Skill-Biased Technological Change and Job Polarization and Evidences from The Turkish Labor Market[*]

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Beceri Yanlı Teknolojik Değişim ve İşgücü Kutuplaşması ve Türkiye İşgücü Piyasasından Kanıtlar

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Abstract

The purpose of this paper is twofold. The first is to present a historical perspective for the theoretical and conceptual change experienced in skill-biased technological change. The second is to test whether the job polarization hypothesis would be confirmed for Turkey. In this study, which is a qualitative analysis, using descriptive analysis method employment data obtained from ILOSTAT database between the years 1982-2019 for Turkey has been organized, categorized, summarized and interpreted. A cause-effect relationship has been established between the findings and comparisons have been made between the cases. In the descriptive analysis, it has been seen that Turkey has been experiencing a significant job polarization for the last two decades. After 2000, the share of high-skilled and low-skilled occupations in total employment has increased, and the share of medium-skilled occupations has decreased in Turkey. This situation is considered to be due to the technology is complementary for the high-skilled labor and the new job opportunities created by the growth of the service sector for the low-skilled.

Keywords: *Skill-biased technological change, job polarization, routine-biased technological change*

Öz

Bu makalenin amacı iki yönlüdür. Birincisi, beceri yanlı teknolojik değişimde yaşanan teorik ve kavramsal değişim için tarihsel bir perspektif sunmaktır. İkincisi, Türkiye için işgücü kutuplaşması hipotezinin geçerli olup olmadığını test etmektir. Nitel bir analiz olan bu çalışmada, betimsel analiz yöntemi kullanılarak ILOSTAT veri tabanından elde edilen 1982-2019 yılları arası Türkiye'ye ait istihdam verileri düzenlenmiş, sınıflandırılmış, özetlenmiş ve yorumlanmıştır. Elde edilen bulgular arasında neden-sonuç ilişkisi kurularak olgular arasında karşılaştırmalar yapılmıştır. Yapılan betimsel analiz sonucunda Türkiye'de son yirmi yılda belirgin bir işgücü kutuplaşması yaşandığı görülmüştür. Türkiye'de 2000 yılı sonrasında yüksek-vasıflı ve düşük-vasıflı mesleklerin toplam istihdam içindeki payı artmış ve orta-vasıflı mesleklerin payı azalmıştır. Bu durumun yüksek-vasıflılar için teknolojinin tamamlayıcı olmasından, düşük vasıflılar için hizmet sektörünün büyümesiyle yaratılan yeni iş fırsatlarından kaynaklandığı değerlendirilmektedir.

Anahtar Kelimeler: *Beceri yanlı teknolojik değişim, işgücü kutuplaşması, rutin yanlı teknolojik değişim*

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1. INTRODUCTION

The economic effects of technological developments are the growing debate in economics literature for a long time. The impact of dramatically changing technology has shown completely different effects in different economies and different sectors. In this paper, a subject related to the impact of technology on employment, changing skill demands and its effects on employment are discussed. The *Skill-Biased Technological Change* (SBTC) hypothesis, developed by Griliches (1969) and Welch (1970), suggests the increasing relative demand for skilled labor with the impact of technology. SBTC has been used for many years to explain the increasing demand for skilled labor due to the impact of technology. However, especially in the job polarization experienced after the 2000s, together with the high-skilled labor, it has also led to an increase in the demand for low-skilled labor. Moreover, the demand for medium-skilled labor has decreased in the same period. With this changing trend, it has been necessary to follow a different approach in SBTC hypothesis. For the first time, *Routine Biased Technological Change* (RBTC) hypothesis, developed by Autor et al. (2003) using *Task Model* approach has been introduced. RBTC has succeeded in explaining the job polarization experienced in the US in the last two decades with a task-based approach. And the same methodology has been tested for different countries and the same hypothesis has been confirmed.

The purpose of this paper is two-fold. The first is to present a historical perspective for the theoretical and conceptual change experienced in skill-biased technological change. The second purpose of this paper is to test whether the job polarization hypothesis would be confirmed for Turkey. In this study, which is a qualitative analysis, using the descriptive analysis method, the data has been presented in an organized, summarized and interpreted manner, and the necessary comparisons between the cases have been made by establishing a cause-effect relationship between the findings. It has seen that the job polarization experienced by developed and developing countries is the case for Turkey too.

In the first part of the paper, some background of the main theoretical frameworks of skill-biased technological change hypothesis is provided, firstly as the classical canonical model and then as a revised task model. In the second part, empirical studies on skill-biased technological change in the literature are included. Finally, skill-biased technological change has been evaluated for Turkey.

2. THEORETICAL FRAMEWORK

The theoretical framework of the paper consists of two main titles. In the first title, skill-biased technological change hypothesis and concepts related to the hypothesis are discussed. In the second title, the process of SBTC's evolution to routine biased technological change and new models of the hypothesis are discussed. In this way, the theoretical foundations of today's job polarization are presented from a historical perspective.

2.1. Skill-Biased Technological Change

The hypothesis of skill-biased technological change has initially been proposed by Griliches (1969) and Welch (1970) in the economics literature. The hypothesis basically describes the relationship and complementarity between technological change and skill levels. The original form of the hypothesis, which is called the "*canonical model*" by Acemoglu and Autor (2010) classifies workers into two main groups as skilled and unskilled, representing educated and uneducated workers. In the first forms of the canonical model, technology is assumed as exogenous. However, this presupposition is forsaken after general equilibrium models, and technology is accepted as endogenous (Raquel and Federico, 2018: 8).

