CHAPTER 3 / BÖLÜM 3

STRUCTURAL ECONOMIC CHANGE AND DIGITAL TRANSFORMATION IN TÜRKİYE'S MANUFACTURING INDUSTRY

TÜRKİYE İMALAT SANAYİİNDE YAPISAL EKONOMİK DEĞİŞİM VE DİJİTAL DÖNÜŞÜM

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ABSTRACT

The fact that the Fourth Industrial Revolution and the digital transformation are changing the balance in the world economy has far reaching consequences for powerful developed countries and emerging ones. As the structural economic change unfolds, only a few countries have achieved high income status by making the right shift between sectors as required by the development process. Looking at Turkey's productivity growth and structural change trends in the decades between 1990 and 2020, we observe that the contribution of structural change to total productivity increased in 1990-2000 and early 2000s similar to Asian countries where structural change was at the forefront. However, the contribution of structural change to total productivity growth in the period of 2011-2020 was the lowest. Examining Turkey's digital technology indicators and the information and communication technology (ICT) intensities of manufacturing sectors, we discern that the share of low and medium-low digital intensity sectors in the Turkish manufacturing industry has decreased by 20 percentage points in the last 50 years, while the share of high and middle-high digital intensity sectors has increased at the same rate. We argue that in order to succeed in designing effective digital transformation policies to increase the productivity in manufacturing sectors, policy makers need to closely follow the digitalization trends in the ICT intensive sectors and improve Turkey's standing in international digitalization indicators by focusing on the priority areas, which will in turn contribute to Turkey's long term macroeconomic targets.

Keywords: Structural Economic Change, Digital Transformation, Turkish Economy, Manufacturing Industry, Information and Communication Technology

ÖZ

Dördüncü Sanayi Devrimi ve dijital dönüşümün dünya ekonomisindeki dengeleri değiştirmesi; ülkeler bu dönüşümü gerçekleştiremezse, güçlü ülkelerin güçlerini kaybetmesine ve yeni aktörlerin doğmasına neden olabilecek yıkıcı bir devrim olarak karşımıza çıkmaktadır. Dünyada birçok ülkede yapısal ekonomik değişim devam ederken, kalkınma sürecinin gerektirdiği sektörler arası geçişi başararak yüksek gelir statüsüne ulaşabilen oldukça az sayıda ülke bulunmaktadır. Türkiye'nin verimlilik artışı ve yapısal değişim eğilimleri 1990-2020 yılları arasındaki 10 yıllık dönemlerde incelendiğinde, 1990-2000 ve 2000'li yılların başında yapısal değişimin toplam verimliliğe yüksek katkı sunduğu gözlenmekte, böylelikle Türkiye yapısal değişimin ön planda olduğu Asya ülkelerine benzediği değerlendirilmektedir. Öte yandan, 2011-2020 döneminde ise yapısal değişimin toplam verimlilik artışına katkısı en düşük düzeyde gerçekleşmiştir. Ekonomik büyüme ve yapısal değişim arasındaki bağlantının üretkenlik kanalıyla sağlanması ve dijital dönüşümün üretkenlik artışının önemli bir sürükleyicisi olması nedeniyle Türkiye'nin dijital teknoloji göstergelerini ve imalat sektörlerinin bilgi iletişim teknoloji (BİT) yoğunluklarını yakından inceledik. En genel anlamda, Türkiye imalat sanayiinde düşük ve orta-düşük dijital yoğun sektörlerin payının son 50 yılda 20 puan azaldığı, yüksek ve orta-yüksek dijital yoğun sektörlerin payının ise aynı oranda arttığı görülmektedir. Politika yapıcıların imalat sektörlerinde verimliliği artırmaya yönelik hazırlayacakları dijital dönüşüm politikalarının başarısı için, dijital yoğun sektörlerdeki eğilimlerin yakından takip edilmesinin ve Türkiye'nin uluslararası dijitalleşme göstergelerindeki yerinin öncelikli alanlara odaklanılarak geliştirilmesinin önem arz ettiği değerlendirilmektedir.

Anahtar Kelimeler: Yapısal Ekonomik Değişim, Dijital Dönüşüm, Türkiye Ekonomisi, İmalat Sanayii, Bilgi İletişim Teknolojileri

1. Introduction

It is well known that the Fourth Industrial Revolution and Digital Transformation are changing the balance in the world economy, and if countries cannot achieve the new transformation, it will be experienced as a devastating revolution that may cause powerful countries to lose their power and new actors to be born.

As the structural economic change continues in many countries in the world, there are a few successful countries that have achieved high income status by making the right shift between agriculture, manufacturing, industry and service sectors as required by the development process. For instance, manufacturing value added to GDP at constant prices ratio reached its peak level in Argentina, South Africa, Brazil, Mexico, Indonesia, and Russia in the early 2000s and decreased afterwards, which is known as "premature deindustrialization" by Rodrik (2015). Therefore, whether structural change in developing countries will resemble the early experiences of developed countries emerges as an area of great discussion on the scientific front.

While economic and technological development are surrounded by uncertainties, governments are developing comprehensive digital economy strategies and action plans to put structural economic change and digital transformation on track. On the other hand, the impact of digitalization is uneven by country and sector. For the success of the policies that policy makers create for digital transformation, it is necessary to analyze the recent trends of the economy in the field of digitalization and to determine the priorities according to the digitalization needs of the sectors.

In this study, we examined the effects of Turkey's last 30-year structural economic change on productivity growth in 10-year periods and discuss digital transformation, which is an important driver of structural change.

Our study proceeded as follows: we started with highlighting structural change from a historical and regional perspective. This is followed by structural change and the productivity path of Turkey in the last 30 years along with composition of the manufacturing industry, respectively. We then reviewed the literature on digital technologies as a driver of productivity growth and presented Turkey's current position in international digital rankings. In the last part of section 3, we analyzed the digital intensities of the Turkish manufacturing industry. Finally, in the last part we provided the reader with concluding remarks.

