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Technology as a determinant of economic inequalities in the global economy

By

Efstathios Psyllakis

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Approved by:

Assistant Professor
Spyridon Roukanas

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Efstathios Psyllakis

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Abstract

Rising inequalities are one of the major concerns of the world's scientific community nowadays. The following research examined the correlation between technological change and increased inequalities for the period after 1970s. "Skill biased technological change" induced the increase in inequalities during 1970s, as relative productivity and demand of skilled labor increased over the unskilled labor. In addition, the interaction of technological change with the transformation of firms' organization, deunionization and international trade were proven as key determinants for the increase in inequalities. Another key determinant of increased inequalities is technological change of capital intensity induced by corporations. Furthermore, the impact of automation on jobs and wages was examined and a negative correlation was found. The fact that automation induces unemployment was based on the argument of technological unemployment and in historical data. More specifically, different occupational categories were affected and 47% of jobs in US are confronted with high risk to computerization and robotic replacement in the future. According to specific researches on US and European labor markets, industrial robots' usage has a negative impact on jobs and wages. To conclude, the crucial role of State, education, culture and society is emphasized in order to decrease inequalities in the new digital era.

Keywords: technological change, inequalities, automation, State, education

1. Introduction

The following research will focus on examining the phenomenon of economic inequalities and to what extent it is influenced from technological change for the period between 1970s and the early 2010s.

The methodological approach of the research will be based on secondary research. Secondary research is consisted of bibliographic research. The data will be analyzed through qualitative analysis methods and more specifically, bibliographic meta-analysis methods. Furthermore, international macroeconomic will be used.

In addition, the following research consists of 5 chapters. Chapter 1 consists of the introduction of the research. In chapter 2, the existing literature about economic inequalities is cited. In chapter 3, the methodological approach of the research is presented. Chapter 4 presents the results of the research and is divided into 4 subchapters: *1) Economic inequalities and technological change, 2) Automation and Jobs, 3) Robots and labor markets, 4) The role of state, culture, education and society.* In addition, chapter 5 consists of the conclusions alongside with the limitations and recommendations of the research.

To conclude, the following research contributes to the existing literature by interconnecting economic inequalities with technological change and by providing key determinants in order to decrease them in the new digital era.

2. Literature Review

2.1 Introduction.

The following research is based on technology and economic inequalities. However, technological change is not the only determinant, which is used to examine increased inequalities. In addition, the interaction of technological change with the transformation of firms' organization, changes in labor market institutions, international trade and capital is controlled. In literature, there are two leading aspects with regard to the way that automation affects jobs. In addition, the impact of automation by occupational categories and its results are examined. Furthermore, the impact of robotics on jobs and wages in EU and US labor markets is determined. To conclude, the following research was based on specific literature about the role of State, education, culture and society in reducing inequalities. In this chapter a summary of the existing literature on economic inequalities will be presented.

2.2 Inequalities.

Rifkin (1995) states the *"trickle down technology"* theory that prevailed in economics, which argues that the profits of the continued introduction of new technology diffuse into society with the passing of time. Indeed, Brynjolfsson's and McAfee's (2014) findings confirm this theory as productivity gains favored all workers until the early 1970s where increased inequalities are observed alongside with increased demand for skilled labor. It is believed that one factor which increased inequalities is technological change induced by rapid advances in IT. Robert Solow's model of skilled biased technological change interprets the increase in inequalities, based on the direction of technological change that favors the skilled labor over unskilled labor (Chataway and Spisak 2017). In addition, according to Daron Acemoglu (2002) and endogenous growth theory, increased supply of skilled labor and increased profit incentives of corporations induced the skilled biased technological change as the skill biased technologies became more profitable.

A second key determinant of increased inequalities is the introduction of frugal production in firms' organization in 1980s. The new form of management alongside with the use of new IT technologies aimed to increase productivity with less work and fewer resources (Rifkin 1995). Brynjolfsson, Hitt and Yang (2002) state the argument above, as they found a complementarity of IT investment and organizational investment that is associated with significant increases in productivity. Brynjolfsson and McAfee (2014) conclude that inequalities have increased by comparing the median income with productivity, as median income growth has been lower than that of productivity.

Daron Acemoglu, Phillipe Aghion and Giovanni L. Violante (2001) argue that the decline of unions have been an important factor in the increase in inequalities. They consider that skill biased technological change induced deunionization. Furthermore, Atkinson (2015) and Stiglitz (2013) emphasize the role of government and legislature in the declining of unions in the early 1980s and its societal consequences. The Organization for Economic Co-operation and Development (OECD 2011) presents the trends in labor market policies and the decreased union rates in many developed countries between 1980 and 2008.

Daron Acemoglu (2000) underlines that international trade induces a skill biased technological change as it interacts with technical change and he argues that trade is the underlying cause of the increase in inequality.

Furthermore, Erik Brynjolfsson and Andrew McAfee (2014) alongside with Loukas Karabarbounis and Brent Neiman (2013) document that advances in IT, induced firms to shift away from labor towards capital because investment in capital equipment became more profitable, as a result the global labor share declined sharply and corporations' profits increased since the early 1980s. Madigan (2011) confirms the aformentioned argument for the years after the Great Recession as the investment in capital continues to grow in contrast to payrolls spending that remain stable.

Atkinson (2015) highlights the imbalance of power in the market between firms and workers, which in the future is expected to lead to a further increase in inequality, as corporations increase their power and take the decisions that are decisive for the production.

2.3 Jobs.

The movement of Luddism, which began in the 19th century in England, was the first response of the workforce against the entry of automation into the workplace (Brynjolfsson and McAfee 2014). In economics prevail two perspectives with regard to the impact of automation on the labor market. The first and predominant argues that new automation technologies increase productivity, resulting in an increased supply that creates its own demand (Rifkin 1995). In addition, decreased employment as a consequence of automation is offset by additional recruitment due to increased productivity (Benedikt and Osborne 2013). The second perspective is based on the argument of technological unemployment, according to which societies fail to adjust to rapid technological change and find new uses for their labor (Keynes 1931). Brynjolfsson and McAfee (2014) interpret Keynes's argument based on inelastic demand, rapid change and great inequality. Distinct emphasis on the rapid pace of technological change is also given in the McKinsey Global Institute report (2017). In addition, Brynjolfsson and McAfee (2014) question the fact that the increase in productivity is accompanied by additional recruitment, as productivity decoupled from employment at the end of the 1990s.

2.4 Automation.

Many studies test the effect of automation by occupational category. In McKinsey Global Institute's report (2017), they measure the employment in manufacturing and agricultural sector since the first wave of automation and they find that employment decreased significantly in many developed countries even as growth in other sectors accelerated.

However, automation has not only affected low-skilled jobs. Acemoglu and Autor (2010) divide occupations into two pairs: cognitive – manual, and routine – non-routine. They find that demand for cognitive and manual routine occupations decreased significantly, as the core job tasks of these jobs can be easily codified in computer software, and as the price of machine substitutes of these tasks fell substantially (Acemoglu and Autor 2010). Jaimovich and Siu (2012) confirm the aforementioned argument in their research. They measure the demand for cognitive and manual routine occupations between 1981 and 2011 and they find that it decreased with an accelerated pace (Jaimovich and Siu 2012). The result was the polarization of the labor market and the decrease in employment in middle-income routine jobs, alongside with the increase in employment in high-income cognitive jobs and low-income manual occupations (Benedikt and Osborne 2013).

Nevertheless, a large percentage of jobs are highly susceptible to computerization in recent years, even if they are non-routine cognitive or non-routine manual occupations (Benedikt and Osborne 2013). Benedikt and Osborne (2013) use a novel methodology based on a Gaussian process classifier to estimate the probability of computerization for detailed occupations and they find that 47 percent of total US employment is in the high risk category. They also emphasize the high risk of computerization in service occupations, a sector where employment increased by 30 percent between 1980 and 2005.

Ross (2016) argues that the substitution of labor by robots depends on a compensation of costs. Human work entails high operating costs, in contrast to high capital costs of robots (Ross 2016). Progressively, as the capital costs of robots are reduced, the more jobs will be eliminated (Ross 2016). Chiacchio, Petropoulos and Pichler (2018) provide robust results in their paper of the decreased price and the increased quality of robots. Furthermore, Ross (2016) emphasizes the crucial role of the formation of appropriate systems by people in order to adapt to the inevitable displacement of labor from robots.

