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Derleme Makalesi

THE RISE OF ROBOTS! EFFECTS ON EMPLOYMENT AND INCOME

ROBOTLARIN YÜKSELİŞİ! İŞSİZLİK VE GELİR ÜZERİNE ETKİLERİ*

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Abstract

Disruptive technological advances will have profound impacts on the employment landscape over the years to come. As in the past, new technologies will change the way humans live and work. Some occupations will become obsolete, while new occupations will emerge. Consequently, people will be displaced from some occupations, be forced to require new skills so that they can work in new occupations. Although the introduction of new technologies –robotization– has many dimensions, its effects will range from structural unemployment to distribution of labor income. The first question would be what will be the impact of new technologies on labor demand? Given that new technologies expectedly increase productivity, hence income, the second question would be how the raise be distributed between low and high skilled labor. Hence, this study focuses on the effects of robotization on the structural unemployment, its implications on labor demand and its income distribution effects. I review the current situation of robotization, and make recommendations to policy makers and corporate managers to get prepared for accelerating robotization and not only to mitigate its potential adverse effects on employment and income distribution, but also to take this as an opportunity to increase the quality of life for all.

Keywords: Robotization, Automation, Unemployment, Labor Market, High-skilled and Low-skilled Labor, Income Distribution, Wage Distribution.

JEL Codes: D30, J20, J23, J24, O10, O30

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Öz

Önümüzdeki yıllarda yıkıcı teknolojik ilerlemelerin istihdam üzerinde büyük etkileri olacaktır. Geçmişte olduğu gibi, yeni teknolojiler insanların nasıl yaşadıklarını ve çalıştıklarını değiştirecektir. Bazı meslekler modası geçip yok olacak, buna karşılık yeni meslekler ortaya çıkacaktır. Sonuç olarak, insanlar bazı meslekleri bırakacak; yeni mesleklerde çalışabilmek için ise yeni beceriler edinmek zorunda kalacaklardır.Her ne kadar robotizasyon gibi yeni teknolojilerin yaygınlaşmasının birçok boyutu olsa da, yapısal işsizlikten gelir dağılımına kadar da muhtemel etkileri olacaktır. Akla gelen ilk soru, yeni teknolojilerin işgücü talebi üzerindeki etkisinin ne olacağıdır? Yeni teknolojilerin üretkenliği, dolayısıyla toplam geliri artırdığı düşünüldüğünde, akla gelen ikinci soru ise gelirdeki artışın çalışanların farklı beceri düzeyleri özellikle de düşük ve yüksek kalifiye işgücü arasında nasıl dağılacağı olmaktadır.Bu nedenle, bu çalışmada robotizasyonun yapısal işsizlik, işgücü talebi ve gelir dağılımına etkileri üzerinde durulmuştur. Robotizasyonun mevcut durumu gözden geçirilerek, gitgide yaygınlaşan robotizasyonun işsizlik ve gelir dağılımı üzerindeki potansiyel olumsuz etkilerinin azaltılmasın yanında robotizasyonun genel yaşam kalitesini yükseltmek için bir fırsat olarak görülmesine yönelik politika yapıcılara ve şirket yöneticilerine tavsiyelerde bulunulmaktadır.

Anahtar Kelimeler: Robotizasyon, Otomasyon, İşsizlik, İşgücü Piyasası, Yüksek Vasıflı ve Düşük Vasıflı İş Gücü, Gelir Dağılımı, Ücret Dağılımı.

JEL Kodları: D30, J20, J23, J24, O10, O30

1.INTRODUCTION

Disruptive technological advances will have a profound impact on the employment landscape over the years to come. As in the past, new technologies will change the way humans live and work. Some occupations will become obsolete, while new occupations will emerge. Consequently, people will be displaced from some occupations, be forced to require new skills so that they can work in new occupations. [1]

Although the introduction of new technologies –referred to as robotization– has many dimensions, its effect will range from structural unemployment as well as distribution of labor income. The first question that comes out as new technologies keep shaping our future is what will be the impact of the new technologies on labor demand? Given that new technologies expectedly increase productivity, hence overall income, the second question is how the raise in income will be distributed among different skill levels of labor, especially between low – and high-skilled labor.

These questions are not new; they have been discussed while we had been experiencing the previous waves of automations in the past. For example, According to Nilsson (1984), Leontief (1983) wrote, "We are beginning a gradual process whereby over the next 30-40 years

1 For example, according to MGI (2017), "75 million to 375 million workers (3 to 14 percent of the global workforce) will need to switch occupational categories" by 2030.

many people will be displaced, creating massive problems of unemployment and dislocation. In the last century, there was an analogous problem with horses. They became unnecessary with the advent of tractors, automobiles, and trucks. ... So what happened to horses will happen to people, unless the government can redistribute the fruits of the new technology." On the other hand, according to Organization for Economic Cooperation and Development (OECD) (1998) study, the income generating effects of a new technology offsets its labor displacing effects and "technological progress has been accompanied not only by higher output and productivity, but also by higher overall employment." i.e. new technologies have positive implications on employment and income. However, we have been observing public concern over robotization. In his testimony before the Little Hoover Commission as mentioned in Atkinson (2018), he sees the reason as "[s]keptics and antagonists have engaged in hyperbolic and emotional rhetoric that the media then repeats and amplifies" about a new technology that it will create employment and income distribution problems.