2. Structural Change from the Historical and Regional Perspective

Structural change is defined as long-term changes in the composition of economic aggregates (Streissler, 1982). Going into the detail of this definition, two aspects come to the forefront. First, in order for the composition of aggregate blocks to change, there must be structural change that affects the disaggregate units by a different magnitude. Consistent with this implication, Simon Kuznets, who received the Nobel Prize in Economics in 1971, claimed that technological innovation has differential effects on sectors, which inevitably leads to rapid changes in the production structure (Kuznets, 1973). Second, these differential effects are effective in the long run, making the phenomenon of structural change an important topic of economic growth. Therefore, structural change could be summarized as a long-term shift in the share of some sectors in the aggregate economy, resulting from the fact that some sectors were growing faster than others (Krüger, 2008).

The link between growth and structural change is provided through the productivity channel, where there is reallocation between low productive and high productive sectors (Chenery et al., 1986). Historical evidence showed that the agricultural sector constituted the largest part of total employment in the early stages of development. In the following stages, the share of the manufacturing industry in total employment first increased in line with the increase in the level of development, and then started to decline after reaching its peak, thus, resembling a hump-shaped curve (Van Neuss, 2019). In the expansion period of manufacturing, as argued by Rodrik (2013) and Felipe et al. (2014), industrialization was claimed to be the engine of economic growth, triggering labor productivity increased by its absorbing capacity of capital and technology. While the share of the service sector in total employment is low in the early stages of development, it has a steady increasing trend in the later stages, and in this respect, it continues to increase its share even in developed countries.

If we look at historical trends in the context of structural change, as seen in Table 1, there were some heterogeneities between developing and developed countries. Asian countries showed similar trends in three main sectors as developed countries in Europe and North America. While the share of the agricultural sector in total employment in the East Asia & Pacific region decreased from 51% in 1991 to 25% in 2019, the share of the manufacturing industry in employment increased from 21% to 26%.

On the other hand, it is evident that the share of manufacturing sector employment in African and Latin American countries peaked and turned downwards before their per capita income level reached to the level of developed countries in North America and Europe. Rodrik

(2015) named the manufacturing sector's transition to the shrinking phase before the country reached a high income level as "premature deindustrialization".

Looking at African regions, it is noteworthy that the agricultural sector still has a very high share. The fact that half of total employment operates in the agricultural sector, which causes low agricultural productivity as well as suppresses economy-wide productivity, explains why there is a large gap in living standards between Africa and other regions. The services sector is still behind in developing countries, which is related to the stages of development. In the first stages of development, service sector activities generally cover basic level works such as housekeeping, trade, and basic transportation activities, while in the advanced stages of development, sectors cover more complex activities such as finance, software, aviation and telecommunication. Therefore, evaluating the service sector in Africa with the stages of development, it is understood that the growth potential of the sector is high with the high potential of the development level of the country.

Table 1. Employment Shares by Sector, %

	Agriculture				**Manufacturing**				**Services**			
	1991	**2000**	**2010**	**2019**	**1991**	**2000**	**2010**	**2019**	**1991**	**2000**	**2010**	**2019**
Africa Eastern & Southern	66	66	63	59	10	9	9	9	24	25	28	31
Africa Western & Central	59	57	49	42	12	11	11	13	29	32	39	45
East Asia & Pacific	54	45	35	25	21	22	26	26	25	33	40	50
South Asia	63	59	51	42	15	16	21	24	22	25	28	34
Latin America & Caribbean	21	19	15	14	24	22	22	20	55	59	63	66
Europe & Central Asia	15	14	10	8	33	28	25	24	51	58	64	68
North America	2	2	1	1	26	24	20	20	72	75	79	79
World	44	40	33	27	22	21	22	23	34	39	45	51

Source: World Bank

2.1. Structural Change and Productivity Growth Path of Turkey in the last 30 years

In this section, Turkey's productivity growth and structural change trends were analyzed in terms of 10-year periods between 1990 and 2020. There are three reasons why we analyzed this time period. First, with the acceleration of the globalization trend since the 90s, rapid changes have occurred in the main sectors of agriculture, industry, and services in developing countries. Considering the mixed results in the Latin America and Asia cases, did structural

change contribute to the productivity increase in Turkey in this period? Secondly, did the structural reform process that affected the services and industry in the early 2000s lead to productivity-enhancing structural changes in the related sectors? Third, could the structural change achieved in the reform process between 2000-2010 be sustained in the 2011-2020 period?

As in the previous section, it is useful to follow the historical development of sectoral employment patterns before calculating the contribution of the structural change in productivity. As can be seen in Figure 1, Turkey's agriculture and service sectors seem to follow the same path that high-income countries in North America and Europe followed in the previous development periods. The agriculture sector, which constituted almost one third of the total employment 30 years ago, has declined to 18%, while the service sector was in a constant state of increase during the same period. On the other hand, as a developing country, the share of the manufacturing industry in total employment decreased by five percentage points in the same period. So, does this outlook mean that Turkey has joined the premature deindustrialization league?

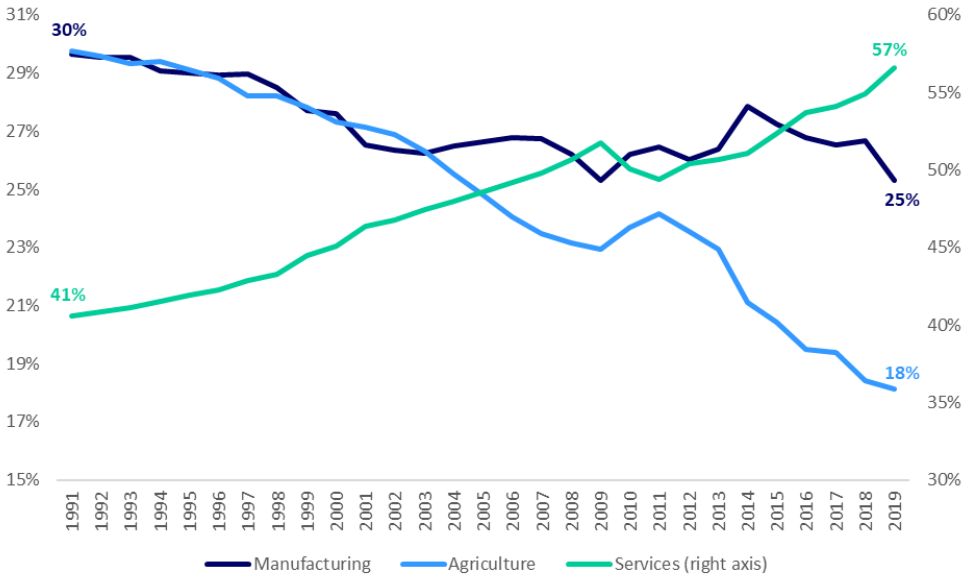

Figure 1. Employment Shares by Sector in Turkey between 1990-2019
Source: World Bank