2.5 Robots.

Recent studies argue that robots usage has a significant effect on wages and employment. According to Acemoglu and Restrepo (2017) and their estimations from US labor markets, each additional robot per thousand workers decreases aggregate employment to population ratio by 0.37 percentage points and aggregate wages by about 0.73 percent. In addition, Chiacchio, Petropoulos and Pichler (2018) find that the impact of one additional robot per thousand workers decreases employment rate by 0.16-0.20 percentage points in their estimations in six EU countries. In contrast, they do not find a substantial negative impact of robots on wage growth (Chiacchio, Petropoulos and Pichler 2018). They also point out that the differences on employment rate between EU and US are interpreted by the dissimilarities of their labor markets (Chiacchio, Petropoulos and Pichler 2018).

2.6 State.

Many authors argue for the crucial role of State and its political system in order to tackle increased inequalities and the consequences from the next wave of innovation. Governments have lost a significant amount of their authority and control over societies, as information is diffused through new digital technologies to people (Ross 2016). Ross (2016) argues that, States should be based on an open system, if they wish to benefit from the new wave of innovation. In addition, open institutions reward innovation and decrease inequalities alongside with the monopolization of political power (Acemoglu and Robinson 2012).

Atkinson (2015) argues that State can affect the direction of technological change through public policy, and more specifically through research funding, in order to reduce inequality. Mazzucato (2013) emphasizes the importance of State funded investments in innovation based on the success of US model.

Furthermore, Atkinson (2015) based on Baumol phenomenon, points out that State should not decrease expenditures in public sector, in contrast it should invest on public services and on human capital as their value will increase in the future.

To conclude, Atkinson (2015) attaches importance to the improvement of State's public administration through new digital technologies in order to tackle, not only, economic but also social inequalities.

2.7 Education.

Many authors emphasize the importance of education in order to reduce inequalities alongside with the use of new digital technologies. Generally, inequalities are increasing when education can not follow the evolution of technology (Brynjolfsson and McAfee 2014). In literature, they mention the massive investment in the education of US future workforce in the mid-20th century as an example and the benefits derived from it (Brynjolfsson and McAfee 2014). In contrast, OECD (2009) notes that the USA's advantage in education has been lost over the last few years. Furthermore, Hanushek and Woessmann (2010) prove that the cognitive skills of population are strongly related to long-run economic growth by studying forty years data from fifty countries.

To continue, Sugata Mitra (2013) criticizes the current educational system and he emphasizes the necessity to use digital technologies in education nowadays. In addition, Mitra noted that *Self-Organizing Learning Enviroments* (SOLEs), a form of technology-based education, provide the chlidren with the necessary skills in order to respond to the challenges of the new digital age (Brynjolfsson and McAfee 2014). Another remarkable example of technology-based education are the *Massive Open Online Courses* (MOOCs) and their benefits (Brynjolfsson and McAfee 2014). They combine the low cost alongside with the high education quality and generate a flow of data that can be used for the benefit of both the teacher and students (Brynjolfsson and McAfee 2014).

2.8 Culture & Society.

In recent literature, distinct emphasis is given to culture as a key determinant in the adoption of new technologies and more specifically, robots. Mims (2010) points out that Eastern culture seems to be more friendly in the development of robotics in contrast to Western culture. His argument is based on the religion of Shintoism that does not make any distiction between inanimate objects and humans (Mims 2010). This cultural ease is also reflected by the increased investment in robotics in Asia and by the increased number of automation departments in Asian universities, in contrast to US (Ross 2016).

The way in which societies will adjust to the new digital age will greatly determine their future development (Ross 2016). Ross (2016) argues that societies need to adapt and invest in new digital technologies and redirect their citizens towards them. In addition, Ross (2016) attaches importance to the conformation of a specific social framework, in lifelong learning and in skills development in order to maintain human competitiveness.

2.9 Conclusion.

In the previous chapter, a summary of the existing literature on economic inequalities was made and it was classified based on the determinants that were used in the research: *1) Inequalities, 2) Jobs, 3) Automation, 4) Robots, 5) State, 6) Education, 7) Culture & Society.*

Increased inequalities are partly attributable to the technological change that has taken place in the early 1970s. In literature, the interaction of technological change with the transformation of firms' organization, the changes in labor market institutions, international trade and capital are also, considered as key determinants of increased disparities. In addition, there are two leading aspects with regard to automation and its impact on wages and jobs. Furthermore, different occupational categories were afflicted by automation with the passing of time and nevertheless, a large percentage of jobs are highly susceptible to computerization in future. Recent studies in US and EU labor markets argue that robots usage has a significant effect on wages and employment. To conclude, State, education, culture and society could play a crucial role in reducing inequalities.

3. Methodology

3.1 Introduction.

In the following chapter, the research's methodology is presented and is divided into three sub-chapters. The first sub-chapter is consisted of the research questions and the methodological approach used in order to address them effectively. The second sub-chapter is comprised of the data on which the research was based and the methods of collection. To conclude, the methods for analyzing the data are presented in the last sub-chapter.

3.2 Research questions & methodological approach.

The main research questions of the following research are:

- *"How technological change affects inequalities?"*
- *"How automation affects jobs and wages?"*

- *“Which occupational categories are the most vulnerable to automation?”*
- *“Which are the effects of robots’ usage on jobs and wages?”*
- *“To what extent does the state, education, culture and society can limit inequalities?”*

In order to adress effectively the research questions above, the methodological approach of the paper was based on secondary research. Furthermore, secondary research was consisted of bibliographic research.

3.3 Data collection.

The data collection of the following research was based on bibliographic research and more specifically on identifying, studying and analyzing data from recent scientific papers and books. In addition, international macroeconomic data has been collected from a wide variety of studies.

3.4 Methods of analysis.

In order to analyze the data, qualitative analysis methods and more specifically, bibliographic meta-analysis methods were used. The theoritical framework was built on theories and arguments which prevail in literature and they were verified through analysis of quantitative (e.g. diagrams, statistics) and qualitative data from specific researches and books.

3.5 Conclusion.

In the previous chapter, the five research questions of the research were quoted and they will be documented in the next chapter. The methodological approach of the paper was based on secondary research. In addition, bibliographic research was used in order to collect the data alongside with the collection of international macroeconomic data. The data were analyzed through bibliographic meta-analysis methods. To conclude, the theoretical framework was verified through analysis of quantitative and qualitative data.

4. Results

4.1 Introduction.

The results of the research will be presented in the following chapter, which is divided into four sub-chapters. The way in which technological change and other determinants affect economic inequalities is analyzed in the first sub-chapter. In addition, the determinant of automation is examined in the second sub-chapter; to what extent it affects employment and more specifically, certain occupational categories. In the third sub-chapter, the results of researches in US and Europe that control the impact of industrial robot usage on jobs and wages are cited. To conclude, the crucial role of State, education, culture and society in reducing inequalities is determined in the last sub-chapter.

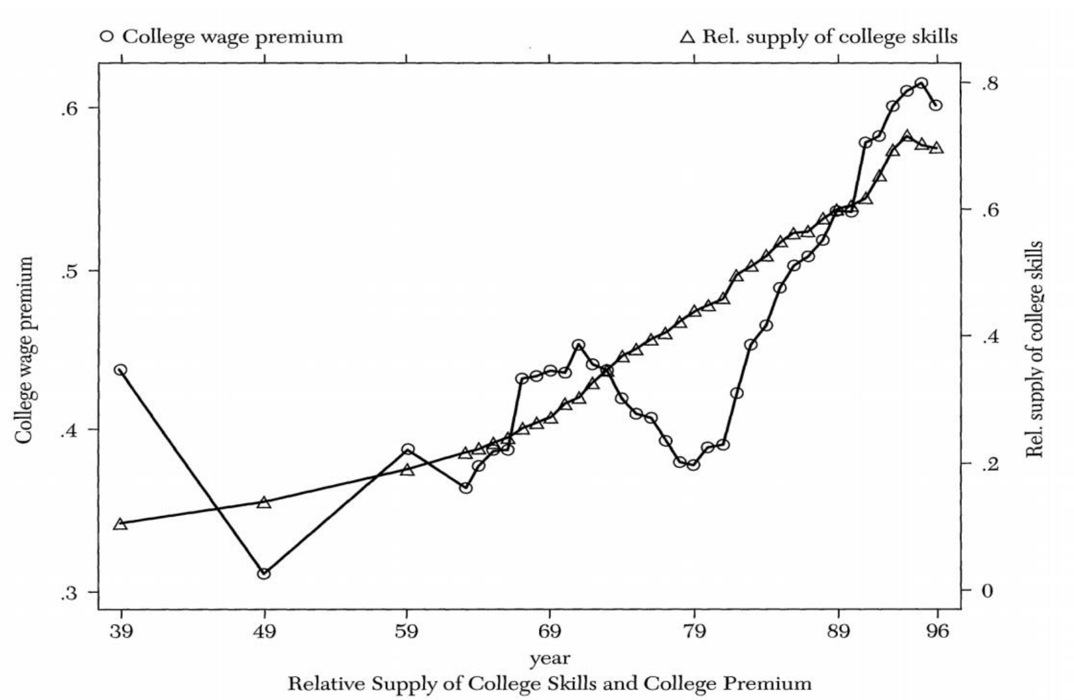
4.2 Economic inequalities and technological change.