According to SBTC, educated workers are in an advantageous position than uneducated workers in the face of developing technology. With the increase in technology, the demand trend in

the labor market also changes. The hypothesis suggests that the demand for high-skilled workers increases, while the demand for low-skilled workers tends to decrease. The literature acknowledges globalization and technological change as the most crucial causes of this increasing relative demand for the skilled worker (Haile et al., 2017: 4). However, the common view on this issue deems technology responsible for this demand shift and suggests that technology is skill-biased and skill-complementary (Tinbergen, 1974, 1975; Card and Dinardo, 2002; Piva et al., 2006; Acemoglu and Autor 2010 and Acemoglu and Restrepo, 2018a, 2018b).

When we look at the change in European Union countries' employment dynamics, it is obvious that the demand for educated workers has been rising for ten years and the demand for uneducated workers has been diminishing at the same period (see Figure 1). It is seen that the share of highly-educated people in employment, which is 29% in 2008, increases to 36% with an increase of approximately 25% in 2019. However, there has been a significant decrease in the employment of low skilled workers in the last decade. The share of low-skilled workers in employment has decreased from 21% to 17%. This figure gives a clear impression of the relationship between skills and unemployment. It is obvious that technology seems non-neutral and employment is relatively rising for skilled (educated) workers.
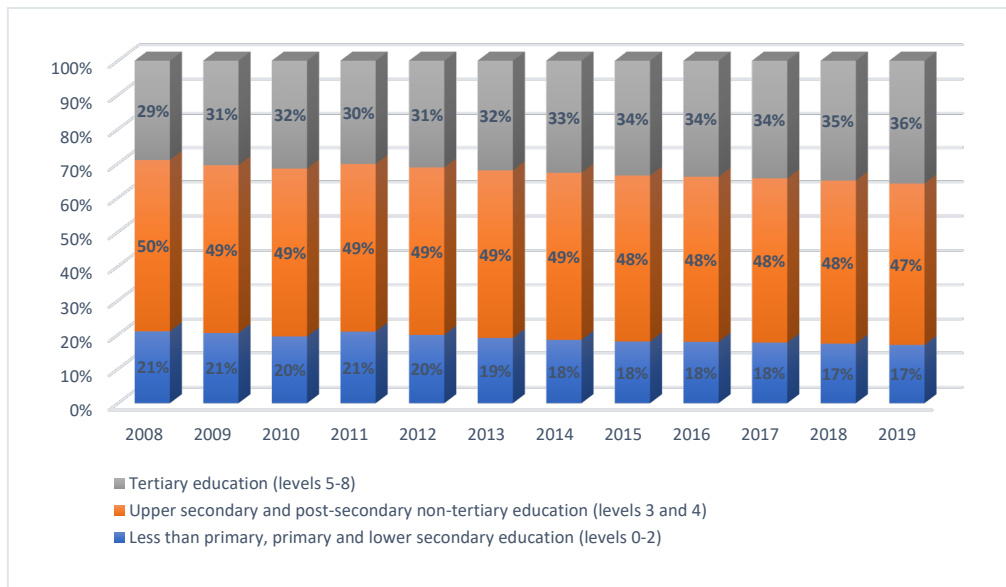

Figure 1: EU Employment by Education Level (Eurostat)
Source: Authors' graphics by using Eurostat (2020) database

Acemoglu and Restrepo (2020) suggest that the main reason for increasing demand in favor of high-skilled workers is rapid automation that has replaced occupations of less-skilled workers. SBTC hypothesis stresses that more skilled workers are more capable of adapting to technological change, and thus they are less likely to be replaced by technology (Hoedemakers, 2017: 12).

2.2. From Canonical Model to Task-Based Model and Job Polarization

The SBTC hypothesis has been served successfully in elucidating for the rise in demand for high-skilled labor throughout the twentieth century. Actually, it has been the standard explication to consider skill shifts in employment trends for less qualified workers in the 1990s (Raquel and Federico, 2018: 9). However, despite its magnificence, SBTC could not explain decline for demand in medium-skilled jobs and relative increment for demand in high-skilled and low-skilled jobs after the 2000s (Autor et al., 2006; Goos and Manning, 2007; Autor and Dorn, 2013 and Raquel and Federico, 2018).

Autor et al. (2003) (hereafter, ALM) revised the canonical model of the SBTC hypothesis and suggested a new hypothesis called *Routine Biased Technical Change*. Rather than using a simplistic classification of the canonical model as high-skilled and low-skilled, ALM developed a different model called *Task Model*. In this model, ALM conceptualize tasks from a *machine's-eye* view and to classify tasks they ask: *"Which of these tasks can be performed by a computer? "*. According to ALM, the tasks accomplished by machines are *routine* tasks such as monitoring the temperature of a steel finishing line or moving a windshield into place on an assembly line (1283). In this context, ALM propose four different categories to classify tasks: Routine manual tasks, routine cognitive tasks, non-routine cognitive tasks, non-routine manual tasks (See Table 1).