Thus, in this study, I focus on the effects of robotization on the structural unemployment, its implications on labor demand and its effects on income distribution. I review the current situation of robotization and make policy recommendations to policy makers and corporate managers to get prepared for accelerating robotization and not only to mitigate its potential adverse effects on unemployment and income distribution, but also to take this as opportunity to increase the quality of life for all.

This paper is organized as follows. The next section discusses the theoretical framework for effects of robotization on employment and changing labor demand due to robotization as well as related literature. Section 3 discusses methodology. Section 4 discusses results and analyses of findings on the impact of robotization on the income of different skill levels, reskilling labor, and makes policy recommendations. Section 5 concludes the paper.

2. THEORETICAL FRAMEWORK AND LITERATURE

2.1. Effects of Robotization on Employment

There are two potential expectations for the impact of robotization on employment. The first is that it does not replace but rather complements humans. Hence, there will likely be more demand for labor, meaning more jobs rather than less. The second is that robots may replace humans, as they are more efficient. They can perform tasks in a much faster, more accurate and more cost-effective way, therefore displacing much of labor. As a result, there will be less jobs for humans, portending challenging times especially for the low-skilled labor-intensive occupations and economies. However, as "creative destruction" predicts, I conjecture that the former is a more plausible expectation. There is no question that new technologies will give way to the creation of new products and processes that are currently beyond our imagination, but

which will become everyday necessities in tomorrow's societies. New products and services would mean new occupations, unbeknown to us today.

In searching for the effects of robotization on labor usage, most analyses focus on existing jobs and occupations disregarding the potential occupations of the future. It is true that new technologies may make some existing jobs obsolete and create structural unemployment. However, who would have thought 50 years ago that search engine optimization (SEO), for example, will emerge and many will be needed to work as SEO experts. Another well-known example could be the smartphone industry. In every corner of our neighborhoods there is an outlet either selling or repairing smartphones or selling smartphone accessories. In many industries and countries, the most in-demand current occupations or specialties did not exist 10 or even five years ago. Most of today's children will end up working in completely new jobs that are unimagined now.

Substitution of humans for robots is most pronounced in jobs with routine repetitive tasks. In such cases, the resulting automation opens opportunities for improving the processes themselves leading to the creation of better quality products and services. The issue of the effects of automation on employment is not new. There has been opposing views since the early times of the discussion as Mokyr, Vickers and Ziebarth (2015) state. They mention opposing Ricardian and post-Ricardian views. On the one hand Ricardo (1821 [1971]) claims that the "substitution of machinery for human labour is often very injurious to the interests of the class of Labourers". He also adds that such substitution "may render the population redundant and deteriorate the condition of the labourer." On the other hand, Mill (1848 [1929]) states his disbelief on "improvements in production are often, if ever, injurious, even temporarily, to the labouring classes in the aggregate." In addition, Keynes (1930) made a note on effects of technological advances on employment by stating that "[t]he increase of technical efficiency has been taking place faster than we can deal with the problem of labour absorption; the improvement in the standard of life has been a little too quick." However, Mokyr et al. (2015) mention that analyses of early political economists lack to consider newly emerging job categories, rather their analyses focus on existing job categories which cannot lead to a complete analysis of effects of automation on labor. Hence, Mokyr et al. (2015) conclude that throughout history, technological advances have created more new jobs than they displaced. Of course, many jobs are displaced but the rate of job creation outpaces the former.

To understand accelerating technological improvement, one may consult Figure 1. It gives technological advancements in the vertical axis from oldest to newest, and the number of years passed until those technologies used by one-quarter of the US population. As seen in Figure 1, technology adoption is accelerating. Now, a new technological advancement spreads at a faster pace than previous ones. Each new technology in Figure 1 probably exterminated some of already existing occupations, and created new ones. This mechanism is prevalent independent of the technology introduced. What is different about the introduction of latest new technologies is that the speed is unprecedented; hence, it puts pressure on labor to update their skill set to accommodate emerging occupations with relative urgency.