Rising inequalities are one of the major concerns of the world's scientific community nowadays. The main driver of them is technological change and its diffusion, which is supported by our economic system. In the light of the following research, the phenomenon of economic inequalities will be determined and the way that it is affected from the development of technology and innovation will be analyzed.

For more than a century, economists preserved that benefits from technological and productivity advancements, such as greater purchasing power, will diffuse to labor at some point, based on "*trickle down technology"* theory (Rifkin, 1995). In contrast, developments in information technology induced substantial income and wealth inequalities between people; they benefited skilled labor against unskilled, increased returns on equity against labor and profits for economic elites. These trends are observed in most developed economies despite of their differences in government policies, institutions and cultures.

Before 1973, American workers have had an intense increase in wages, which was in line with productivity gains, irrespective of their education level. After this period, increasing wage inequality is observed, alongside with rapid advances in IT and higher demand for skills (Brynjolfsson and McAfee 2014). To understand the increasing inequalities during 1970s, the so-called "skill-biased technological change" should be examined and the forces that shape technological progress. In 1957, Robert Solow stated that when the direction of technological change favors the skilled labor over unskilled labor by increasing its relative productivity and relative demand, increased wage inequality is observed. That was the first introduction of the "skilled biased technological change" (Chataway and Spisak 2017). It is worth noting that the supply of college graduates grew rapidly at the same period. In a free market, normally, increased supply of skilled labor would have depressed the *wage premium* between them and unskilled labor and their demand. In contrast, as shown in Figures 1 and 2, college wage premium and relative demand of skills were increased substantially for the period between 1939 and 1996 alongside with the increased supply of skilled labor.

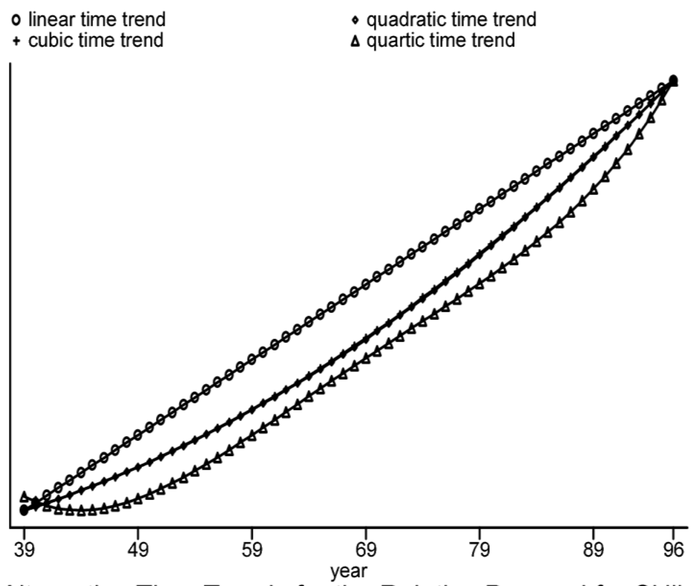
Figure 1. Relative Supply of College Skills and College Premium



The Behavior of the (log) College Premium and Relative Supply of College Skills (weeks worked by college equivalents divided by weeks worked of noncollege equivalents) between 1939 and 1996. Data from March CPSs and 1940, 1950, and 1960 censuses.

Source: Daron Acemoglu (2000)

Figure 2. Alternative Time Trends for the Relative Demand for Skills



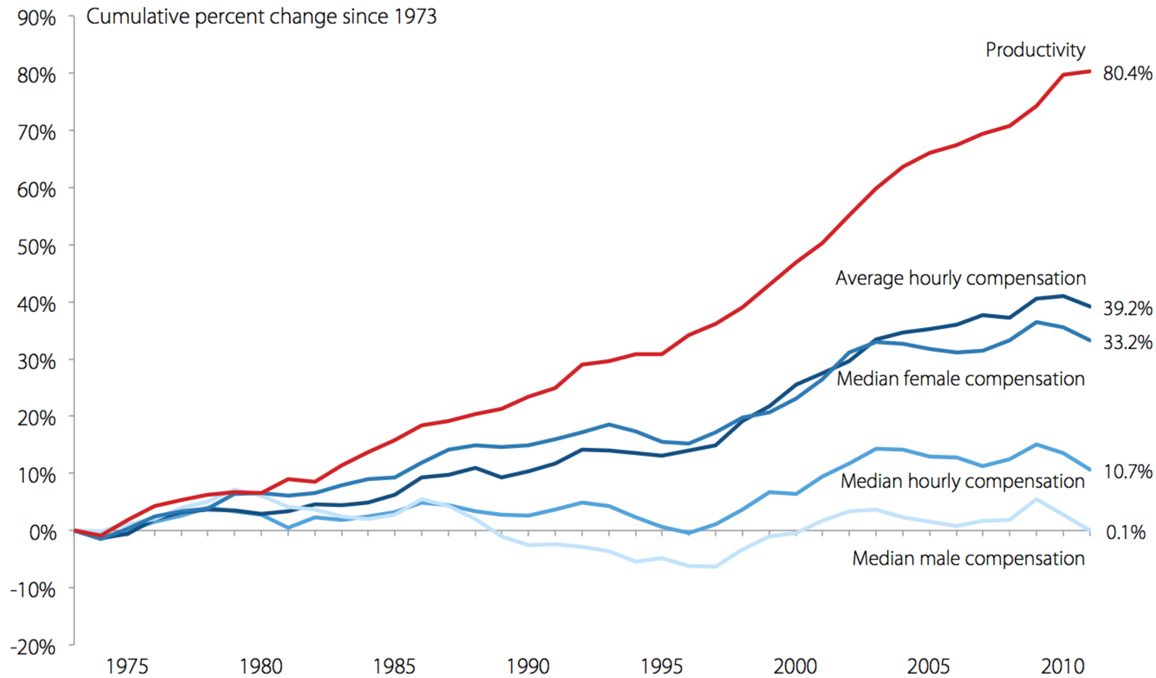
Alternative Time Trends for the Relative Demand for Skills

Source: Daron Acemoglu (2000)

At this point, technological change is examined as an endogenous actor, based on Daron Acemoglu's monumental paper *"Technical Change, Inequality and The Labor Market"* and *endogenous growth theory.* According to *endogenous growth theory,* profit incentives or demand-pull determine the type of technologies that are developed and adopted. A key determinant of profitability is market size because the development of skill-biased technologies will be more profitable for entrepreneurs when they have a larger clientele. As a result, increased supply of skilled workers led to skill-biased technological change and the capital-labor ratio for low-skill workers fell alongside with their wages as firms responded to technological developments (Acemoglu 2002). To understand in a better way rising inequality, the interaction of technological change with the transformation of firms' organization, changes in labor market institutions (deunionization) and international trade should be considered.

In the 1980s, increased competition in the world market as a result of globalization pressed American and European corporations to restructure their management and organization processes through new digital technologies with the aim of reducing their labor cost in production costs. The new form of management (which replaced mass production) was "frugal-austere" production that emerged in the Japanese automotive industry after WWII. Its basic principle was to combine new processes of administration with contemporary machines to produce more goods with fewer resources and less work (Rifkin 1995). The result of this change was the spectacular increase in productivity and the reduction in the size of corporations. In specific sectors, for each dollar invested in capital equipment, there was equivalent to 10$ additional investment in "organizational capital" or investments to restructure corporation processes (Brynjolfsson, Hitt et al. 2002). If the first wave of automation stroke workers, revolution in management of firms stroke middle class. A significant amount of jobs disappeared at middle management levels and profits from increased productivity and Gross Domestic Product (GDP) growth were not distributed equally. To recognize this fact easier, the average income has to be compared with median income. Regularly, changes in average income are in line with changes in median income. However, Figure 3 shows that the average hourly compensation decoupled from the median hourly compensation between 1973 and 2011, as the average hourly compensation increased by 39.2%, in contrast to the median hourly compensation that increased by 10.7%.