The recent literature criticized the use of the share of sectors in total employment as an indicator of industrialization. There were studies arguing that if the productivity was high enough, even if the share of the industrial sector in employment decreased, the share of total industrial production in GDP might not decrease, so deindustrialization could not be claimed for a country in such a case (Škuflić and Družić, 2016). Some of the studies that raised this criticism started to use the share of industry value added in to the GDP as an indicator of deindustrialization. However, new criticisms have emerged for this indicator as well. Since the prices of manufactured products tend to decrease and service prices tend to increase during the economic development process, the share of the manufacturing industry in GDP could decrease without a decrease in total production, and it would not be correct to argue that there is deindustrialization in production for an economy in this situation. The share of the value added of the manufacturing industry in GDP with constant prices has been used as a solution to these arguments (Rowthorn and Ramaswamy, 1997).

As it is seen in Figure 2, the share of Turkey's manufacturing industry value added in to the GDP at constant prices peaked at 17% in 2017 and remained close to this value in the following three years. Therefore, contrary to the manufacturing employment rate indicator in Turkey, it is understood that there is no shrinkage in the manufacturing industry in terms of value added. In this sense, Turkey differs positively from Latin American countries as well as South Africa and Russia, which entered deindustrialization in both employment and production indicators at an early stage. On the other hand, China, India, and Poland do not show deindustrialization in either indicator.

While the manufacturing employment share decreased by five percentage points in the last 30 years and the deindustrialization problem was not seen in the production angle, this situation can be interpreted as an ongoing increase in productivity which puts pressure on employment in Turkey. On the other hand, the agricultural sector, whose share in employment declined to 18% as of 2020, has the potential to further decline to 5%, which is the level of developed countries, in the coming years. In this case, there is the risk that the unemployment rate may rise as a result of the inability to sufficiently employ the workforce that will emerge from the agricultural sector in the services sector.

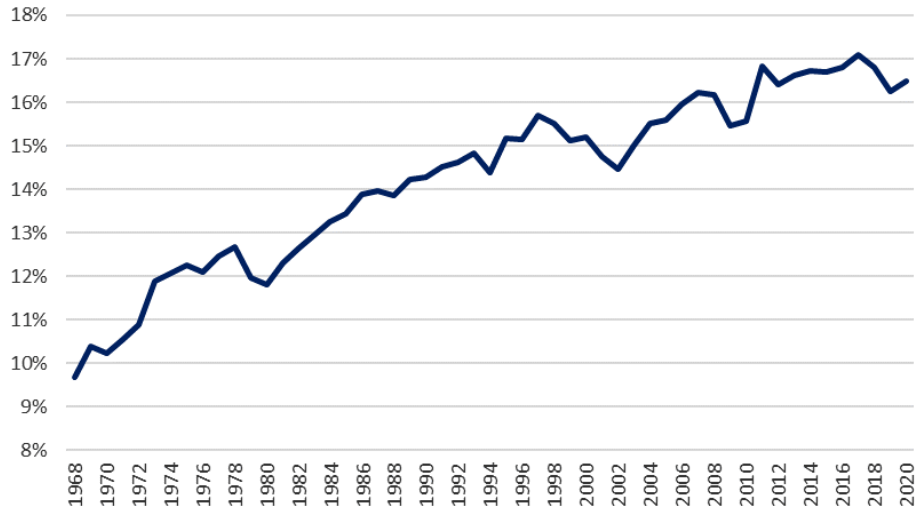

Figure 2. Manufacturing Value Added Share in GDP (constant 2015 US$) in Turkey between 1968-2020
Source: World Bank

Another important issue that we needed to analyze in this section was to what extent and direction the sectoral changes affected the productivity growth in the last 30 years. Structural change and productivity calculations of Turkey were studied by Rodrik (2010) for the period 1990-2005. We updated Rodrik's calculation for the 2005-2020 period in order to address the issues of sectoral structural change and digital transformation together.

Since the employment data in the NACE Rev.1 classification published by TURKSTAT starts from 1989, the starting year of the analysis period was set as 1990. Due to the fact that the sectoral employment data published after 2009 is in the NACE Rev.2 classification, 18 sectoral employment data of NACE Rev.2 format for the 2011-2020 period were distributed to 9 sectors in the NACE Rev.1 branch of activities. In order to create a long-term sectoral value-added series, the national accounts data set published by TURKSTAT was used. Sectoral value added in chain linked volume with 2009 benchmark year for the 1998-2020 period and sectoral value-added series for the period of 1990-1997 at 1987 basic prices were linked to each other by adjusting the series with the 1987 benchmark year by using sectoral value-added growth rates and regrouping sectors in both series in NACE Rev. 1 format. Sectoral decomposition created for the partial analysis in this study is shown in Table 2.