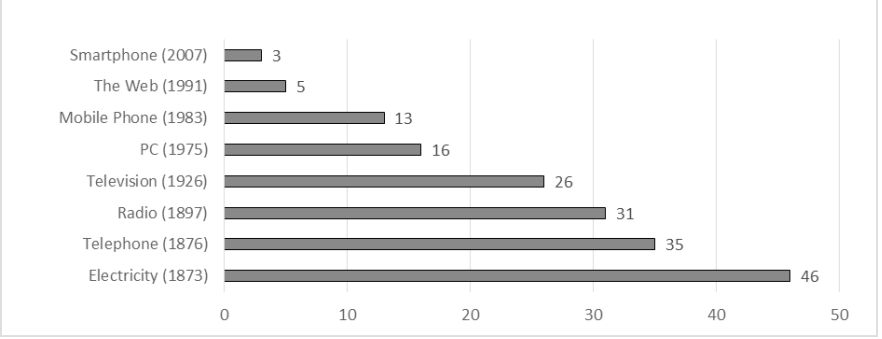

Figure 1: Technology Adoption (Years until used by one-quarter of the US population)
Data Source: Nielson

Some occupations are more prone to being displaced by automation, especially those that have routine and repetitive tasks. According to a report by McKinsey Global Institute (MGI) (2013), typists and telephone operators have been almost fully displaced in the U.S. data. In 2010, these occupations employ around 20% of what they used to do in 1972. Such a trend has been observed in other occupations as well. Secretary positions employ around 40%, general clerks and bookkeeping jobs employ around 60% of what they used to employ in 1972 according to MGI (2013).

Although there was a slowdown in the pace of automation due to the 2008-2009 economic and financial crisis, robot usage is again increasing at an accelerated pace as seen in Figure 2. The first effect of robotization is the reduction at the level of employment because of substituting labor with robots. However, the new production technology would lead to lower costs and higher levels of economic activity, hence higher aggregate demand. That, in turn, leads to higher employment. Furthermore, the use of robots would increase product variety; new products are created, that means economic activity is boosted further. Finally, the induced effect of reskilling of human capital would lead to higher demand for labor.

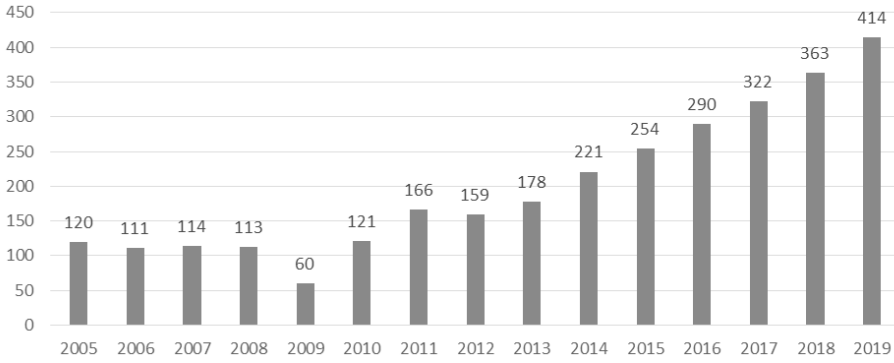

Figure 2: Worldwide Anuual Supply of Industrial Robots
Data Source: IFR World Robotics

Given that businesses adapt to new needs and governments provide necessary regulatory framework to provide incentives for innovations and adaptation, robotization could drive the creation of many new occupations. Education and training for new skills will help to satisfy the new labor demand due to new occupations.

Table 1: New Jobs Created by Robotics

Until 2008	8 to 10 million
2008 – 2011	500K to 750K
2012 – 2016	900K to 1.5 million
2017 – 2020	1 to 2 million

Source: Gorle and Clive (2013).

Gorle and Clive (2013) estimate the total effect of robotization on employment. Their estimate for the total number of jobs created as a result of using robots for the period up to and including the year 2008 is ranging between 8 to 10 million worldwide. [2] For the period of 2008-2011, they estimate between 500,000 to 750,000 new jobs; for the period from 2012 to 2016, they predict 900,000 to 1.5 million new jobs; from 2017 to 2020, their prediction is 1 to 2 million new jobs. Greatz and Michaels (2015) show that there is not any significant relationship between robotization and employment. Similarly, Gregory, Salomons and Zierahn (2016) estimate that robotization has raised labor demand by up to 11.6 million jobs across Europe, corresponding to almost half of the total observed employment increase over the period of 1999-2010. In other words, job-destruction effect is outpaced by job-creation effect resulting in net job gains.

A recent study by Asian Development Bank (ADB) iterates how technology affects jobs. [3] According to ADB (2018), the concern of negative effect of technology –read as robotization– on employment stem from taking only the displacement effect of automation into consideration. The study mentions that automation influences jobs in two broad lines: within firm or within industry and across industries. In the first one, three main straits are mentioned for automation's impact on jobs: the first one is displacement effect, the second is productivity effect, and the third one is reinstatement effect. In the first one, robots displace labor in routine tasks; as a result, labor demand decreases. i.e. displacement has negative effect on employment. In the second one, as productivity increases due to robotization, production costs decrease hence, price of products decrease, which increases demand for products. Such an increase in demand for products would increase labor demand as well. Hence, productivity effect might partially or fully offset the displacement effect. The last one is the omitted effect which is called by the ADB (2018) as reinstatement effect, meaning the effect of newly created occupations which will increase demand for labor. In addition to these effects, there might be ef-

