen.

Deloitte's report [24] characterizes the Fourth Industrial Revolution as "a mixture of hope and doubt." On the one hand, new technologies create opportunities for sustainable economic growth and reduction of unemployment; create new job positions in innovative sectors; contribute to the strengthening of competitiveness and productivity of workers and businesses, to the increase of labor income and business gains, to the improvement of human life quality, and to the physical and mental health improvement increasing life expectancy; allow for high levels of innovation and knowledge; facilitate the access to quality education for all; and contribute to the early diagnosis of extreme weather events, to the sustainable urbanization, and to the fight against inequalities, poverty, and hunger. On the other hand, the loss of millions jobs due to automation, the invasion of artificial intelligence even in jobs where the human factor is crucial, the potential income and socioeconomic inequality gap widening with the poor and developing economies to be more affected, the gender gap expansion, the increase of poverty and hunger because of the potential job loss, the violation of personal data, the use of new technologies for illegal activities, the national and international security issues such as the threat of a nuclear or a chemical conflict, and the climate change with the increasing extreme weather phenomena are some of the most important challenges related with the Industry 4.0.

Indicative key policies that governments could follow to deal with these challenges and take advantage from opportunities arising from the Fourth Industrial Revolution are the following: (1) give priority to the *education and* the *training* for people of all ages (with an emphasis to STEM issues) in order to obtain the cognitive and social skills required by the labor market and protect job positions from automation; (2) create *new well-paid jobs*, so as to moderate the potential job loss (due to automation) and deal with income and socioeconomic inequality;

(3) *strengthen social security networks*, especially for those who have difficulty to be adapted to new technologies; (4) apply *tax transformations* in order to increase tax revenue from workers whose earnings will increase due to the Industry 4.0 and apply a tax relief for workers whose income will be reduced; (5) *support entrepreneurship*, by giving small and start-up businesses the chance to improve their efficiency and increase their revenue using new technologies; (6) promote *women's participation in STEM programs* and activities in order to reduce the gender gap; (7) *support countries' cooperation*, for a better diffusion of knowledge and best practices among national governments; (8) give an emphasis to *transparency* through digital portals and accountability mechanisms; (9) impose strict rules to prevent the use of new technologies for *illegal activities* and protect people from a possible violation of their personal data; (10) institutionalize strict laws and regulations to protect people from a possible nuclear or chemical conflict with unpredictable consequences; (11) promote *smart agricultural production* in order to deal with hunger; and (12) support *sustainable use of resources*, *protection of ecosystems,* and new forms of "clean" energy as renewable sources of energy in order to deal with *climate change* and ensure *energy autonomy*. All the policies must be fully compatible with the *Sustainable Development Goals of the United Nations* in order to effectively deal with the challenges of the Industry 4.0 and ensure a sustainable economic growth.

Finally, the case study of Greece is set under consideration in this paper. Greece does not belong to the heavy industrial economies of Europe, but it has a more people-focused labor market. Greece has the fourth lowest rate of exposure to the automation risk (about 24%) among other economies worldwide, with men being more exposed to the risk of automation than women mainly because of the nature of the tasks they undertake that is easier to be automated, for example, manual works. According to the results, the highest rate of exposure is observed for middle-aged people who have medium educational level. The high rates of "Not in Education, Employment, or Training" middle-aged people in Greece and their very low participation in re-skilling and up-skilling programs and the fact that the tasks of medium-educated employees can be easily replaced by artificial intelligence offer an explanation for this result. The industry that appears to be most exposed to automation in Greece is the manufacturing sector. Humanitarian activities such as care services, education, and teaching that require high social, cognitive, and communication skills exhibit low rates of exposure to automation; especially the rate of exposure to the automation risk of the educational sector is lower than the average of all countries worldwide, emphasizing the anthropocentric nature of the Greek educational system that makes difficult the total replacement of human factor by machines and robots in the long run.

Author details

Evanthia K. Zervoudi
Athens University of Economics and Business, Athens, Greece

*Address all correspondence to: zervoudiev@aueb.gr

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