Table 1: Predictions of Task Model for the Impact of Computerization

	Routine Tasks	*Nonroutine tasks*
	Analytic and interactive tasks	
Examples	Record-keeping Calculation Repetitive costumer service (e.g., bank teller)	Forming/testing hypotheses Medical diagnosis Legal writing Persuading/ selling Managing others
Computer impact	Substantial substitution	Strong complementarities
	Manual Tasks	
Examples	Picking or sorting Repetitive assembly	Janitorial services Truck driving
Computer impact	Substantial substitution	Limited opportunities for substitution or complementarity

Source: (Autor et al.,2003: 1286)

Task model defines input of labor in terms of tasks. The main difference between SBTC and RBTC is their approach to skills and tasks. Acemoglu and Autor (2010: 2) define a task as *"unit of work activity that produces output (good and services)"*, and a skill as *"worker's endowment of capabilities for performing various tasks"*. RBTC presents a more appropriate approach to explain the shift in skill demand over the last two decades. For this reason, this model is used as the main methodology in many pieces of research investigating skill patterns after the 2000s.

Using ALM's task model Acemoglu and Autor (2010) show that demand for routine jobs and tasks has fallen no matter if they are cognitive or manual. This means a drop in middle-skilled jobs, while the demand for both high-skilled and low-skilled jobs are rising. Goos and Manning (2007: 118) call this process *"job polarization"*. Actually, they are the first to explain the relationship between routine tasks and job polarization (Raquel and Federico, 2018: 15). Raquel and Federico (2018: 6) see RBTC as the main driver behind job polarization. Goos and Manning (2007) explain the job polarization process as follows: Non-routine tasks as skilled professional and managerial jobs are well-paid skilled jobs and they are complementary to technology. Unskilled jobs such as cleaning are not directly affected by technology, but the technology-caused impact in the economy causes an increase in these jobs. So, technological development creates a rise in the relative demand for well-paid skilled jobs and low-paid least-skilled jobs, while it costs a drop in demand for medium-skilled jobs.

Job polarization is a clear phenomenon that has been seen worldwide in the last decades with the effect of rapidly developing technology. The distribution of this effect among skill levels depends on various factors such as geography, economic development level, labor force dynamics, educational infrastructure, as well as technology. Nevertheless, this process points to polarization at both tails, in the form of a rise in the high-skilled and low-skilled labor demand and a decline in the medium-skilled labor force at almost every level of development (See Figure 2).
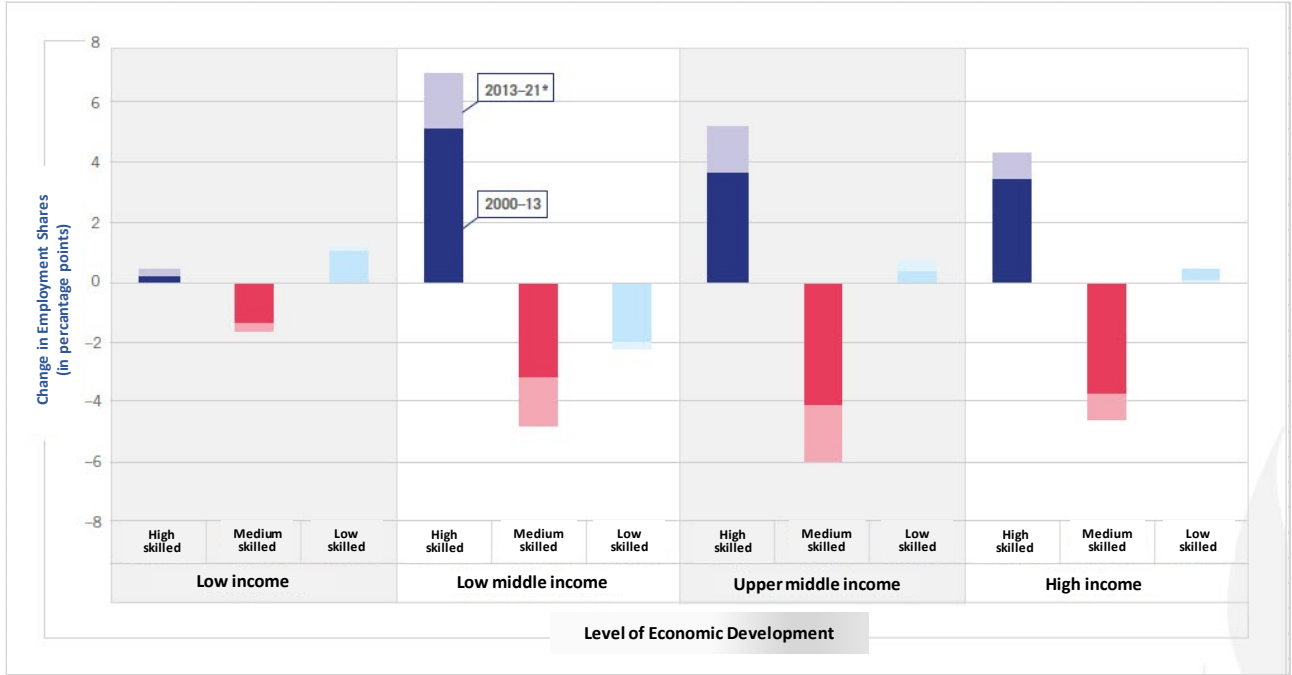
Figure 2: Job Polarization Around the World
Source: (ILO, 2018)