2 They cover mainly automotive, electrical and electronics industries.

3 Asian Development Bank (ADB) (2018) How Technology Affects Jobs, Manila, Philippines.

fects due to cross-industry interaction. i.e. changes in one industry causes changes in another industry either through what is called income effect or substitution effect. After considering all these together with complementarity of labor and technology, elasticity of labor supply and adoption of new skills required by the changing workplace needs by labor would decide the net effect of automation, robotization on employment, ADB (2018) decides that "the anxiety over automation is overblown, and that predictions are unfounded that a majority of jobs in the developing world may be lost to automation." ADB (2018) claims that robotization has no significant impact on overall employment, although "[r]outine employment decreases with the increased usage of robots, while nonroutine employment increases."

Another important point raised by ADB (2018) is that most of the studies focus on technical feasibility of automation of tasks rather than economic feasibility; technical possibility does not mean that such a change is economically feasible. Figure 3 explains technical vs. economic feasibility of automation.

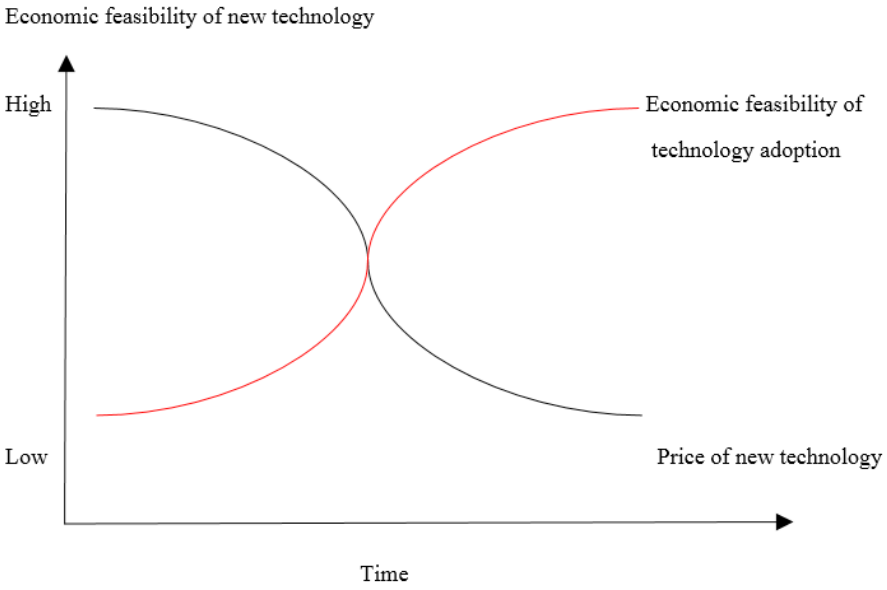

Figure 3: Technical versus economic feasibility of automation

Source: ADB (2018)

According to Figure 3, as time passes, price of new technology decreases. This, in turn, will increase its economic feasibility of adoption. ADB (2018) claims that "job displacement by robots to be economically more feasible in capital – and skills-intensive manufacturing such as transport equipment, chemicals, and electrical equipment … robot usage more common in sectors where wages are higher … the impact of robots on labor demand is larger in

developed countries than in developing countries." That is to say, employment in developed countries is in more danger than in developing countries, which is a counter intuitive claim by ADB (2018).

However, such a claim is backward looking. i.e. it is derived from the past and current state of the world. It does not consider the future. Following the logic of ADB (2018), as seen in Figure 3, economic feasibility of a new technology will increase in time. Hence, it may not be feasible to adopt robots for a certain task/occupation with a relatively higher wage today, but it will be feasible to adopt it tomorrow. As time passes, robotization will become more widespread towards lower wage categories as well. Therefore, ADB's (2018) claim is not right; the developing nations are not immune to potential effects of robotization, as time passes it will be feasible to adopt robots in developing nations as well. For example, Ozcan (2018) develops an index to show relative positions of Islamic Development Bank member countries.

2.2. Robotization and Changing Labor Demand

As the working environment changes due to automation and robotization, newly emerging jobs require new skills, and skills required to do existing jobs change as well. Introduction of automation and adaptation of robots make some basic skills insufficient to carry out a task by requiring higher skills. Either way skills required are changing. A report by McKinsey Global Institute (MGI) (2018) studies the coming shifts in demand for workforce skills by focusing on banking and insurance, energy and mining, healthcare, manufacturing and retail sectors. MGI (2018) considers skills in five broad categories, which are physical and manual, basic cognitive, higher cognitive, social and emotional, and technological skills.