Figure 3. Growth of hourly productivity, real average hourly compensation, and real median hourly compensation (overall and by gender), 1973-2011

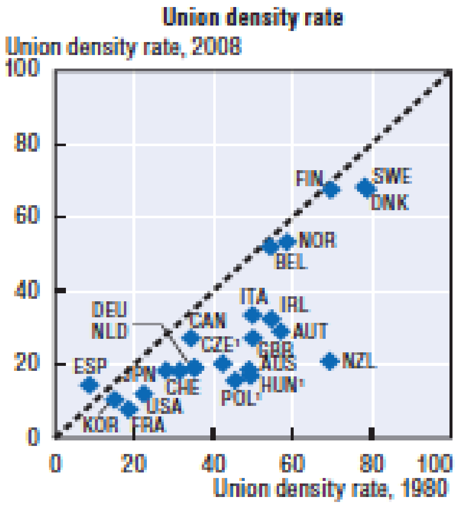


Source: Economic Policy Institute (2012)

In general terms, the more distorted the incomes, the more average income tends to deviate from median. In total, between 1973 and 2011, median hourly wages rose only 0.1% per year. In contrast, productivity increased by an average of 1,56% yearly, with an acceleration to 1,88% from 2000 to 2011. The fact that the increase in the median income was the lower is, mainly, due to the increase of inequality (Brynjolfsson and McAfee 2014). Below, the impact of corporations and capital combined with technological change in terms of increasing inequalities will be examined more extensively.

Along with reducing labor costs to production costs, corporations wanted to decrease the influence of labor unions on wages, working conditions and social benefits. Many authors argue that the declining importance of labor unions and collective bargaining contributed to the dilation of inequality in the distribution of incomes. Figure 4 from OECD's report "*Divided We Stand*" indicates that trade union density rates decreased in every OECD country, excluding Spain, and the percentage of workers who were members of unions was lower in 2008 than in 1980 (OECD 2011).

Figure 4. Union Density Rate



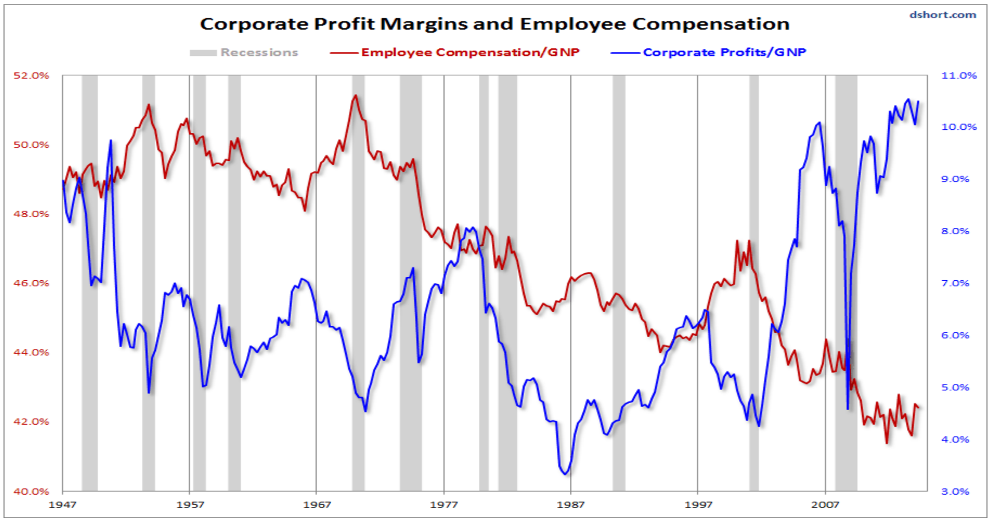
Source: OECD (2011)

According to Daron Acemoglu, Philippe Aghion and Giovanni Violante, deunionization is an outcome of skill-biased technological change, as it undermines the alliance of skilled workers with the unskilled ones on which the bargaining power of unions is based, and the consequent decline of unions induce the extensive dispersion of wages (Acemoglu, Aghion et al. 2001). Another determinant that contributed to the decline of unions are the political developments during 1980s. Conservative governments in US and UK voted legislature restricting their legal framework and action, a tendency that prevailed among developed countries (Atkinson 2015). Joseph Stiglitz argues, distinctively, that deunionization *"constituted an imbalance in the distribution of economic potential and a political vacuum"* (Stiglitz 2013 pp.64), with the consequence that employees lost the most effective means of representing their interests against employers in terms of ways and conditions of work, in addition to the distribution of profits.

To continue, globalization and international trade and their interaction with technological change could be a very important factor in determining increased inequality. The integration of world markets due to globalization resulted in an extensive increase in trade between countries. According to standard trade theory, increased international trade should increase the demand for skills in the labor market. At this point if it is assumed that we live in a world with endogenous technical change, increased trade induces an increase in the relative price of skill-intensive goods and the prompt effect will be an elevation in the developing of skill-biased technologies, while skill intensive goods become more profitable. As a result, skill-biased technological change instigates, employment of skilled workers is increased in all sectors and it is assumed that trade is the underlying cause of the increase in inequality and the decline in the wages of low–skill workers (Acemoglu 2002).

Another key determinant of increased inequalities during the last decades is the impact of capital and corporations in combination with technological change. In the post-war period, the rise of the wage share in national income has contributed to the decline of disparities, this trend seems to have been inverted over the past years as the share of profits has increased. Technology can affect the distribution of national income between capital and labor – the two conventional inputs in production. Technological change can take effect for the benefit of capital in exactly the same way, as shown above, in relation to skilled and unskilled work. Corporations, based on future cost savings in production and profit incentives, invest in technology. As long as they have an economic incentive to substitute work with capital, the labor markets are moving towards to a technological change of capital intensity where the proportion of capital inflow to labor will increase. Figure 5 presents that the share of total GDP that corresponds to work and corporate profits remained remarkably stable between 1947 and the late 1980's but this trend altered over the last years and the share of work in GDP decreased sharply (Brynjolfsson and McAfee 2014) .

Figure 5. Corporate Profit Margins and Employee Compensation



Source: Federal Reserve

Furthermore, this trend is not only observed in the US but globally. The economists Loukas Karabarbounis and Brent Neiman in their paper *"The Global Decline of the Labor Share"* establish that:

"The global labor share has declined significantly since the early 1980's, with the decline occurring within the large majority of countries and industries." (Karabarbounis and Neiman 2013, pp. 2)

Two trends interpret in part the decline in the share of work: 1) employed people are less and 2) employed people's compensation is lower than before. To conclude, the owners of capital are those who really benefit from the increased productivity (Brynjolfsson and McAfee 2014). In 2013, *"profits reached historic highs, both in absolute terms (1,6 trillion dollars) and as a percentage of GDP (26,2% in 2010, above the average of 20,5% of the years 1960-2007)"* (Brynjolfsson and McAfee 2014 pp. 241). According to Kathleen Madigan, at the same time, actual costs in capital and software increased by 26%, in addition to total wage costs that remained substantially stable (Madigan 2011).

Acceleration in the levels of inequality is partly reflected by the fact that the balance between market forces is at the expense of consumers and workers. The main issue with technological innovation is that it elevates the power of corporations and their decisions on the way of production can exacerbate disparities as they gain relative experience. In the long run, automation will substitute more and more people, as substitution becomes progressively advantageous (Atkinson 2015).

Increasing inequalities observed in the 1970's are interpreted by skilled biased technological change that favored skilled labor over unskilled labor by increasing its relative productivity and its relative demand. The transformation of firms' organization, deunionization and international trade were key determinants of increased inequalities alongside with technological change during 1980s. The introduction of frugal production resulted in an immense increase of productivity and it stroke middle class by decreasing real median incomes and by reducing a significant amount of jobs. Furthermore, deunionization induced the extensive dispersion of wages and the loss of unions' bargaining power. International trade caused an elevation in the developing of skill-biased technologies that reinforced the employment of skilled workers and the decline in the wages of low-skill workers. To conclude, technological change took effect for the benefit of capital and induced the decline of global labor share in GDP alongside with the increase in corporations' profits.

4.3 Automation and Jobs.

More and more economists argue that we are in the midst of a Third Industrial Revolution, fueled by technological advances in automation, and raising concerns about jobs and wages have accelerated. Over the past decades, a significant number of jobs have been substituted from computers and, more recently, the reduced performance of labor markets across advanced economies has exaggerated the debate about technological unemployment. But could unemployment actually be induced by technological changes?