Table 2. Sectoral Aggregation			
	Sector	**Full Name**	**Sectoral Aggregation**
1	AGR	Agriculture	"Agriculture and livestock production", "Forestry","Fishing"
2	MIN	Mining	"Mining and quarrying"
3	MAN	Manufacturing	"Manufacturing"
4	PU	Public utilities	"Electricity, gas, water"
5	CON	Construction	"Construction"
6	WRT	Wholesale & retail trade	"Wholesale and retail trade", "Hotel, restaurants services"
7	TSC	Transport & communication	"Transport & communication"
8	FIRE	Finance & business services	"Financial institutions", "Ownership of dwelling", "Business and personal services", "Imputed bank service charges"
9	CSPSGS	Government & public services	"Government services", "Private non-profit institutions"

Sector-based productivity growth in an economy is formulated in a two-part structure consisting of within industry and structural components, Rodrik (2010):

$$\Delta LP_t = \sum_{i=n} \alpha_{i,t-k}\ \Delta lp_{i,t} + \sum_{i=n} lp_{i,t}\ \Delta\alpha_{i,t}$$

LP_t and $lp_{i,t}$ in this equation represent labor productivity for the overall economy and sector i, respectively, while $a_{i,t}$ shows the share of sector i in total employment. Δ is the difference between the t and t-k periods in the related variables. The first term in the equation is called "within" component which consists of sum of the productivity changes in individual sectors weighted by the beginning period employment shares of each sector. The second term is called "structural" component which captures the labor movements across different sectors. If the changes in employment shares result in an increase in the overall productivity change in the economy, structural change component in the equation should be positive.

Table 3 presents the components of total productivity growth in Turkey over the last 30 years. In the 1990-2000 period, when the noticeable change in the main sectors of agriculture, industry and services began with the contribution of trade and financial liberalization, 84% of the total productivity increase in Turkey came from structural change.

In the period of 2001-2010 when solid reforms were made in the economy and integration with the EU accelerated, the growth enhancing structural change component continued to make significant contributions to the increase in total productivity. In this period, 69% of the total productivity increase of 3.8% came from the structural change resulting from the shift of labor from low-productivity sectors to high-productivity sectors. Making an international

comparison in terms of the significant contribution of structural change to total productivity increase in the early 2000s, Turkey resembled some Asian countries where structural change was at the forefront, rather than Latin American countries where structural change gave a negative contribution.

On the other hand, the contribution of structural change to total productivity growth in the 3rd period covering the years of 2011-2020 was the lowest. Seventy-six percent of the productivity increases in this period were derived from within sector productivity increases.

Table 3. Decomposition of Turkey's Productivity Growth for the 1990-2020 Period

	Within Component	Structural Change	Total Productivity Growth
1990-2000	0,22%	1,11%	1,33%
2001-2010	1,16%	2,63%	3,80%
2011-2020	2,44%	0,76%	3,19%

Source: TURKSTAT, Authhor's calculations

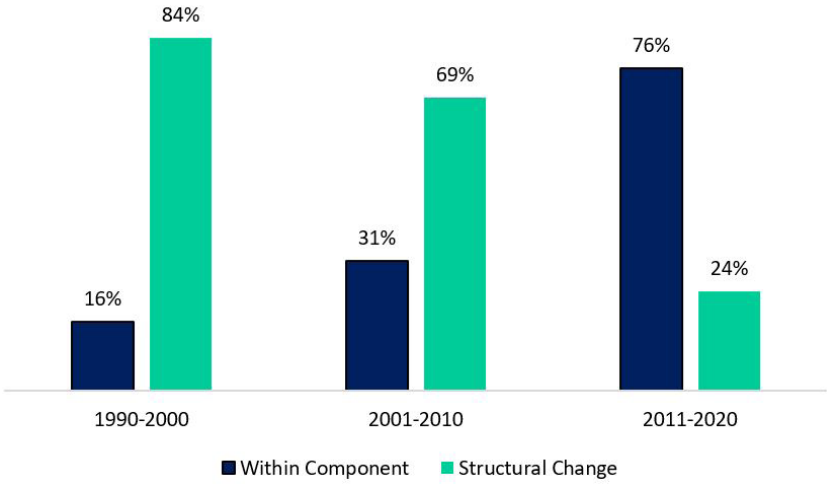

Figure 3. Contribution Share of Within and Structural Change Components to Overall Productivity Change
Source: UNIDO, authors calculations

2.2. Structural Change in Sectoral Composition of Turkey's Manufacturing Industry

As the technological innovations and digital transformation were evaluated in terms of

their ability to be developed and their potential for diffusion in the economy, significant differences emerged between sectors. For this reason, the sub-sector composition within the manufacturing industry was equally important as the share of aggregate industrial sector in the total economy. In this section, various indicators were analyzed in sub-sector detail to examine the quantitative and qualitative changes in the Turkish manufacturing industry.

Table 4 shows the value-added shares of the manufacturing sectors for the last 6 decades. In the calculation of sectoral shares, the INDSTAT database in ISIC Revision 3 classification was used, since UNIDO publishes the longest historical data set available. The sectors in the table were grouped according to the technology classification of the OECD's "Economic Activities Based on R&D Intensity" study.

Table 4. Sectoral Composition of Turkey's Manufacturing Industry by Technological Classification

Technology Class	ISIC-Rev.3	Sector	1963	1970	1980	1990	2000	2010	2019
High-technology	33	Medical, precision and optical instruments	0,0%	0,1%	0,1%	0,3%	0,6%		
High-technology	30	Office, accounting and computing machinery					0,2%	1,6%	2,5%
High-technology	32	Radio,television and communication equipment					2,1%		
High+Medium-high-technology	24	Chemicals and chemical products	6,9%	6,5%	10,2%	9,9%	10,1%	8,3%	8,0%
High+Medium-high-technology	35	Other transport equipment					0,7%	1,5%	2,1%
Medium-high-technology	29	Machinery and equipment n.e.c.	2,7%	4,0%	4,7%	4,9%	5,0%	7,0%	8,1%
Medium-high-technology	31	Electrical machinery and apparatus	2,4%	1,4%	4,3%	5,1%	2,6%	5,6%	5,2%
Medium-high-technology	34	Motor vehicles, trailers, semi-trailers	3,5%	2,8%	5,0%	6,0%	6,6%	7,4%	7,8%
Medium-low-technology	23	Coke,refined petroleum products,nuclear fuel	5,3%	15,4%	14,5%	17,3%	12,0%	1,8%	2,2%
Medium-low-technology	25	Rubber and plastics products	1,5%	2,8%	3,0%	2,7%	3,6%	5,5%	5,8%
Medium-low-technology	26	Non-metallic mineral products	5,6%	5,2%	6,8%	8,2%	6,6%	8,2%	5,8%
Medium-low-technology	27	Basic metals	6,8%	10,6%	9,9%	6,9%	5,4%	7,7%	10,4%
Medium-low-technology	28	Fabricated metal products	6,2%	4,5%	3,6%	3,1%	3,1%	6,5%	7,0%
Low-technology	15	Food and beverages	22,4%	16,4%	14,0%	11,9%	12,5%	13,2%	10,3%
Low-technology	16	Tobacco products	6,5%	9,8%	4,3%	4,0%	5,2%	0,5%	0,6%
Low-technology	17	Textiles	22,0%	13,8%	14,2%	11,2%	10,5%	9,2%	9,6%
Low-technology	18	Wearing apparel, fur	1,1%	0,7%	1,1%	3,7%	4,6%	6,4%	5,9%
Low-technology	19	Leather, leather products and footwear					0,6%	1,0%	0,7%