Table 2: Skills Shift Across Categories **(**United States, All sectors, 2002-2030)

	Evolution in Skill Categories			**Change in Hours Worked**	
	% of time			**% difference**	
Skill Categories	**2002**	**2016**	**2030**	**2002-16**	**2016-30**
Physical and Manual	33	31	26	3	-11
Basic Cognitive	20	18	15	1	-14
Higher Cognitive	21	22	22	9	9
Social and Emotional	17	18	21	13	26
Technological	9	11	16	27	60

Source: MGI (2018).

Their results show significant changes at the weights of skills categories as automation gets widespread and more robots adopted in processes. As seen in Table 2, the biggest change occurs in technological skills category with subcategories basic digital skills, advanced IT skills

and programming, advanced data analysis and mathematical skills, technology design, engineering and maintenance, and scientific research and development. Table 2 shows that there are also increases at weights of other categories.

Social and emotional skills experience second highest increase after technological skills category. Advanced communication and negotiation skills, interpersonal skills, leadership and entrepreneurship, adaptability and continuous learning, and teaching and training others are mentioned as subcategories of social and emotional skills category by the report. Part of the weight basic cognitive skills category loses is gained by the higher cognitive skills category. The weight of the physical and manual skills category decreasing substantially, however, it sustains its top position among all the categories even after potential shifts occur. Hence, although the importance of physical and manual skills deteriorates, its share is still the largest.

The shift between 2002 to 2016 and 2016 to 2030 are different as well. There is an acceleration of the shift. Social and emotional skills and technological skills will experience accelerating gains between 2016 and 2030, compared to 2002 to 2016. Physical and manual skills and basic cognitive skills shares shrink faster in the period of 2016-2030.

These figures imply that demand for technological skills will rise significantly. Though at a lesser degree, the same conclusion can be made for social and emotional skills as well. i.e. there is going to be higher demand for social and emotional skills. There is a move of demand from basic cognitive skills to higher cognitive skills. As mentioned above in discussing weights of categories, although demand for physical and manual skills will decrease, the largest demand is still for the physical and manual skills category.

Economic structure plays a role in decision of skills shift. Although the trend is expected to be the same, different economic structures would imply different size shifts in skills categories. The figures in Table 3, which are given by MGI (2018), illustrate that different skill categories responds differently in size to automation and robotization. Technological skills category sees the highest hours worked percentage change in Spain and the lowest in Germany for example. For physical and manual skills category, Germany will experience the highest percentage decrease in hours worked as opposed to the lowest percentage decrease in United Kingdom. Since MGI (2018) analysis are done for United States and five European countries; United Kingdom, Germany, France, Italy and Spain, their findings are applicable to developed countries, whereas they may not be directly applicable to developing nations. Hence, similar studies have to be conducted to find out whether the findings of MGI (2018) are applicable for developing countries as policy makers take such findings as input to develop policies in order to cope with the changes coming due to automation and robotization.

Table 3: Skill Shifts Across Countries (Change in hours worked between 2016 and 2030, (%))

Skill Category	US	UK	Germany	France	Italy	Spain
Physical and Manual	-11	-12	-22	-15	-15	-20
Basic Cognitive	-14	-13	-22	-18	-15	-18
Higher Cognitive	9	9	5	6	9	4
Social and Emotional	26	21	23	20	27	20
Technological	60	52	41	53	61	66
Source: MGI (2018).						

In addition, robotization may also affect different skilled workers differently as automation may create demand for high-skilled labor, but mostly replace low-skilled workers. Greatz and Michaels (2015) provide evidence that "robot densification shifts demand from the low-skilled towards the high-skilled." That is, there is higher demand for skilled labor whereas demand for low-skilled labor suffers from robotization. In other words, low-skilled workers are the most vulnerable group to robotization.

According to Arntz, Gregory and Zierahn (2016) "[i]t is mostly low skilled and low-income individuals who face a high risk of being automatable." Supporting his findings, Frey and Osborne (2013) predicts labor market polarization. i.e. low-skilled and low-wage occupations are under more danger of robotization. Hence, low-skilled labor has to be reallocated to new jobs by acquiring necessary skills.

A survey done by Infosys with participants spread over 9 countries finds that over one-third of respondents claim they have had to learn new skills for their current job. In addition, they are aware that success in their career will depend on learning new skills continuously throughout working lives. Gaining new skills and training are now viewed as lifelong pursuits.

According to the findings mentioned so far, robotization does not put pressure on employment; rather, its impact is positive. However, there is constant need to update the skills set of workers in order to keep up with evolving division of tasks between machines and humans. Hence, the main challenge for the future of employment is not the number of jobs available; it is the form of jobs and required skill set, and how to acquire those skills.

3. METHODOLOGY

As pointed out earlier, disruptive technological advances will have a profound impact on the employment landscape over the years to come. Although this will have profound impact on human life at every aspect, this study focuses on the effects of robotization on the structural unemployment, its implications on labor demand and its effects on income distribution. After analyzing the current situation of robotization, the study aims to increase awareness on the potential effects of robotization by making policy recommendations to policy

makers and corporate managers to get prepared for accelerating robotization and not only to mitigate its potential adverse effects on unemployment and income distribution, but also to take this as opportunity to increase the quality of life for all.