2020s technologies such as artificial intelligence, internet of things, big data, blockchain, industrial and service robots, 3D printing, machine learning and, quantum computers make the job-replacement possible for routine tasks. Chiacchio et al. (2018) argue that the displacement effect is more effective for medium-educated workers. Autor et al. (2003) attribute this job-saving effect to decline in the price of computer capital. These technologies will change skill requirements in almost every sector. Skill shortages and mismatches will cause increased labor costs, unfilled vacancies and higher unemployment rates (MGI, 2018). Conversely, thanks to adaptable re-training programs, appropriate skills will boost economic growth. Today's technologies are significant indicators for the skill requirements in the future (see Figure 3). These are some potential contributors to the job polarization phenomenon (Autor, 2010: 8):

- *Routine tasks replacing technological change*
- *International trade and offshoring of goods and services*
- *Declining private sector labor union penetration*
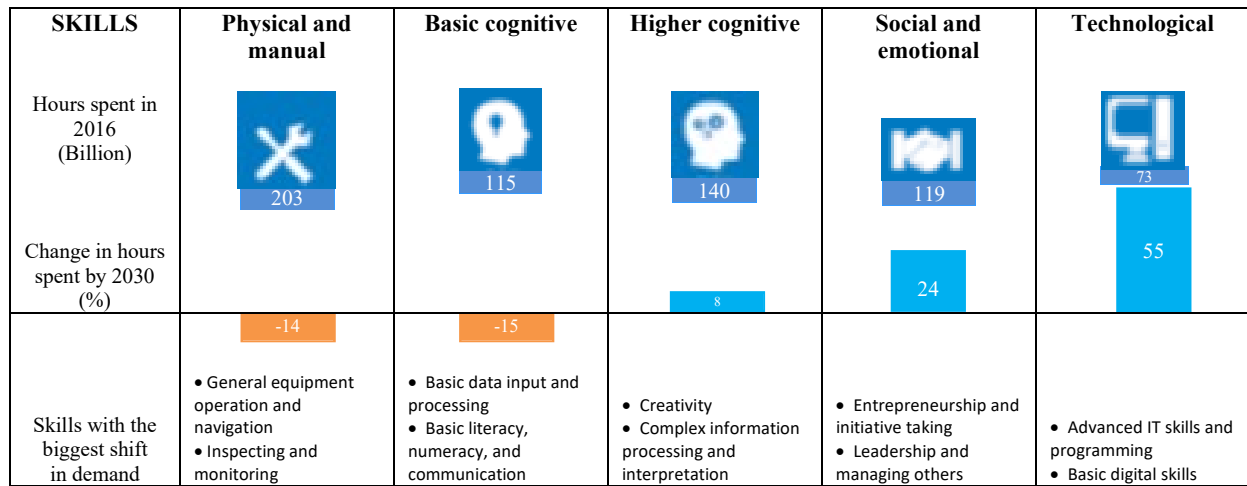- *The falling real value of the minimum wage*

SKILLS	Physical and manual	Basic cognitive	Higher cognitive	Social and emotional	Technological
Hours spent in 2016 (Billion)	203	115	140	119	73
Change in hours spent by 2030 (%)	-14	-15	8	24	55
Skills with the biggest shift in demand	• General equipment operation and navigation • Inspecting and monitoring	• Basic data input and processing • Basic literacy, numeracy, and communication	• Creativity • Complex information processing and interpretation	• Entrepreneurship and initiative taking • Leadership and managing others	• Advanced IT skills and programming • Basic digital skills

Figure 3: The Possible Change in Skill Requirements in 2030
Source: (MGI, 2018)

Moreover, SBTC and RBTC are two mechanisms that may increase inequality, because they favor particular groups of the labor force and reduce the employment possibilities for the others (Dachs, 2018: 29). Tuzemen (2019) claims job polarization is a contributing factor to the natural rate of unemployment and it lowers the rate. Job polarization mechanisms increase the demand in favor of high-skilled and low-skilled workers at the expense of the decreasing demand for medium-skilled manufacturing and routine office workers. High-skilled workers are complementary to technology and they are more prone to it. So, this provides a logical explanation for the increase in high-skilled employment. The share of the service sector in most of the economies has been increasing recently and this gives new opportunities for the low-skilled workers. So, this explains the rising demand for low-skilled workers. All of these polarizations seem to the disadvantage of middle-skilled workers and the trend for the last two decades confirms this phenomenon.

3. PREVIOUS EMPIRICAL STUDIES

Autor et al. (2003), using the task model they first developed, explore computerization is associated with reducing the demand of routine manual and routine cognitive tasks and increasing demand of nonroutine cognitive tasks for 1960 to 1998. And their model interprets the relative demand polarization favoring high-educated labor from 1970 to 1998. Thanks to their model translating task shifts into education demand, they succeed to explain 60% of the polarization in high-skilled labor.

Following Autor et al. (2003), Goos and Manning (2007) explain the process of job polarization in the UK. Although the SBTC model fails to explain the decline in demand for medium-skilled jobs, they prove that the task model seems appropriate for the job polarization in the UK and these findings are compatible with the analysis for the U.S. by Autor et al (2003).

Michaels et al. (2010) test the job polarization hypothesis for the US, Japan, and some European countries with the industrial-level data of the period between 1980 and 2004. Following task model approach by Autor et al. (2003), they find that the polarization is associated with information and communication technologies (ICT) in chosen countries. Their evidence suggests that the growth of ICT brings drop for middle-educated workers, whereas increases the relative demand for high-educated workers.