Low-technology	20	Wood products (excl. furniture)	1,5%	0,9%	1,1%	0,6%	0,7%	1,6%	1,4%
Low-technology	21	Paper and paper products	3,3%	2,6%	1,9%	1,9%	1,8%	2,2%	2,9%
Low-technology	22	Printing and publishing	2,1%	1,9%	0,9%	1,5%	3,6%	1,3%	0,7%
Low-technology	36	Furniture; manufacturing n.e.c.	0,5%	0,5%	0,4%	0,6%	1,7%	3,6%	2,9%
Low-technology	37	Recycling							
	D	Total manufacturing	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

In the last 60 years, the manufacturing industry production in Turkey shifted from low-technology sectors to medium-technology sectors, and the share of high-tech sectors remained low compared to its peers (See Figure 4).

During this period, while the shares of three traditional low-technology sectors of food, textiles, and tobacco decreased radically, the 2.5-fold increase in medium-high technology sectors such as motor vehicles, machinery, and electrical machinery was the most significant structural shift in the composition of the manufacturing industry.

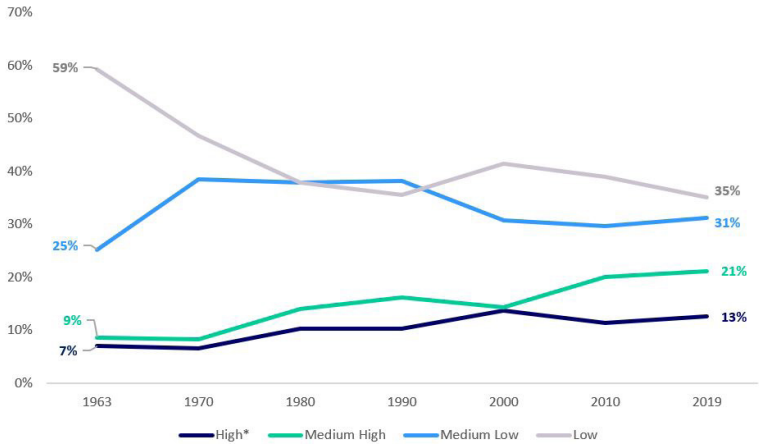

Figure 4. Technological Shares in the Manufacturing Industry
Source: UNIDO, authors calculations

* Chemicals and chemical products and other transport equipment sectors includes both high and medium-high technology products in ISIC-Rev.3 classification. Their values are assumed to be added to the high technology sectors in the graph.

Looking at the indicators, the HERFIND index is calculated by the sum of the squares of the shares of the sectors in the total industrial value added and gives an idea about the long-term change of the sectoral concentration. It is concluded that as the index value decreases, the production diversity increases. According to the calculation made over 23 sectors, the index value of the sub-sectoral concentration of the Turkish manufacturing industry decreased

from 0.13 to 0.07 in the 1963-2019 period (See Figure 5). In other words, it can be concluded that the diversity capability of the manufacturing sector nearly doubled in the last 60 years.

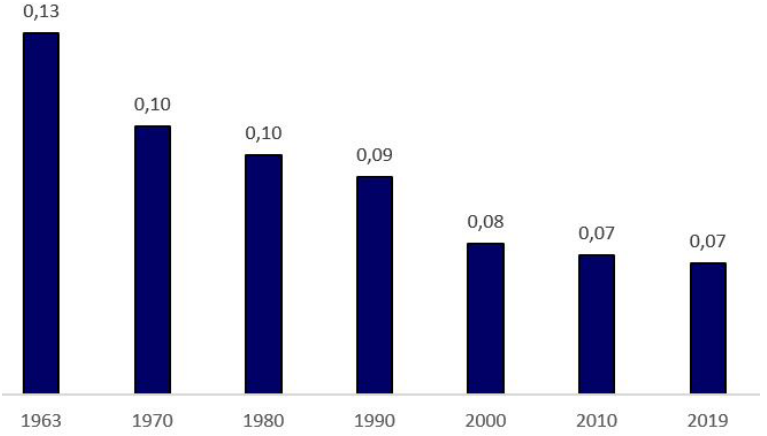

Figure 5. HERFIND Index of Manufacturing Industry
Source: UNIDO, authors calculations

As an alternative, we calculated GINI coefficients over sectoral value-added shares to measure sectoral concentration. According to these results, the GINI coefficient showed a tangible improvement from 1963 to 2010, indicating that the diversity in the manufacturing industry increased structurally, but this transformation flattened in the last 10 years (See Figure 6).