This study searches for the effects of robotization on labor usage and its income distributional effects. In the literature, most analyses studying robotization's labor usage effects focus on existing jobs and occupations disregarding the potential occupations of the future. In addition, another question to be answered is who will get how much of the raise in income due to increased productivity because of robotization. i.e. how the raise in income will be distributed among different skill levels of labor, especially between low and high skilled labor. As the introduction of robots change the required skill set of an occupation, updating skill set of a worker or giving new skills required by a new occupation has paramount importance. However, the related literature is currently at infancy due to lack of data and robotization being at its early stages. There are introductory reports and some theoretical studies as mentioned in the previous sections. In order to answer these questions, this study first locates the related studies in the literature, and then investigates the studies that analyze effects of robotization. Finally, this study makes qualitative inferences for policy makers and corporate managers by comparing the results.

4. RESULTS AND ANALYSIS OF FINDINGS

4.1. Impact of Robotization on the Income of Different Skill Levels

Another important question is the impact of robotization on the income of different skill levels of labor. Past waves of mechanization and automation have been associated with higher labor productivity and wages. Similarly, as the introduction of robots increases productivity, the overall output will increase. As laid out in previous sections, the main worry today is not joblessness, but is a future in which the earnings of workers are still or falling, and the share of income going to the owners of robots increases. The big question becomes who is going to get how much of the raise in income. i.e. how the raise in income will be distributed among different skill levels of labor, especially between low – and high-skilled labor. This section discusses the facts about and findings of the effects of robotization on income of high and low-skilled labor.

Technology is complementary to low-skilled workers at the low technology levels. i.e. higher capital usage leads to an increase in demand for these workers. However, as the technology advances, it increasingly complements high-skilled workers. This leads to a relative shift in labor demand from low – to high-skilled workers. Accordingly, higher wage inequality, i.e. an increasing return to high-skilled workers is predicted by Arntz et al. (2016). They show that relative demand for high skilled labor increased on average by roughly 3% per year

in the 1970s and 1980s. This resulted in a decline of relative employment and relative wages for low-skilled labor. A comparable shift in relative labor demand and employment towards high-skilled workers in several OECD countries is also documented by Machin and van Reenen (1998). Note that high-skilled workers can create their own jobs like those in today's Silicon Valley. By using the data from O*NET [4], Frey and Osborne (2013) shows that wages exhibit a strong negative relationship with the probability of computerization –read it as robotization. In other words, as average median wage for an occupation decreases, the probability of computerization increases. Hence, high-skill and high-wage occupations are the least susceptible to robotization.

MGI (2013) states that benefits of robotics may not be evenly distributed, it could even contribute to widening income inequality. A recent study by Graetz and Michaels (2015) also shows that the introduction of robots led to an increase in labor demand for high-skilled relative to low-skilled workers between 1993 and 2007 by using data for 17 countries from International Federation of Robotics. The need for skilled labor will only grow with the adoption of technology. As robots are one of the latest technological advancements, they are expected to complement skilled workers as mentioned by Johnson (1997). Hence, they are likely one of the sources of the increasing inequality between high and low-skilled labor income. A World Economic Forum study (2017) states that the distribution of the value created due to the usage of new technologies is not even across countries. Economies mostly dependent on labor arbitrage will experience slowing economic growth, as technologies progressively facilitate competitive production in higher-cost environments. Hence, technologies will make current inequalities worse.

Guvenen, Kuruscu, Tanaka and Wiczer (2015) for example approach the topic from matching skills with occupations perspective. They claim that if workers are unable to adjust to the changing skill requirements at the same speed as the accelerating technological progress, in other words accelerating robot usage, the matching of workers' skills with occupations worsens. Such a mismatch early in one's life has a strong effect on his/her future wages.

Workers who are poorly matched with their occupations' skills requirements get lower wages even many years after they switch to a different occupation. The gap between best and worst matched is steady and over 15 years the cumulative difference is about $121,000 (in 2002 dollars) according to Guvenen et al. (2015). Hence, matching a worker's skills set with an occupation's skills requirement is important. As the introduction of robots change the required skill set of an occupation, updating skill set of a worker or giving new skills required by a new occupation has paramount importance.

4 O*NET is an online service developed for the US Department of Labor. The data contain information on 903 detailed occupations.

4.2. Reskilling

Compared to high-skilled workers, low-skilled workers have more adjustment needs since they are the ones whose tasks are more prone to automation. Therefore, investing in further training and occupational re-training may be a venue of increasing the probability of the employability of these workers. Studies like Sanders and De Grip (2004) indeed show that training raises the employability of low-skilled workers. However, according to Bassanini and Ok (2004), low-skilled workers in the past received much less training than high-skilled ones. Hence, given current technological trends, policies should address potential barriers to the participation of low-skilled workers in training and qualification measures.