Historically, this question was answered many years ago. Between 1811 and 1817, the introduction of automated looms threatened a large number of jobs and resulted in the attack against factories and machines by the English textile workers. That was the so-called movement of Luddites, which was suppressed by the English government. The movement of Luddites is considered as the early example of a widespread and significant new flow: automation of large-scale that penetrated in the workplace and affected wages and employment of people. Soon, economists were divided into two camps (Brynjolfsson and McAfee 2014). The first and most populous maintained that new job-saving technologies increase productivity and permit suppliers to produce more goods at a lower cost per unit product. Increased supply generates its own demand. Greater demand results, in turn, in additional production that increases again demand, an endless cycle of production and consumption (Rifkin 1995). Therefore, according to Benedikt Frey and A. Osborne and their paper *"The Future of Employment: How Susceptible are Jobs to Computerization"*:

"Technological progress has two competing effects on employment. First, as technology substitutes for labour, there is a destruction effect, requiring workers to reallocate their labour supply; and second, there is the capitalization effect, as more companies enter industries where productivity is relatively high, leading employment in those industries to expand." (Benedikt and Osborne 2013, pp. 13)

As a result, unemployment is temporary and it is not a major issue. On the other hand, the idea that technological innovations contribute to perpetual growth and employment has been contradicted by the passing of time. In 1931, John Maynard Keynes in his book *"Essays in Persuasion"* postulated aptly the placement of the second camp – that automation could indeed create unemployed labor on a permanent basis, especially if it penetrated progressively in various industries. Furthermore, in his essay made a prophetic forecast:

> *"We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely, technological unemployment. This means unemployment due to our discovery of means of economizing the use of labour outrunning the pace at which we can find new uses of labour."* (Keynes 1931, pp. 358)

This was the first reference to the phenomenon of *technological unemployment*, the threat of which subsided during WWII as demand for labor increased enormously, but reignited when computers showed up. In recent years, the first perspective has prevailed in the field of economic science.

The fact that technology affects employment temporary and not in a fundamental way, is based on two arguments: 1) economic theory and 2) two hundred years of historical data. These two arguments are less determined than they appear initially. First of all, with regard to theory, there are three economic mechanisms that interpret technological unemployment: 1) inelastic demand, 2) rapid change, 3) increased inequality (Brynjolfsson and McAfee 2014).

Whether technology leads to a more efficient use of labor and not to a reduction on its demand, depends on the elasticity of demand, which is defined as the percentage increase in the requested quantity for each percentage reduction in the price. For some goods and services, e.g. electricity, demand was relatively inelastic and thus indifferent to the reduction in prices as they were more efficient. Furthermore, relatively inelastic demand can affect major sectors of the economy such as agriculture and manufacturing where employment decreased at the time that they became more efficient. Decreased prices and enhanced product quality have not led to an increased demand to offset productivity gains (Brynjolfsson and McAfee 2014). In the long run, Keynes argued that demand would not be unconditionally inelastic, saturation would occur in the markets and the consumption would be less. As a result, work would be critically reduced.

The second argument for technological unemployment is incited by short-term limitations: limitations of our skills, corporations and institutions to keep pace with technological change. When technology eradicates a type of job, affected labor should develop new skills and search for a new job. Since, workers and corporations need time to adapt technological advancements, as a consequence, rapid technological change can lead to intermittent gaps and to increased probabilities of technological unemployment (Brynjolfsson and McAfee 2014). To emphasize, I cite an excerpt from the report of McKinsey Global Institute *"Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation"*:

"*Our view is that the recent technical advances, enabling machines to read lips or X-rays more proficiently than human experts, are indeed remarkable and that if this pace of innovation continues rather than encountering a new AL "winter", the rate of automation innovation could indeed be faster than in the past. If so, the potential disruption of workforce models and displacement of labor could be greater than past technological revolutions*." (Institute 2017, pp. 49)

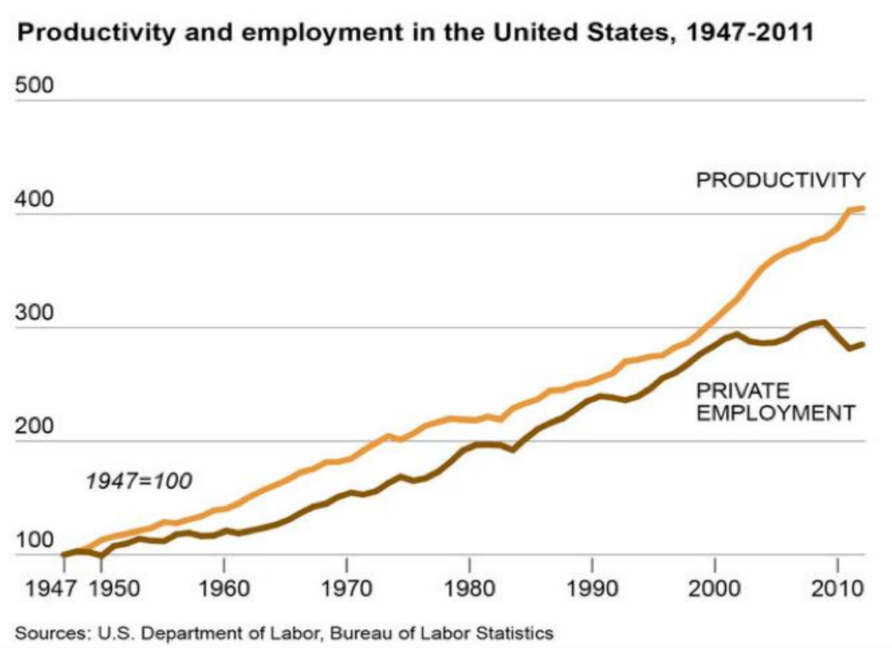
Continuing with the third argument for the technological unemployment, recent advances in technology have increased inequalities through skill-biased and capital-intensive technological change, while decreasing demand for certain types of work and skills. In the free market, the balance between supply and demand is restored by the adjustment of prices, and indeed, millions of people in US have seen their real wages to be reduced. As long as wages reach a threshold and there is not a lucrative job requiring the skills and abilities of a worker, then he will remain unemployed in perpetuity. According to Brynjolfsson and McAfee:

"Over history, this has happened to many other inputs to production that were once valuable, from whale oil to horse labor. They are no longer needed in today's economy even at zero price" (Brynjolfsson and McAfee 2014 pp. 296).

In other words, technology can induce increased inequalities and unemployment in the same fundamental way (Brynjolfsson and McAfee 2014).

To continue, according to historical data, technology increased productivity to an excessive degree alongside with employment. Figure 6 verifies the aforementioned argument, as productivity seems to have grown in parallel with private employment by the end of 20th century, after this period employment bent and decoupled from the upward trend of productivity.