Autor (2010) deals with the job polarization in the US since the late 1980s. He sees the polarization in both tails of the occupational skill distribution is clear for the US high-educated and well-paid occupations (professional, technical, and managerial occupations) and low-educated and

low-paid occupations (food service, personal care, and protective service) have been rising since the 1980s in the US. He also finds this polarization contributes to earnings inequality.

Jaimovich and Siu (2012) suggest jobless recoveries and job polarization phenomena are related in the US over the last 35 years before 2012. They realize employment drop in medium-skilled routine occupations takes place during economic downturns. They classify the changes by occupations in three periods as 1982-1992, 1992-2002 and 2002-2017 (See Figure 4)
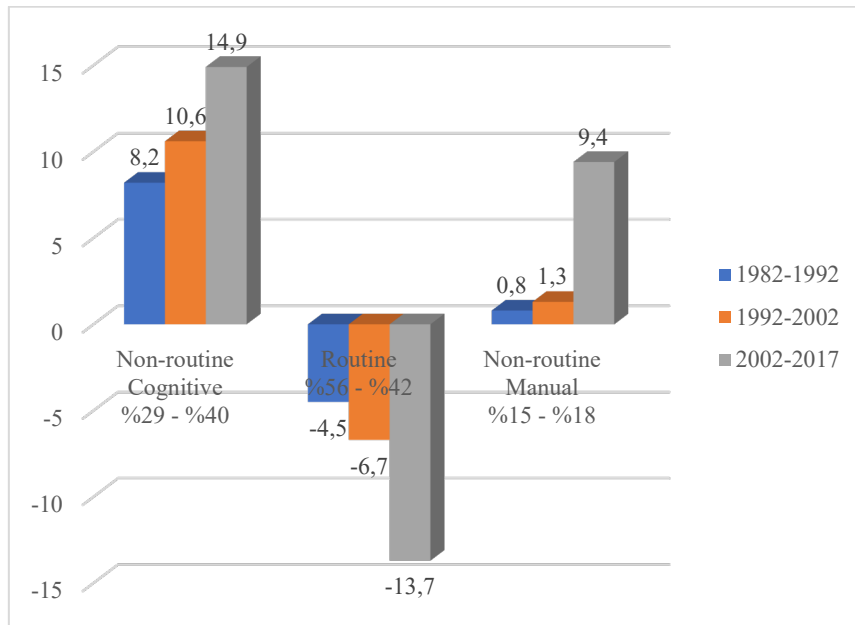

Figure 4: Percent Change in Employment Shares by Occupation Group
Source: Jaimovich and Siu (2012)

Autor and Dorn (2013) analyze the job polarization and wage polarization in the US over the period 1980-2005 in service jobs. With an equilibrium model, they conclude four implications for the analysis: Adaptation process for routine jobs in local labor markets is different, replaced low-skilled labor further reallocated into the service sector, earnings growth at the tails, an increase for skilled labor. Akcomak and Gürcihan (2013) analyze the labor market in Turkey and they find polarization trends similar to the industrialized countries during the period 2004 to 2010. They explain these trends with technology and globalization.

Goos et al. (2014) find the shares of employment for well-paid professionals and low-paid service workers are rising, whereas the shares of employment for manufacturing and routine jobs are falling. They explain this job polarization with RBTC and offshoring in European countries between 1993 and 2010. They also explain job polarization has within-industry and between-industry components using the shares of occupations.

Fonseca et al. (2018) explore job polarization in Portugal between 1986 and 2007. Their paper shows an increase in employment and wages for abstract tasks relative to routine tasks. They find the drop in routine manual jobs is sharp, but the drop in routine cognitive jobs is modest. They conclude that the results show polarization from the mid-1990s and this is consistent with technological change. Vom Lehn (2019) evaluates the job polarization hypothesis using cross-industry in the US economy. He finds that the decline in labor share is driven by routine jobs and associated with the replacement of high-skilled jobs since 2000.

Balsmeier and Woerter (2019) find that increased investment in digital technologies is associated with increased employment of high-skilled workers and most of the jobs are

complementary to technology. The findings for Switzerland suggest that low-skilled and middle-skilled occupations are in relatively greater risk to automation. Apart from these studies, Falk and Seim (2001), Aguirregabiria and Alonso-Borrego (2001), Gera et al. (2001), Piva et al. (2005), Meschi et al. (2011, 2016), Haile et al. (2017), Ikenaga (2009) and Montresor (2019) provide evidence of labor polarization from respectively Germany, Spain, Canada, Italy, Turkey, Ethiopia, Japan and UK.

4. EVIDENCE FROM THE TURKISH LABOR MARKET

The International Standard Classification of Occupations (ISCO) is one of the main international classifications for occupations. The methodology of the system ISCO has been updated many times since its first version in 1957. In our paper, we use three versions of ISCO in our descriptive analysis to look into the data for Turkey. In order to avoid possible methodological deviations in comparisons, we evaluate the data in this way in three periods. The data of the first period from 1982 to 2000 is in the system of ISCO-68, the second period from 2001 to 2010 is in the system of ISCO-68 and last period from 2011 to 2019 is in the system of ISCO-08 which is the last updated version of ISCO. ISCO allows making classification in terms of a set of occupational titles and skill levels for these occupations.