Card, Kluve and Weber (2010) show that vocational training has beneficial medium and long-term effects on participants. As mentioned in Arntz et al. (2016), for example, vocational training in Germany raised the employment rate of participants by up to 13 percentage points in the medium term. Therefore, policies need to be tailored to different needs for training and occupational re-training to improve the chances of all skill levels to benefit.

By using survey data for 21 OECD countries, Arntz et al. (2016) concludes that low-skilled labor take most of the burden of the adjustment costs as the robotization of their jobs is higher compared to high-skilled labor. Thus, the challenge is to handle rising inequality and ensuring sufficient re-training especially for low-skilled labor. It is mostly low skilled and low-income individuals who face a high risk of being automatable. Hence, countries with a strong focus on high-qualified workers typically have lower shares of workers at high risk.

According to Frey and Osborne (2013) with the introduction of new technologies low-skill workers will be required to be reallocated to tasks requiring creative and social intelligence. For this, however, the workers will have to get necessary trainings and education in order to acquire creative and social skills. According to their estimate, 47% of total US employment is in the high-risk category.

4.3. Policy Recommendations

Given the effects of robotization on low-skilled labor, it is a potential danger not to act promptly and take preventive measures to soften the structural unemployment due to robotization. Timely measures will help protect and even enhance competitiveness in the international arena. Not acknowledging and not acting in a timely manner will create huge costs for individuals and countries.

As robotization affects mostly low-skilled labor and require workers to acquire new skills, the question is then how to hasten updating the skill set to enable workers to fill newly created positions resulting from robotization, be them in totally new jobs or an updated versions of existing jobs.

Extensive studies are needed to fully understand the effects of robotization. Initiatives to gather data on robotization should be supported so that in depth studies would be possible. Hence, policy makers should grasp the importance of the subject and increase their awareness to produce sound solutions in a timely fashion.

Research on effects of robotization on different industries should be supported. Such support is important to reach a critical mass of resources and studies that will help to construct relevant right policies in dealing with robotization. For example, as algorithmic trading has changed trading landscape hence manipulation at stock markets, in depth studies are needed in order to update existing policies or to develop new policies against new manipulation schemes (see Ozcan, 2012). Such studies are important in finding skills that are or will be in short supply and in addressing deficiencies originated from robotization.

The current education system need to be reformed. It is not enough to give 4-year college education and expect from a college graduate to perform well during the rest of his career. A recent World Economic Forum report finds that "[t]he global workforce is expected …to experience significant churn between job families and functions," and hence significant reskilling will be needed. Education becomes a lifelong process. Together with college education, conventional training and online training are important in spreading opportunities and learning new skills.

Rising income inequality creates economic, social and political challenges. As robotization might have adverse effects on income distribution, the issue is to produce policies parallel to the goal of lessening adverse effects of robotization on labor income of different skill levels. In addition, as countries whose economies mostly rely on labor cost arbitrage may be more prone to such adverse effects, policies need to be developed especially for such countries. In this regard, policies that invest in the human capital are key. Policies that promote the up-skilling have extreme importance in reversing the trend towards further growth in inequality. In other words, acquiring and deploying new and upgraded professional capabilities – reskilling– has the central role in achieving a just sharing of the created value.

Poverty, income inequality, limited access to many of the basic elements of well-being and limited economic and employment prospects constrain and threaten the stability and welfare of some of the most vulnerable groups in society. Hence, policies for inclusive growth are indispensable. In designing related policies, it is important to pay attention to inclusive human capital investment. Tax and transfer policies should be developed accordingly. In cash or in-kind government transfers may play an important role in making low-skilled labor not to fall further behind in income distribution. For example, developing relevant tax policies to spread job-related on-the-job trainings for the low-skilled would help to improve their productivity and earnings.

To achieve these goals, public resources may not be adequate, hence, public-private partnership projects on primary and secondary school education, as well as apprenticeships, internships, higher education and workforce reskilling and upskilling programs should be developed.

5. CONCLUSION

Robotization is an inevitable phenomenon. People will see more and more robot usage at every point in their lives from driverless cars to service robots. Although the introduction of new technologies i.e. robotization, has many dimensions, its effects will range from structural unemployment as well as distribution of labor income. The first question that comes out is what will be the impact of robotization on labor demand? Given that new technologies expectedly increase productivity, hence overall income, the second question becomes how such a raise in income will be distributed among different skill levels of labor, especially between low and high skilled labor. This study focuses on the effects of robotization on the structural unemployment, its implications on labor demand and its income distributional effects.

In search of effects of robotization on labor usage, one should focus not only on existing jobs and occupations but also on potential occupations, that robotization might bring out in the future. Some occupations are more prone to being displaced by automation, especially those that have routine and repetitive tasks. However, as Mokyr et al. (2015) point out, technological advances have created more new jobs than they displaced. Of course, many jobs are displaced but the rate of job creation outpaces the rate of job displacement.