Figure 6. Productivity and employment in the United States, 1947-2011

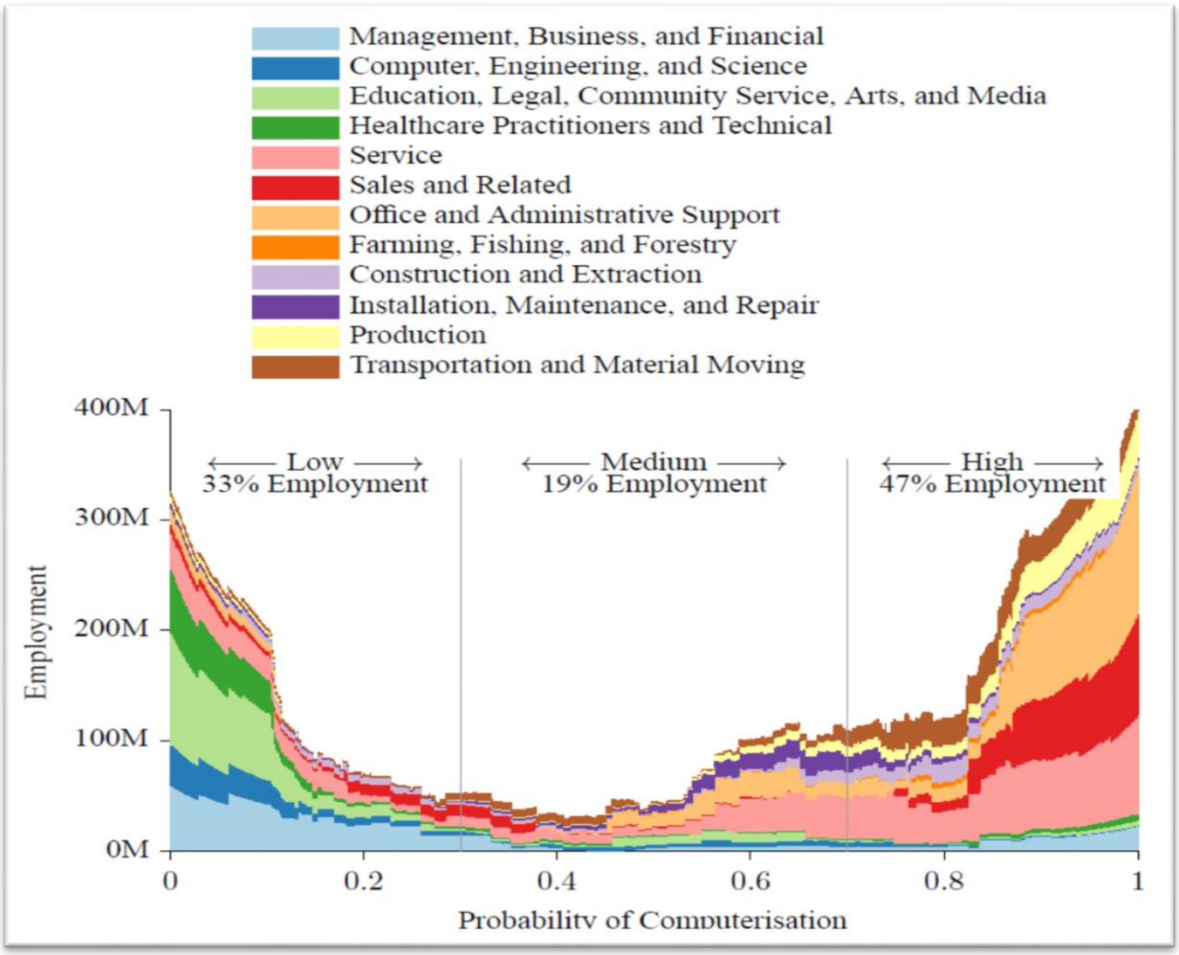


Nowadays, the proportion of employment to the population is lower than any other period over the last 20 years. In contrast, productivity, GDP, corporate investment and profits ascend at record levels. The power of exponential and digital forces, along with the dawning of mechanical and networked intelligence forebodes even greater rearrangements (Brynjolfsson and McAfee 2014).

Following the analysis, the impact of automation by occupational category and its results is examined. Since 1960, the first wave of automation induced a significant decrease in manufacturing employment and low-skilled labor. In United States, for instance, employment in the manufactory sector fell from 27 percent of total employment to 9 percent and, in Japan, fell from 25 percent to 13 percent in 2015 (Institute 2017). Since 1980, however, automation has not only affected low-skilled jobs, but "jobs that machines can perform better than humans, have often been affected". According to Daron Acemoglu and David Autor and their research work *"Skills, Tasks and Technologies: Implications for Employment and Earnings",* professions can be divided into two pairs: cognitive - manual, and routine - non-routine. They found out that demand for work decreased significantly for routine tasks, even if they are cognitive or manual (Acemoglu and Autor 2010). There is no coincidence that, while computerization of the economy made headway, recruitment trends altered. Compared to 1980s, 1990s and 2000s, demand for routine cognitive occupations, e.g. cashiers, as well as routine manual occupations, e.g. machine operators and builders, decreased with an accelerated pace: by 5,6% between 1981 and 1991, 6,6% between 1991 and 2001 and 11% between 2001 and 2011 (Jaimovich and Siu 2012). In parallel, employment in low-skill service occupations increased as long as workers reallocated their supply at this sector. More specifically, the share of US labor hours in service occupations increased by 30 percent between 1980 and 2005 after having been flat or declining in the three prior decades. As a result, there has been an increasingly polarized labor market, with middle-income routine occupations hollowed-out, accompanied by rising employment in high-income cognitive occupations and low-income manual jobs (Benedikt and Osborne 2013).

Nevertheless, in recent years, jobs in the service sector are at risk in industrialized countries, those that have experienced distinctive development during the last wave of mechanization. During the last world recession of 2008, 1 out of 12 service workers were dismissed. According to Figure 7, 47% of jobs in USA are confronted with high risk to computerization and robotic replacement, while 19% face a moderate degree of risk.

Figure 7. Probability of Computerization

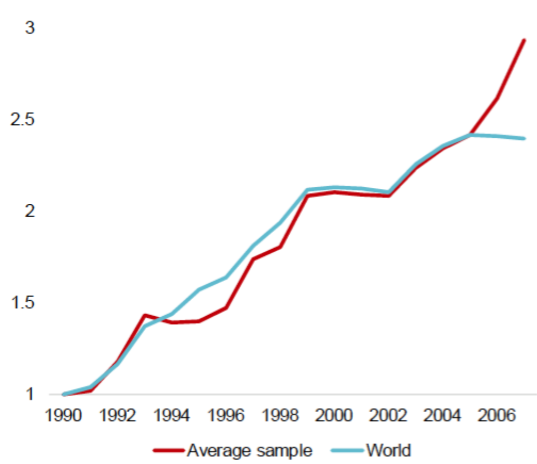


Source: Benedikt Frey and Osborne (2013)

The highest threat concerns 60% of the US workforce employed in the gathering and exploitation of information. Authors classify occupations on the basis of the retentive determinants in which mechanization collides and they are not confined to the distinction between routine and non-routine occupations or the distinction between manual and cognitive work (Benedikt and Osborne 2013).

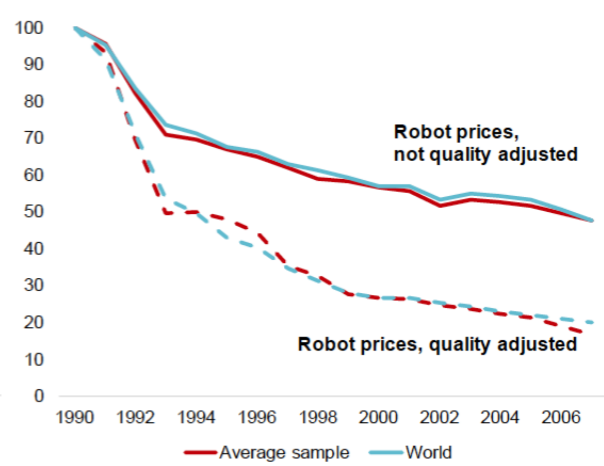
To summarize in economic terms, the selection between employment of people and robots (and the market) is determined by a compensation of costs. Minimum capital expenditure – e.g. upfront payments – and increased operating costs - i.e. daily costs such as wages and benefits - are required for human labor. On the contrary, robots are characterized by increased upfront capital costs and insignificant operating costs. Employers will prefer robots instead of human labor, as capital costs of robots are reduced, while operating costs of people are rising (Ross 2016). Continuing the analysis, Figures 8 and 9 show that industrial robots increased their competence and efficiency and their prices fell significantly between 1990 and 2006. Figure 8 shows that robots increased their average quality by three times between 1990 and 2005. In addition, Figure 9 shows that robots' price fell by more than 50 percent between 1990 and 2007.

Figure 8. Quality of Robots



Source: Calculations based on IFR (2006)

Figure 9. Robot prices



Source: IFR (2006)

The future of human employment seems to be uncertain, as robots become more efficient and profitable (Chiacchio, Petropoulos et al. 2018).

To conclude, there are two perspectives with regard to the impact of automation on the labor market. The first and most populous argues that new automation technologies, in spite of the fact that they reduce employment, increase productivity and result in the creation of new jobs. The second perspective is well represented by Keynes and is based on the argument of technological unemployment. The argument above is interpreted by three economic mechanisms: 1) inelastic demand, 2) rapid change, 3) increased inequality and by the decoupling of productivity and employment at the end of 20th century. In addition, automation affected different occupational categories with the passing of time. The first wave of automation induced a significant decrease in low – skilled employment and, since 1980, middle – income routine occupations were affected; accompanied by the polarization of the labor market. In the future, 47% of jobs in the US are confronted with high risk to computerization and robotic replacement, while 19% face a moderate degree of risk. To summarize, the substitution of human labor by robots entails a compensation of costs. As robots become more efficient and profitable for the employers, more and more jobs will eradicate.

4.4 Robots and labor markets.

As noted previously, rapid technological advancements in robotic technology and the increased use of industrial robots provoked major concerns about the future of employment and wages. For this reason, in the light of the research, the results of researches in US and Europe that analyze the impact of industrial robot usage on jobs and wages will be presented.

According to Acemoglu and Restrepo and their paper "*Robots and Jobs: Evidence from US Labor Markets",* they measure the equilibrium effect of industrial robots on local US labor markets between 1990 and 2007. Their analysis is based in a model where workers compete with robots for production and it points that:

"*The impact of robots on employment and wages in a labor market can be estimated by regressing the change in these variables on the exposure to robots, a* *measure defined as the sum over industries of the national penetration of robots into each industry times the baseline employment share of that industry in the labor market."* (Acemoglu and Restrepo 2017, pp. 3)

Furthermore, their empirical work is based on commuting zones, which are the US local labor markets. According to their results:

"Quantitatively, our estimates imply that the increase in the stock of robots (approximately one new robot per thousand workers from 1993 to 2007) reduced the employment to population ratio in a commuting zone with the average US exposure to robots by 0.37 percentage points, and average wages by 0.73 percent, relative to a commuting zone with no exposure to robots." (Acemoglu and Restrepo 2017, pp. 4)

In addition, they state that:

"The impact of robots is distinct and only weakly correlated with the prevalence of routine jobs, the impact of imports from China, imports from Mexico, offshoring, other computer technology, and total capital stock." (Acemoglu and Restrepo 2017, pp. 36)

To conclude, they assume that robots affect employment mostly in manufacturing sector; and low skilled workers (Acemoglu and Restrepo 2017).