The first period for Turkey from 1982 to 2000 is the period in which the agriculture sector is the dominant in the economy. Thus, the share of the jobs related to this sector is predominant (see Figure 5 upper left). Agriculture, animal husbandry, forestry workers, fishermen and hunters are the first in the classification of occupations in this period. Over the 18 years, the share of these jobs in employment increases from 4% to 34%, meaning an increase of eight times in total. In this period, production and related workers, transport equipment operators and laborers experience the most employment loss. While the share of these jobs in employment is 43% in 1982, it drops to 27% in 2000. When we look at the share of professionals and managing jobs representing high-skilled occupations, the share is around only 10% and seems stable during the period. Since the shifts to the service sector in the economy coincided with only the end of this period, there is no distinctive increase in the service workers share during the period.

The second period, after the 2000s, is the period that the agriculture sector loses its dominance in the Turkish economy. The 2000s is a period in which the share of the services sector in total employment throughout the world increased. While the share of agriculture in total employment worldwide is approximately 40% in 2000, this rate decreases to 33% in 2010 in ten years (World Bank, 2020). During the same period, the share of the services sector in total employment rises from 39% to 44%. Looking at the distribution of employment by sector, a similar trend is also the case for Turkey. Within ten years, while the share of the agricultural sector has decreased from 36% to 23%, the share of the services sector has increased from 40% to 50% (ILOSTAT, 2020).
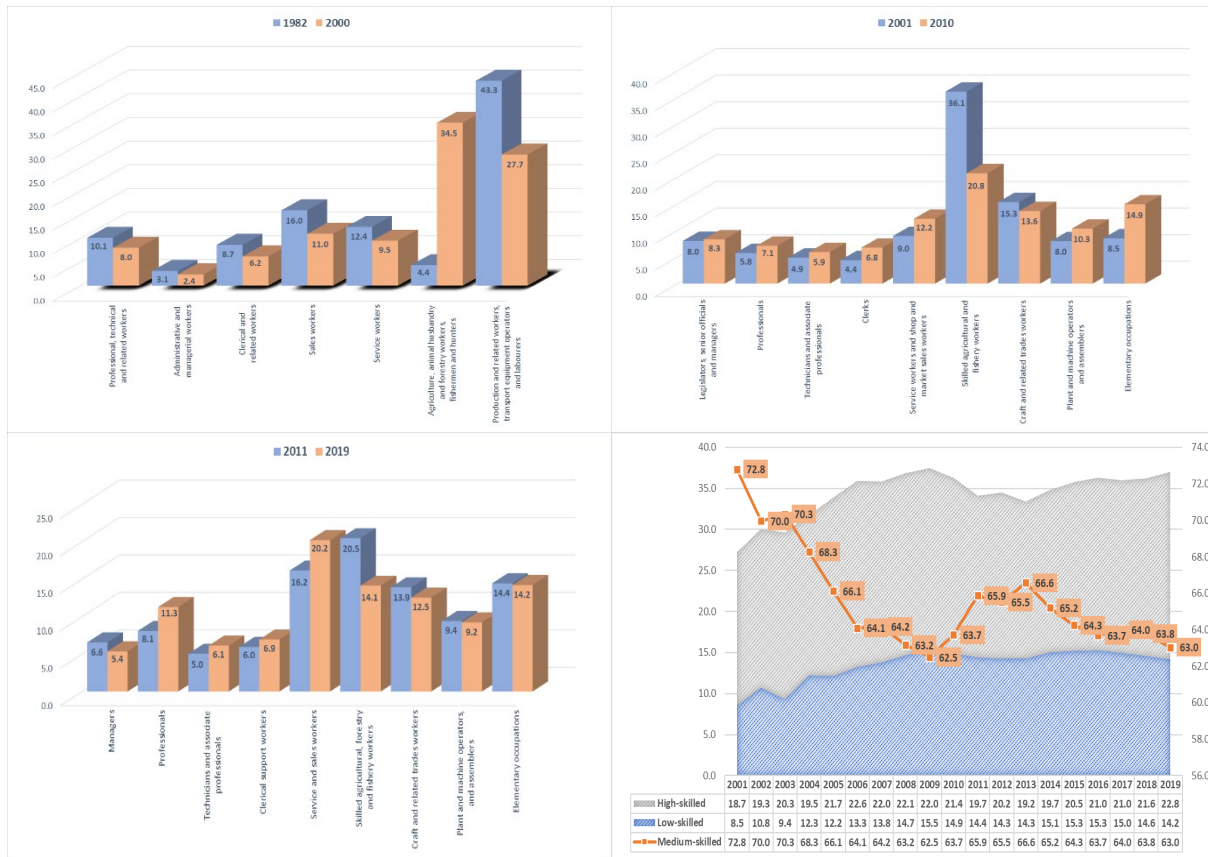
Figure 5: Job Polarization in Turkey
Source: Authors' graphics by using ILO (2020) database.

This change in the sectoral distribution of employment is also seen in the distribution of employment by occupational groups. The share of agriculture sector related jobs, which has the largest weight in the first period decreases from approximately 36% to 21% in ten years in Turkey (see Figure 5 upper right). According to the International Labour Organization (ILO) classification; managers, professionals, technicians and associate professionals are high-skilled occupations. The share of high-skilled jobs in total employment in Turkey rises from about 19% to 21% between 2001 and 2010. Likewise, elementary occupations representing low-skilled occupations in ILO classification increases from 8% to 14% in a decade (see Figure 5 bottom right).