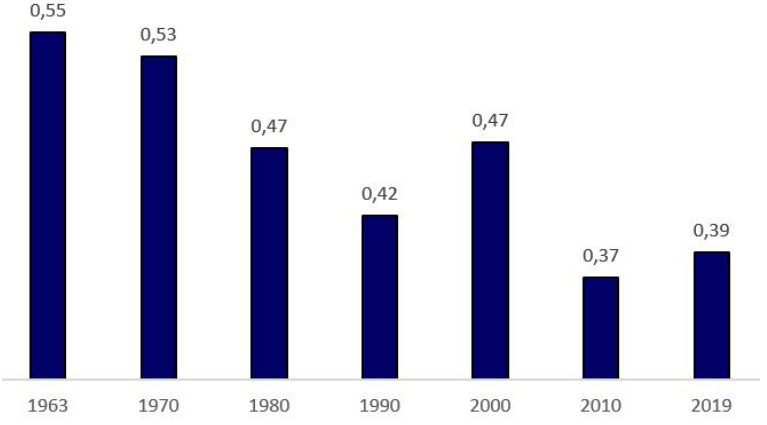

Figure 6. GINI Coefficients of Manufacturing Industry
Source: UNIDO, authors calculation

3. Digital Technologies as a Driver of Productivity Growth and Turkey's Position in International Digital Rankings

Due to the large number of digital technology related indicators, the relationship between digital technologies and productivity related effects has been studied from different perspectives. When evaluated in general terms, the literature studies reported that there was a positive relationship between access and use of digital technologies and economic productivity and growth, although it varied according to the income group of the countries.

For instance, Vu (2011) conducted a study on a sample of 102 countries for the 1996-2005 period, where ICT development accelerated across the countries. The results of the study showed that ICT was an important source of economic growth and emerged as a driver of structural change in the relevant period. Manyika et al. (2013) studied the ICT impact on productivity and economic growth for a sample of 14 countries which account for 90% of Africa's GDP. They showed that if internet penetration increased from its current level of 16% to its potential of 50% by 2025, then the internet contribution to productivity gains in key sectors would increase from $18 billion to $300 billion. Donou-Adonsou et al. (2016) studied the impact of the telecommunications infrastructure in Sub-Saharan Africa and found that a 10% increase in internet and mobile phone usage raised economic growth by 1.2% and 0.3%, respectively. Strohmaier et al. (2019) analyzed the structural effects of digital transformation on socioeconomic systems of Western and Asian countries for the period between 2007 and 2016 by using ICT related indicators such as access to internet, quality of broadband, e-participation, and patent applications in ICT. They found a positive impact of digital transformation on socioeconomic development for almost all countries.

According to the studies that were based on a national scale income group comparison; Dedrick et al. (2013) found strong evidence that IT investments in developing countries increased productivity only if they reached a certain level of IT capital stock or minimum level of accumulated stock of experience. Farhadi et al. (2012) examined the relationship between the ICT use index and economic growth in a sample of 159 countries. Results of this study showed that the high-income group of countries had the highest effect of the ICT use index on real GDP per capita, while the low-income group had the lowest effect. Banga and Velde (2018) found that doubling the internet penetration increased labor productivity by 11.3% for middle-income countries and 3.3% for low-income countries. The reason that access to ICT had a lower impact in low-income countries was because these countries had lower-skilled labor and consequently a lack of absorption capacity for ICT technological transformation.

While the studies in the literature revealed the relationship between digital technologies and productivity and growth in a concrete way, there are a couple of global indices that countries can follow in the comparative levels of digitalization on an international scale and areas that need to be improved for sustainable growth and productivity increases. In the remainder of this section, Turkey's current position in the Network Readiness Index (NRI), International Digital Economy and Society Index (I-DESI) and E-Government Development Index (EGDI) and the topics that need to be improved in these indexes such as digital technology use, access and infrastructure were examined.

With the Network Readiness Index (NRI), the readiness of countries for the internet-based information economy is measured within the scope of 4 different pillars, namely technology, people, governance, and impact, and these pillars have been populated by 60 variables. In this respect, the NRI index has the most comprehensive structure compared to other digitization indexes.

Turkey ranks 45th among 130 countries in the 2021 NRI index. The rankings in the sub-indicators are close to the ranking of the main index, however, the impact pillar consisting of the indicators in the economy, quality of life, and Sustainable Development Goals (SDGs) stands out as the component that needs the most progress (#74).

The first three indicators where Turkey has achieved success: e-commerce legislation (#1), tertiary enrollment (#2) and international internet bandwidth (#7).

Sub-indicators in which Turkey has a ranking of #100 and above in world rankings and which are a top priority to be improved: Investment in emerging technologies (#103), privacy protection by law content (#100) and freedom to make life choices (#125).

Figure 7 shows the relationship between the NRI score and GDP capita (PPP) of 130 countries. Turkey is slightly below the curve and has a gap to increase and improve its network readiness corresponding to its current income level.

Comparing the scope of regional and income level, Turkey ranks 4th in the upper-middle-income countries group (China is in the 1st place) and 30th in the European region.

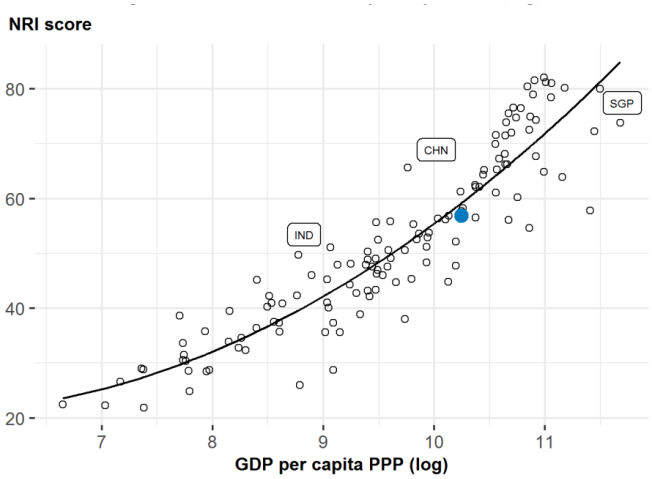

Figure 7. NRI Score vs GDP Per Capita PPP (log)
Source: Portulans Institute

The International Digital Economy and Society Index (I-DESI), which is reported by European Commission, evaluates the digital performances of EU member countries and 18 non-EU countries, with five key areas: connectivity, human capital, use of internet, integration of digital technology, and digital public services.