To continue, according to Chiacchio, Petropoulos and Pichler and their paper *"The impact of industrial robots on EU employment: A local labour market approach"*, they measure the equilibrium effect of industrial robots on jobs and wages in six EU countries which are most exposed to robots. They use the local labor market approach established by Acemoglu and Restrepo for the US market for the same period. According to their results:

"We find that one additional robot per thousand workers reduces the employment rate by 0.16-0.20 percentage points. Thus a significant displacement

effect dominates. We find that the displacement effect is particularly evident for workers of middle education and for young cohorts. Our estimates, however, do not point to robust and significant results on the impact of robots on wage growth, even after accounting for possible offsetting effects across different populations and sectoral groups." (Chiacchio, Petropoulos et al. 2018, pp. 1)

In addition, they point out that the more active labor market policies in Europe and the more liberalized labor market in the US probably interprets the difference on employment rates between EU and US (Chiacchio, Petropoulos et al. 2018).

To conclude, the future increase in robots' usage could induce substantial consequences on employment rates and wages. Societies should adjust their welfare systems and workforce to this change through the redesigning of their labor market policies and regulations, if they want to decrease the possible social costs of disruption.

4.5 The role of State, culture, education and society.

Nowadays, States confront various and related challenges, as they have to achieve balance between growth and stability in an era of increasing inequalities. In addition, they have to tackle effectively the emerging challenges from the next wave of innovation and globalization in order to constitute the developing center of this innovation.

Technologies such as Internet and social media have led to a systematic loss of control over society by governments, as the government and the media no longer own the monopoly of information of citizens. Currently, society and politics are guided by the ideas and views that are shaped by citizens and consumers, as they are informed through an immense network. The powers that were exclusively intended for media corporations and governments have already been provided to citizens and citizens' networks through interconnection technologies. States and their economic performance will be greatly influenced by their response to this systematic loss of control and the diffusion of power (Ross 2016).

The confrontation between "open" and "closed" systems constitutes the main political bipolar of 21st century, in contrast to the last half of 20th century, which was the confrontation between communism and capitalism. According to Alec Ross:

"A society to successfully tackle the next wave of globalization and innovation should be open in order to exchange new ideas, conduct research away from political interference and undertake creative endeavors. Innovation requires this kind of openness." (Ross 2016, pp. 342)

In an economy of information, the economic success entails the openness of a system (Ross 2016).

Furthermore, Daron Acemoglu and James Robinson present another convincing argument for open institutions such as democracy, in their article "*The Problem With U.S. Inequality".* They argue that open institutions lead to prosperity and closed ones lead to poverty, offering us significant suggestions and caveats for the future:

"*Prosperity depends on innovation, and we waste our innovative potential if we do not provide a level playing field for all: we don't know where the next Microsoft, Google, or Facebook will come from, and if the person who will make this happen goes to a failing school and cannot get into a good university, the chances that it will become a reality are much diminished.*

The real danger to our prosperity lies in political inequality. The U.S. generated so much innovation and economic growth for the last 200 years because, by and large, it rewarded innovation and investment. This did not happen in a vacuum; it was supported by a particular set of political arrangements — inclusive political institutions —, which prevented an elite or another narrow group from monopolizing political power and using it for their own benefit and at the expense of society.

So here is the concern: economic inequality will lead to greater political inequality, and those who are further empowered politically will use this to gain a greater economic advantage by stacking the cards in their favor and increasing economic inequality yet further — a quintessential vicious circle."

As a result of their analysis, increased inequality of recent years could create closed institutions that will hinder our trajectory towards the new digital era with devastating effects on societies around the world (Acemoglu and Robinson 2012).

Continuing the analysis, the role of State and its impact on the direction of technological change for the benefit of society while decreasing inequalities will be examined. Acceleration in inequalities is not due to technological forces that leak from our control and the state can affect their course through public policy. Policy makers should have a definite concern on the direction of technological change and promote innovation of the type that the employment is increased and the human dimension of services provision is highlighted. The first expedient to attain this objective is the funding of scientific research. The iphone in the US constitutes the example of the crucial role of public funding, as its design was based on fundamental scientific and technological innovations that their research was funded from the Federal Government. Technological innovation is influenced in different ways by the State (Atkinson 2015). According to Mazzucato:

"It is important to recognize the 'collective' character of innovation. Different types of firms (large and small), different types of finance and different types of State policies, institutions and departments interact sometimes in unpredictable ways" (Mazzucato 2013, pp. 193)

If it is accepted that innovation stems from cooperative networks, the state has to advocate different policies and different organizational forms, e.g. flexible patent laws, open standards, interdisciplinary interaction (Atkinson 2015). To conclude, distribution effects of innovation policies should be the main concern of the state and should aim at the interest of society as a whole.

In addition, policy makers must take into account the importance of public employment and public services, which derives from the progress made in the overall economy, as their value will increase in the future. According to the Baumol phenomenon, which mainly applies to the public sector, slower productivity growth suggests that the relative cost of public services such as medical care, education and public administration is increasing over time, creating financial problems. As a result, some conclude that expenditures on public services should decrease alongside with public sector employment. In contrast, Baumol himself points out that, as societies become richer, public services should be attached with more value, as both the activity (e.g. teach in a school or treat a patient) and the value attributed to them determines their productivity. Therefore, States should aim to increase the productivity of the public sector employees by increasing investment in human capital (Atkinson 2015).

Furthermore, distinctive emphasis should be imputed to improve public administration. The effectiveness of public administration can lead to building a just society and improving the quality of its relations with citizens. A fair society should ensure transparency, fairness and acceptance of its services (e.g. taxation, public expenditures and legislature). The attainment of this objective entails investment in new processes and an independent and highly knowledgeable public administration. Improving State's efficiency can be accomplished through new technologies. When a State attempts to balance the cost savings that technological advancements entail, it should ensure the disadvantaged citizens, not only materially, but also with reference to their relation with new technologies. To conclude, disparities in access to information and communication technologies are often accompanied by increased economic inequalities (Atkinson 2015).

Many economists emphasize the importance of education for the creation of an innovative ecosystem and its role as a retentive determinant to economic inequalities. According to Claudia Goldin and Lawrence Katz, when education can not keep pace with rapid technological advancements, in general inequalities are increasing. Based on this ascertainment in the beginning of the last century, US made significant investments in primary education. As a result, in 1955, US had more than doubled percentage of students in secondary education beside any other European country at that time (Brynjolfsson and McAfee 2014). Over the past fifty years, this robust advantage in primary education eroded. According to the Organization For Economic Co-operation and Development (OECD) and its research *"Program for International Student Assessment (PISA)"*, held in 2009, ranked the fifteen-year-old American between 14th and 25th place among the thirty-four countries in reading, science and mathematics (OECD 2009). Potentially, US economy could benefit significantly from the closure of this gap. According to Eric Hanushek and Ludger Woessmann and their study on forty years data from fifty countries, the improved test score of students and the increased economic growth are strong correlated. This means, that US could have a significant impetus to GDP growth, if they were able to improve their students' educational level. However, in order to attain the above objective, every country, not only US, should reformulate its educational system for the purpose of reducing inequalities and benefiting from rapid technological change (Hanushek and Woessmann 2010).

Educational researcher Sugata Mitra, in his speech at the TED conference in 2013, gave a provocative explanation of how the current educational system was created and its emphasis on memorizing:

"I tried to look at where did the kind of learning we do in schools, where did it come from…it came from the last and the biggest of the empires on this planet (The British Empire).

What they did was amazing. They created a global computer made up of people. It's still with us today. It's called the bureaucratic administrative machine. In order to have that machine, running you need lots and lots of people. They made another machine to produce those people: the school. The schools would produce the people who would then become parts of the bureaucratic administrative machine. They must know three things: They must have good handwriting, because the data is handwritten; they must be able to read; and they must be able to do multiplication, *division, addition and subtraction in their head. They must be so identical that you could pick one up from New Zealand and ship them to Canada and he would be instantly functional."*

As Mitra points out, the Victorian English education system had been designed quite well for the time. But in a digital era, computers replaced people in this system. As a result, we should provide education by introducing digital technologies to ensure that people will benefit over digital work (Mitra February 2013).