According to the findings, robotization does not put pressure on employment; rather, its impact is positive. However, there is constant need to update the skills set of workers to keep up with evolving division of tasks between machines and humans. Hence, the main challenge for the future of employment is not the number of jobs available; it is the form of jobs and required skill set, and how to acquire those skills since robotization is likely one of the sources of the increasing inequality between high and low-skilled labor income. Related literature predicts higher wage inequality, i.e. an increasing return to high skilled workers due to robotization.

Introduction of automation and adaptation of robots make some basic skills insufficient to carry out a task by requiring higher skills. Skill set required are changing. Economic structure of a country plays a role in skills shift; different economic structures would imply different size shifts in different skills. In addition, robotization may also affect different skilled workers differently as automation may create demand for high skilled labor, but mostly replace low skilled workers. Evidence show that there is higher demand for skilled labor whereas

demand for low-skilled labor suffers from robotization. In other words, low-skilled workers are the most vulnerable group to robotization.

References

Arntz, M., Gregory, T. & Zierahn, U. (2016). *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis*. *OECD Social, Employment and Migration Working Papers,* No. 189.

Atkinson, R.D. (2018). *Testimony of Robert D. Atkinson Before the Little Hoover Commission, Hearing on Economic and Labor Force Implications of Artificial Intelligence.* Information Technology and Innovation Foundation.

Bassanini, A. & W. Ok, (2004). *How do Firms' and Individuals' Incentives to Invest ın Human Capital Vary Across Groups?* CEPN Working Papers.

Card, D., Kluve, J. & A. Weber. (2010). Active labour market policy evaluations: A meta-analysis. *The Economic Journal*, 120, F452-F477.

Frey, C. B. & M. A. Osborne (2013). *The Future of Employment: How Susceptible are Jobs to Computerization?* University of Oxford, Oxford.

Gorle, P. & A. Clive. (2013). *Positive Impact of Industrial Robots on Employment*. International Federation of Robotics, Metra Martech, London.

Graetz, G. & G. Michaels. (2015). Robots and work. *IZA Discussion Paper* 8938.

Gregory, T., Salomons, A. & U. T. Zierahn (2016). *Technological Change and Regional Labor Market Disparities in Europe*. Centre for European Economic Research, Mannheim.

Guvenen, F., Kuruscu, B., Tanaka S. & D. Wiczer. (2015). Multidimensional skill mismatch. *NBER Working Paper,* 21376.

Johnson, G. (1997). Changes in earnings inequality: The role of demand shifts. *Journal of Economic Perspectives*, 11(2), 41-54.

Keynes, J. M. (1930). *Economic Possibilities for Our Grandchildren. In Essays in Persuasion [1963]*. W.W. Norton, New York, NY.

Leontief, W. (1983). The New New Age That's Coming is Already Here. *Bottom Lane/Personal*, 4(8), 1.

Machin, S. & J. van Reenen. (1998). Technology and changes in skill structure: Evidence from seven OECD countries. *The Quarterly Journal of Economics*. 113, 1215-1244.

McKinsey Global Institute (2013). *Disruptive Technologies: Advances that will Transform Life, Business, and the Global Economy*. McKinsey & Company.

McKinsey Global Institute (2017). *Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automatio*n. McKinsey & Company.

McKinsey Global Institute (2018). *Skill Shift Automation and the Future of the Workforce*. McKinsey & Company.

Mill, J. S. 1848 [1929]. *Principles of Political Economy*, edited by W. J. Ashley. Longmans, Green and Co. London.

Mokyr, J., Vickers, C. & N. L. Ziebarth (2015). The history of technological anxiety and the future of economic growth: Is this time different? *Journal of Economic Perspectives*. 29(3), 31-50.

Nilsson, N. J. (1984). Artificial Intelligence, Employment, and Income. *AI Magazine*. 5(2), 5-14.

Organisation for Economic Co-operation and Development (OECD). (1998). *Technology, Productivity and Job Creation: Best Policy Practices*, Paris.

Ozcan, R. (2012). An analysis of manipulation strategies in stock markets. *Istanbul Stock Exchange Review*. 13(49), 19-37.

Ozcan, R. (2018). How will robotization affect relative positions of the IDB member countries? *The Journal of Knowledge Economy & Knowledge Management*. 13(1), 1-20.

Ricardo, D. 1821 [1971]. *Principles of Political Economy*. (3rd ed.) Pelican Classics, Harmondsworth.

Sanders, J. & A. De Grip. (2004). Training, task flexibility and the employability of low-skilled workers. *International Journal of Manpower*. 25(1), 73-89.

World Economic Forum (2017). *Technology and Innovation for the Future of Production: Accelerating Value Creation*, World Economic Forum, Geneva.

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