Turkey ranks last in the I-DESI index and improvement in areas such as open data, preparation for 5G technology, e-commerce, e-banking, qualified ICT personnel, 4G coverage, big data, and cloud computing would enable it to rank higher in the future. In order to achieve national improvement in these sub-indicators, progress must be made on the axis of individuals, companies, and government.

Finally, E-Government Development Index (EGDI) is published by the United Nations and used to measure capability and readiness of a government to use ICT. The index is based on three components: (1) availability of online services, (2) telecommunication infrastructure and (3) human capacity.

According to the results of EGDI for 2020, Turkey ranks 53rd among 193 countries. Looking at the sub-components of the index, Turkey ranks 22nd in the online service index, while it ranks 79th in the telecommunication sub-index calculated by internet user rate, fixed broadband subscription rate, active mobile broadband subscription rate, and mobile line subscription rate.

While the average EGDI index value of EU countries for 2020 was 0.85 points, Turkey's index value in the same year was 0.77 points. In order for Turkey to catch up with the EU average, it is necessary to take steps to make progress in the telecommunication infrastructure.

3.1. Digital Intensity of Turkish Manufacturing Industry

For the success of the policies that policy makers will create for digital transformation, it is necessary to analyze the recent trends of the economy in the field of digitalization and to determine the priorities according to the digitalization needs of the sectors. For this purpose, it is useful to look at the digitalization intensity of the sectors to examine the priority digitalization indicators and sectors according to the current structural production pattern of the country.

In this part of the study, we examined how the ICT intensity of Turkey's manufacturing industry evolved by tracking the shares of sectors historically taken from the total industrial value added with their digitalization intensities. At this stage, a globally accepted ICT classification of sectors was needed. To the best of our knowledge, McKinsey (2015) and Calvino et al. (2018) were the only two studies in the literature attempting to propose a taxonomy of digital intensity by sectors.

When these two studies were compared in various aspects, Calvino et al. (2018) seemed more appropriate as a globally accepted taxonomy. First of all, McKinsey's study was only applied to the USA and calculations were made on a small number of aggregated sectors. In addition, since some of the data used was privately collected with company-based surveys, it was not applicable to other countries to form a global taxonomy.

In order to provide a concrete basis for which parts of the economy would use digital transformation to what extent, Calvino et al. (2018) made calculations on 12 countries and 34 sectors using 7 indicators including technology, market, and human capital aspects. Digital intensities of manufacturing sectors are shown in the Table 4.

For the investment in software and ICT tangible investment manufacturing sectors showed significantly low intensities, since they were relatively more physical capital intensive and the ICT investments corresponded to a smaller portion in the overall investment expenditures compared to service sectors. The same rationale applied to the purchases of ICT goods indicators of the manufacturing sectors.

Stock of robots per employees by sector was used as an indicator of automation systems that are increasingly used in industrial production. In the table, the intensity of robot use

is highest in rubber and plastics, computer and electronics, electrical equipment, transport equipment and furniture sectors.

On the online sales side, trade on digital marketplaces gained momentum especially after the 2020 Covid-19 outbreak. E-commerce can be both a complement and/or a substitute for conventional trade activities, and in this respect, it has become an important component of today's digital transformation process. In the table, especially food and beverages, tobacco, refined petroleum, chemical products, machinery, electrical machinery, motor vehicles and other transport equipment exhibit the highest shares of turnover from online sales.

As an indicator of human capital, which is an important component of digitalization, the employment of ICT experts by sectors, such as software and applications developers, databases and network professionals, ICT service managers, was used. The sectors that intensively employ ICT experts are refined petroleum, chemical products, office, accounting and computing machinery, television and communication equipment, medical, precision, and optical instruments, motor vehicles and other transport equipment.

Table 5. Taxonomy of Digital Intensity in Manufacturing Industry by Indicator

Digital Intensity	Sector	Software investment	ICT tangible investment	Intermediate ICT goods	Intermediate ICT services	Robot use	Revenues online sales	ICT specialists
Low	Food and beverages							
Low	Tobacco products							
Medium-Low	Textiles							
Medium-Low	Wearing apparel							
Medium-Low	Leather, leather products and footwear							
Medium-High	Wood products (excl. furniture)							
Medium-High	Paper and paper products							
Medium-High	Printing and publishing							
Medium-Low	Coke,refined petroleum products,nuclear fuel							
Medium-Low	Chemicals and chemical products							
Medium-Low	Rubber and plastics products							

Medium-Low	Non-metallic mineral products							
Medium-Low	Basic metals							
Medium-Low	Fabricated metal products							
Medium-High	Machinery and equipment n.e.c.							
Medium-High	Office, accounting and computing machinery							
Medium-High	Electrical machinery and apparatus							
Medium-High	Radio,television and communication equipment							
Medium-High	Medical, precision and optical instruments							
High	Motor vehicles, trailers, semi-trailers							
High	Other transport equipment							
Medium-High	Furniture; manufacturing n.e.c.							
		Data NA	Bottom Quartile	Second Quartile	Third Quartile	Top Quartile		

Source: OECD

The digital intensity classification of the manufacturing sectors, which is the average of 7 indicators, is shown in the first column of Table 5. The last 50-year trend of the shares of Turkey's manufacturing sectors by their digital intensity is shown in Figure 8.

In the most general sense, the share of low and medium-low sectors in the Turkish manufacturing industry decreased by 20 percentage points in the last 50 years, while the share of high and middle-high sectors increased at the same rate. In this period, the Turkish industry sector achieved significant acceleration in the field of other transport equipment, which includes combat drones and other defense industry vehicles, and motor vehicles with high digital intensity. To the extent that Turkey can meet the tangible and intangible ICT goods and services needed by these sectors in a domestic way, a visible improvement in macroeconomic indicators can be achieved through the increase in sectoral value-added.