Immense benefits from the use of technology in education over the next decade could be expected, as it is less useable than in other domains. For instance, Mitra noted that *Self-Organizing Learning Enviroments* (SOLEs) seem to teach children, even the poor and without education, the skills that will assure them with the necessary advantages for the new digital era. In his studies, groups of children are formed, relevant information are searched through the use of technology, learning material is discussed with each other, and eventually new ideas (to them) - very often proven to be right - are coming up. In other words, the skills of ideation, recognition of standards and composite communication are acquired and demonstrated by them. SOLEs have conformed multiple humans who have excelled with machines over the past few years (Brynjolfsson and McAfee 2014).

Furthermore, another remarkable example of the combination of technology and education are the *Massive Open Online Courses* (MOOCs) and the benefits that people can obtain from them. The first and most obvious one is that MOOCs allow, at low cost, the use of the best teachers, methods and content. Soon, students will have access to an abundance of free-form courses. The second and less distinct advantage of digitizing education is the most significant. An extensive data stream derives through digital education, which allows the feedback of both, the teacher and the student. As a result, teachers can continuously sharpen up and controllably experiment on new teaching methods. The real impact of MOOCs will be seen in the future, as greater number of people will have access to the best teachers, the overall level of teaching will increase by inventing new methods, and the progress of students will accelerate (Brynjolfsson and McAfee 2014). To conclude, our society is ready to use digitization and new technologies to attain a set of advances in existing approaches of teaching and learning.

Additionally, as robotics spreads rapidly, the culture of each country will affect the success rate of adopting robots and the benefits that will derive from them. The dealing of robots by the Eastern culture differs significantly in relation to the Western culture. Japan's technological know-how and cultural predisposition constitute significant advantages in order to adapt robotics effectively. The majority of Japanese embraces the ancient religion of Shintoism, which embodies faith in animism. According to animism, there is no distinction between humans and inanimate objects. In such a culture, robots could constitute equal members of a society and not just tools. On the contrary, the danger of escaping the creatures of man from his control prevails in the Western culture. A large part of the Eastern Asian culture is represented by Japan's cultural dynamics and as a result, the Asian robotic industry has the opportunity to grow rapidly (Mims 2010). A cultural ease with their presence is reflected by the investment in robotics. In China, there are more automation departments compared to US In addition, they are very well represented and respected in the academic community. The combination of cultural, demographic and technological determinants offers the advantage to Eastern Asia to benefit from the development of robotic technology (Ross 2016).

The competitiveness and stability of societies will be affected by the way of adapting to the new digital era. Societies and corporations should adapt and redirect their citizens to developing industries, such as robotics, in order to derive the greater profits that will emerge from new technologies. For instance, China invests massively in developing industries and she is not confined to forced urbanization to produce inexpensive labor. It is essential for societies to invest in developing sectors, but at the same time, they should ensure that the unemployed would find new jobs by establishing a social safety net. For example, the social safety net is strengthened in many Northern Europe's countries so that marginalized workers are likely to reappear in new sectors. As a result, the reinvestment in education and skills development of workers will be funded from the profits of new technology industries. As mentioned above, robots entail only capital costs. Nevertheless, the necessary operating costs for humans still remain. In the economy of tomorrow, the continuous cost of maintaining human competitiveness should be taken into account by societies (Ross 2016).

To conclude, the political system of a State and its institutions are key determinants in order to reduce inequalities and tackle the next wave of innovation. A state should attach distinctive emphasis to research funding, investment in the public sector and the improvement of public administration. In addition, every country should reformulate its educational system alongside with the use of new digital technologies in order to create an innovative ecosystem and reduce inequalities. Culture constitutes another key determinant for the adoption of new technologies and especially robots as it can provide a significant advantage to a country with regard to their development. Nevertheless, greater profits from the new digital era will end up to societies that invest in developing industries and ensure the maintenance of human competitiveness in the economy.

4.6 Conclusion.

In the previous chapter, the results of the research were presented. The way in which technological change and other determinants affect economic inequalities was analyzed. In addition, the determinant of automation was examined; to what extent it affects employment and more specifically, certain occupational categories. Furthermore, the results of researches in US and Europe that determine the impact of industrial robot usage on jobs and wages were cited. To conclude, the crucial role of State, education, culture and society in reducing inequalities was determined.

5. Conclusions

The above research examined and found a negative correlation between technological change and increased inequalities for the period after 1970s. In addition, automation affects jobs and wages in a fundamental way and more significant results seem to be induced in the future, as robots become more efficient and profitable. On the contrary, State, education, culture and society could act as key determinants in reducing inequalities.

In the light of the above research, "skill biased technological change" induced the increase in inequalities during 1970s, as relative productivity and demand of skilled labor increased over the unskilled labor. According to endogenous growth theory, the acceleration in the supply of skilled workers led to the development of skill-biased technologies as they became more profitable for corporations. As a result the capital-labor ratio for low-skill workers fell alongside with their wages. In addition, the interaction of technological change with the transformation of firms' organization, deunionization and international trade were proven as key determinants for the increase in inequalities. In the early 1980s, the introduction of frugal production resulted in an immense increase of productivity alongside with a significant loss of middle skill jobs and a reduction in real median incomes. At the same period, deunionization induced the extensive dispersion of wages and the loss of unions' bargaining power. International trade caused an elevation in the developing of skill-biased technologies that reinforced the employment of skilled workers and the decline in the wages of low-skill workers. Another key determinant of increased inequalities is technological change of capital intensity induced by corporations, as the global labor share in GDP decreased alongside with the increase in their profits.

In addition, the impact of automation on jobs and wages was examined and a negative correlation was found. The fact that automation induces unemployment was based on the argument of technological unemployment, that is well represented by Keynes (1931), and was interpreted by three economic mechanisms: 1) inelastic demand, 2) rapid change, 3) increased inequalities. Furthermore, the argument of most economists that productivity gains from new automation technologies result in the creation of jobs is questioned, as productivity decoupled from employment at the end of 20th century and the proportion of employment to the population is lower than any other period over the last 20 years.

To continue, the impact of automation on different occupational categories was examined. Since 1960, the first wave of automation induced a significant decrease in manufacturing employment and low-skilled labor. In recent years, automation affected middle-income routine occupations and resulted in a polarized labor market. Between 1981 and 2011, demand for routine cognitive and manual occupations decreased by 23,2% overall. In the future, 47% of jobs in the US are confronted with high risk to computerization and robotic replacement, while 19% face a moderate degree of risk. To summarize, the substitution of human labor by robots entails a compensation of costs. As robots become more efficient and profitable for the employers, more and more jobs will eradicate.

According to Acemoglu and Restrepo (2017), industrial robots' usage has a negative impact on jobs and wages on US labor markets. They found that each additional robot per thousand workers decreases aggregate employment to population ratio by 0.37 percentage points and aggregate wages by about 0.73 percent. In addition, Chiacchio, Petropoulos and Pichler (2018) examined the impact of industrial robots in six European labor markets. They found that each additional robot per thousand workers decreases employment rate by 0.16-0.20 percentage points, mainly for middle-skill workers, youth employees and men. In contrast, they do not found substantial negative impact of robots on wage growth.

To conclude, the "openess" of State's political system and its institutions are key determinants in order to reduce inequalities in the new digital era. A State can influence the direction of technological change through public policy and more specifically, through research funding, in order to increase the employability of workers and benefit the society as a whole. In addition, States should aim to increase the productivity of the public sector by increasing investment in human capital and they should improve public administration through new technologies. Furthermore, another key determinant in reducing inequalities and creating an innovative ecosystem is education. Every country should reformulate its educational system alongside with the use of new digital technologies, as the improved educational level of students could have a significant impetus on GDP growth. To conclude, culture constitutes another key determinant for the adoption of new technologies and especially robots as it can provide a significant advantage to a country with regard to their development. Nevertheless, greater profits from the new digital era will end up to societies that invest in developing industries and ensure the maintenance of human competitiveness in the economy.

5.1 Limitations

There were some limitations in the above research. Initially, the literature focuses on the impact of technological change mainly on the US economy and less on the European. In addition, the data of the examined literature were limited to the beginning of 2010s. To conclude, the papers and the data referred to the impact of industrial robots on jobs and wages were very limited.

5.2 Recommendations

An interesting field for future research is the pace of technological change and to what extent it affects inequalities, as societies seem to have adjusted to previous majors technological changes relatively easy in contrast to rapid advancements in IT technologies.

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