The other occupations including clerks, service workers, shop and market sales workers, skilled agricultural and fishery workers, craft and related trades workers, plant and machine operators, and assemblers are medium-skilled. The share of medium-skilled jobs in Turkey dropped from %73 to 64% in this decade (see Figure 5 bottom right). An increasing trend for both high and low skilled occupations and decreasing trend for medium-skilled occupations are clear evidence of job polarization for this period. And the job polarization trend is compatible with the job polarization trend in developed countries which we tell in detail in the theoretical framework of this paper.

In the last period, including 2011-2019, the decreasing trend of employment in the agriculture sector and the increasing trend of employment in the service sector is going on. Turkey also follows this trend along with other developed and developing countries. The share of employment in agriculture sector drops to %19 of total employment and the share of employment in service sector rises to 54% in 2019 in Turkey (ILOSTAT, 2020). The share of agricultural workers decreases from %20 to 14% and the share of service and sales workers increases from %16 to 20% between 2011 and 2019 (see Figure 5 bottom left).

The skill shift also seems to continue in the last decade. The share of high-skilled occupations reaches about 23% which is the highest rate of history for Turkey. The rate for low-skilled

occupations seems close to the last period and it is about %14. It seems stable after 2008 and the rate is between 14% and 15% in the last two decades. The share of medium-skilled occupations declines from 66% to 63% between 2011 and 2019. It also seems stable in Turkey for the last two decades. When we look at the figures of 2010 and 2019, the shares of high, medium and low skilled occupations are respectively 21.4%, 63.7%, 14.9% for 2010 and 22.8%, 63%, 14.2% for 2019. So, job polarization trend does not seem to get deep for the last decade, but it seems stable in this period. Nevertheless, job polarization hypothesis argues the polarization in the last two decades. Therefore, when we look at the figures of the last two decades, 2001 and 2019, the shares of high, medium and low skilled occupations are respectively 18.8%, 72.8%, 8.5% for 2010 and 22.8%, 63%, 14.2% for 2019. The rise of employment in both high-skilled and low-skilled occupations and the drop in employment in medium-skilled occupations in the last two decades are clear-cut. Certainly, this case indicates the presence of job polarization for Turkey in the last two decades. Moreover, this polarization trend is close to developed countries even though Turkey is still a developing country.

It is considered that the main reason for job polarization in Turkey is technology-based, which is also accepted as the main reason for job polarization throughout the world. The shift between sectors in favor of the services sector plays an important role in skill shift. The rise in the services sector brings with rising demand for low-skilled labor. Technological changes, on the other hand, increases the demand for high-skilled labor and reduces the demand for medium-skilled labor.

5. CONCLUSION

Technology is not-neutral for the job skills and it affects the skill demand since the first industrial revolution. Shifting skill demands are firstly explained by SBTC developed by Griliches (1969) and Welch (1970). The SBTC hypothesis argues the increasing relative demand for skilled labor. However, the polarization trend for skills has changed since 2000. In the new trend, the employment demand for both high-skilled and low-skilled labor increases, whereas the demand for medium-skilled labor decreases. Autor et al. (2003) explain this new trend with routinization of jobs and tasks and develop a new model called task model. In this model, job polarization is explained by RBTC.

The shifting demand for skills is also experienced in Turkey. The share of high-skilled employment increases from 8.5% to 14.2%, the share of medium-skilled employment drops from 72.8% to 63%, the share of low-skilled employment rises from 18.8% to 22.8% in the last two decades. Therefore, job polarization trend is obvious in Turkey for the last 20 years. Moreover, this polarization is compatible with the trend in developed countries. High-skilled workers are complementary to technology, thus the rising trend of these workers in the age of technology seems natural. The share of the service sector in the economy has been rising dramatically since 2000. Therefore, the replaced workers from the manufacturing occupations have an opportunity to find a new job in the service sector. That can be accepted as one of the most important factors to explain the rising demand for low-skilled labor.

In the age of Industry 4.0 (the fourth industrial revolution), technology is at home, at school, at work. Technology is everywhere particularly with mobile internet, artificial intelligence, internet of things, big data, mobile phones, cloud platforms. Smart technologies also occupy the manufacturing industry with smart factories. Industrial robots, 3D printers, artificial intelligence and other new technologies have started a new silent production revolution in the manufacturing industry. This revolution has changed the skill demands for the workers of smart factories. As humankind, we have to discover the benefits of these technologies and use them in favor of human. Shifting demand for skills is a clear fact. We should accept this fact and learn to adapt it.

REFERENCES

Acemoglu, D. and Autor, D. (2010). Skills, tasks and technologies: Implications for employment and earnings. *NBER Working Paper No. 16082*.

Acemoglu, D. and Restrepo, P. (2018a). Low-skill and high-skill automation. *Journal of Human Capital*, *12*(2), 204-232.

Acemoglu, D. and Restrepo, P. (2018b). Artificial intelligence, automation and work. *NBER Working Paper No: 24196*, National Bureau of Economic Research Inc.

Acemoglu, D. and Restrepo, P. (2020). Unpacking skill bias: automation and new tasks. *AEA Papers and Proceedings*, 110, 356-61.

Aguirregabiria, V. and Alonso-Borrego, C. (2001). Occupational structure, technological innovation, and reorganization of production. *Labour Economics*, *8*(1), 43-73.

Akcomak, S. and Gurcihan, B. H. (2013). Türkiye işgücü piyasasında mesleklerin önemi: Hizmetler sektörü istihdamı, işgücü ve ücret kutuplaşması", *Türkiye Cumhuriyeti Merkez Bankası Çalışma Tebligi*, 13/21.