Turkey achieved significant breakthroughs in sectors with medium-high ICT intensity in the last 50 years, and the share of these sectors in total industrial production increased more

than twice. Note that, among these sectors, especially the medical precision and optical instruments, radio, television and communication equipment and office, accounting and optical instruments sectors are also in the high-technology classification according to R&D intensity. In addition to this, the machinery and electrical machinery sectors, which are among the other medium-high ICT-intensive sectors, have an important catalyst role that raises the technology level of the overall manufacturing industry, thanks to the high forward and backward linkages established with other sectors. Therefore, following the digital transformation trends in these sectors and developing point-to-point policies will be effective steps that will contribute to Turkey's long term macroeconomic targets.

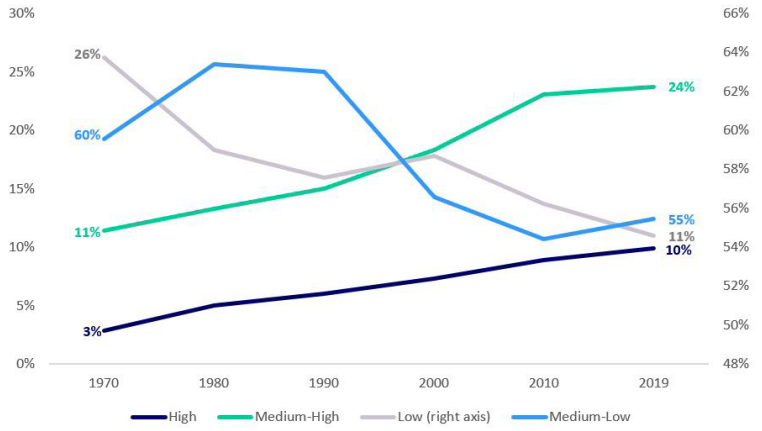

Figure 8. Technological Shares in the Manufacturing Industry
Source: OECD, authors calculation

4. Concluding Remarks

While the structural economic change process continues in the vast majority of countries, the forces driving this change are being investigated with great interest. In this study, we examined the effects of Turkey's last 30-year structural economic change on productivity growth in 10-year periods and discussed digital transformation, which is an important driver of structural change, in the context of literature and ICT intensity of the Turkish manufacturing sectors.

As the sectoral employment shares of Turkey were analyzed from a historical perspective, it followed the path of high-income countries in North America and Europe in the agriculture and services sectors. However, employment in the manufacturing sector tended to decline before reaching the high-income level, which led to the discussion of the premature deindustrialization phenomenon in Turkey.

Recent literature criticized the ways that the share of sectors in total employment was used as an indicator of industrialization. Recent studies argued that if productivity was high, even if the share of the industrial sector in employment decreased, but the share of total industrial production to the GDP did not decrease, then deindustrialization could not be claimed for a country in that case. Therefore, if we use the ratio of the value added of the manufacturing sector to GDP at constant prices as an alternative to the employment indicator, we see that this ratio peaked at 17% in 2017 and remained close to this value in the following three years. Therefore, contrary to the manufacturing employment indicator, there was no shrinkage in the manufacturing industry in terms of value added in Turkey. In this sense, Turkey differed positively from Latin American countries as well as South Africa and Russia, which entered deindustrialization in both employment and production indicators at an early stage.

Another important issue that we analyzed in this study was to what extent and direction the sectoral changes effected the productivity growth in the last 30 years. In both 1990-2000 and early 2000s structural change, which emerged as a result of trade and financial liberalization, structural economic reforms, and acceleration in the integration with EU, gave a significant contribution to productivity growth and in this manner, Turkey resembled Asian countries where structural change was at the forefront, rather than Latin American countries where structural change gave a negative contribution. In 1990-2000 and 2001-2010 periods structural change accounted for 84% and 69% of productivity growth, respectively. However, the contribution of structural change to total productivity growth in the 3rd period covering the years of 2011-2020 was the lowest.

Going one step further, we examined the structural change in manufacturing sectors by technology levels and sectoral diversity in general. Results showed that, in the last 60 years, manufacturing industry production in Turkey shifted from low-technology sectors to medium-technology sectors, and the share of high-tech sectors remained low compared to its peers. During this period, while the shares of three traditional low-technology sectors such as food, textiles, and tobacco decreased radically, the 2.5-fold increase in medium-high technology sectors such as motor vehicles, machinery and electrical machinery was the most significant structural sectoral shift in the composition of the manufacturing industry.

Since the link between growth and structural change is provided through the productivity channel, where there is reallocation between low productive and high productive sectors, and digital transformation emerged as an important driver of productivity growth, we took a closer look at Turkey's digital technology indicators and the ICT intensities of the manufacturing sector.

Turkey's current position in the Network Readiness Index (NRI), International Digital Economy and Society Index (I-DESI) and E-Government Development Index (EGDI) shows some areas to be improved especially for investment in emerging technologies, telecommunication infrastructure, privacy protection by law, and barriers to the development of cloud computing systems.

On a macro scale, these digital indicators provide valuable information about the overall position of the country in international comparison. However, in a more detailed look, there are heterogeneities in digital use intensities among sectors and this leads to divergence of digital indicators in respect to their priorities. For this purpose, we analyzed the digital intensities of the manufacturing sectors to examine the priority digitalization indicators and sectors according to the current structural production pattern of Turkey.

In the most general sense, the share of low and medium-low digital intense sectors in the Turkish manufacturing industry decreased by 20 percentage points in the last 50 years, while the share of high and middle-high sectors increased at the same rate.

In this period, the Turkish industry sector achieved significant acceleration in the field of other transport equipment, which includes combat drones and other defense industry vehicles, and motor vehicles with high digital intensity.

Turkey achieved significant breakthroughs in sectors with medium-high ICT intensity in the last 50 years, and the share of these sectors in total industrial production increased more than twice. Note that, among these sectors, especially the medical precision and optical instruments, radio, television and communication equipment and office, accounting and optical instruments sectors are also in the high-technology classification according to R&D intensity. In addition to this, the machinery and electrical machinery sectors, which are among the other medium-high ICT-intensive sectors, have an important catalyst role that raises the technology level of the overall manufacturing industry, thanks to the high forward and backward linkages established with other sectors. Therefore, following the digital transformation trends in these sectors and developing point-to-point policies will be effective steps that will contribute to Turkey's long term macroeconomic targets.

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