Autor, D. (2010). The polarization of job opportunities in the us labor market: implications for employment and earnings. *Center for American Progress and The Hamilton Project.*

Autor, D. H. and Dorn, D. (2013). The growth of low-skill service jobs and the polarization of the US labor market. *American Economic Review*, *103*(5), 1553-97.

Autor, D. H., Katz, L. F. and Kearney, M. S. (2006). The polarization of the U.S. labor market. *American Economic Review Papers and Proceedings*, *96*(2), 189-94.

Autor, D., Levy, F. and Murnane R. (2003). The skill-content of recent technological change: An empirical investigation. *Quarterly Journal of Economics*, 118, 1279-1333.

Balsmeier, B. and Woerter, M. (2019). Is this time different? How digitalization influences job creation and destruction. *Research Policy*, *48*(8), 103765.

Card, D. and Dinardo, J.E. (2002). Skill-biased technological change and rising wage inequality: some problems and puzzles. *Journal of Labor Economics*, *20*(4), 733-83.

Chiacchio, F., Petropoulos, G. and Pichler, D. (2018). The impact of industrial robots on EU employment and wages: a local labour market approach. *Bruegel Working Paper*, 18 April 2018, Issue 02.

Dachs, B. (2018). The impact of new technologies on the labour market and the social economy. *The STOA Project*, The European Parliament's Science and Technology Options Assessment (STOA) Panel.

Eurostat (2020). European Commission Eurostat [database]. Available from https://ec.europa.eu/eurostat/data/database?node_code=org.

Falk, M. and Seim, K. (2001). The impact of information technology on high-skilled labor in services: Evidence from firm-level panel data. *Economics of Innovation and New Technology*, *10*(4), 289-323.

Fonseca, T., Lima, F. and Pereira, S. C. (2018). Job polarization, technological change and routinization: Evidence for portugal. *Labour Economics*, 51, 317-39.

Gera, S., Gu, W. and Lin, Z. (2001). Technology and the demand for skills in Canada: An industry-level analysis, *Canadian Journal of Economics*, *34*(1), 132-48.

Goos, M. and Manning, A. (2007). Lousy and lovely jobs: the rising polarization of work in Britain. *Review of Economics and Statistics*, *89*(1), 118-33.

Goos, M., Manning, A. and Salamons, A. (2014). Explaining job polarization: routine-biased technological change and offshoring. *American Economic Review*, *104*(8), 2509-26.

Griliches, Z. (1969). Capital-skill complementarity. *Review of Economics and Statistics*, 51, 465-68.

Haile, G., Srour, I. and Vivarelli, M. (2017). Imported technology and manufacturing employment in Ethiopia. *Eurasian Business Review*, *7*(1), 1-23.

Ikenaga, T. (2009). Polarization of the Japanese Labor Market: The adoption of IT and changes in task contents. *The Japanese Journal of Labour Studies*, 584, 73-90.

ILO (2018). The impact of technology on the quality and quantity of jobs. *The Future of Work*, International Labour Office (ILO), Issue Brief Series No 6.

ILOSTAT (2020). International Labour Organization database [database]. Available from https://ilostat.ilo.org/data/.

Jaimovich, N. and Siu, H.E. (2012). The trend is the cycle: job polarization and jobless recoveries. *NBER Working Paper Series*, Working Paper 18334, Revised November 2018.

Meschi, E., Taymaz, E. and Vivarelli, M. (2011). Trade, technology and skills: Evidence from Turkish microdata. *Labour Economics*, 18, 60–70.

Meschi, E., Taymaz, E. and Vivarelli, M. (2016). Globalization, technological change and labor demand: a firm level analysis for Turkey. *Review of World Economics*, 152, 655–80.

MGI (2018). Skill shift automation and the future of the workforce. *McKinsey Global Institute*, Discussion Paper, May 2018.

Michaels, G., Natraj, A. and Van Reenen, J. (2010). Has ICT polarized skill demand? Evidence from eleven countries over 25 years. *NBER Working Paper,* No. 16138.

Montresor, G. (2019). Job polarization and labour supply changes in the UK. *Labour Economics*, 58, 187-203.

Piva, M., Santarelli, E. and Vivarelli, M. (2005). The skill bias effect of technological and organisational change: Evidence and policy implications. *Research Policy*, *34*(2), 141-57.

Piva, M., Santarelli, E. and Vivarelli, M. (2006). Technological and organizational changes as determinants of the skill bias: Evidence from the Italian machinery industry. *Managerial and Decision Economics*, 27, 63-73.

Raquel, S. and Federico, B. (2018). The routine biased technical change hypothesis: a critical review. *Joint Research Centre*, Technical Report, European Commission, Luxembourg.

Tinbergen, J. (1974). Substitution of graduate by other labour. *Kyklos*, 27(2), 217-26.

Tinbergen, J. (1975). Substitution of academically trained by other manpower. *Review of World Economics*, *111*(3), 466-76.

Tuzemen, D. (2019) Job polarization and the natural rate of unemployment in the United States. *Economics Letters*, 175, 97-100.

Vom Lehn, C. (2018). Understanding the decline in the U.S. labor share: Evidence from occupational tasks. *European Economic Review*, 108, 191–220.

Welch, F. (1970). Education in production. *Journal of Political Economy*, 78, 35-59.

World Bank (2020). The World Bank DataBank [database]. Available from https://databank.worldbank.org/home.aspx.