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TECHNOLOGICAL STRUCTURE AND LABOR PRODUCTIVITY OF THE SERBIAN MANUFACTURING INDUSTRY – THE SECTOR LEVEL

Vladimir Mićić[1*], Ljubodrag Savić[2], Gorica Bošković[3]

[1]University of Kragujevac, Faculty of Economics, Kragujevac, Serbia
[2]University of Belgrade, Faculty of Economics, Belgrade, Serbia
[3]University of Niš, Faculty of Economics, Niš, Serbia
[*] *micicv@kg.ac.rs*

Abstract

Labor productivity of the manufacturing industry is an important factor of economic growth and compatibility. The aim of the research is to point out the significance of conducting efficient structural and technological changes in the manufacturing industry of the Republic of Serbia and to examine their impact on the growth of labor productivity. Technological structure was examined according to the technological intensity and methodology of OECD. Labor productivity was analyzed by partial productivity measure, value added per employee from the aspect of impact of various factors on its growth, shift-share analysis. The results of the research show that labor productivity growth rates in the manufacturing industry are high and positive, that they are higher than gross value added, which is the result of change in the number of employees. Productivity growth is higher in areas that belong to high and medium-level technology and is based on the inter-sector effect. The results of this research are useful to the creators of industrial politics when initiating structural changes and relocating the factors that impact labor productivity towards more productive areas of the manufacturing industry.

Key words: labor productivity, technological changes, structural changes, manufacturing industry.

ТЕХНОЛОШКА СТРУКТУРА И ПРОДУКТИВНОСТ РАДА ПРЕРАЂИВАЧКЕ ИНДУСТРИЈЕ РЕПУБЛИКЕ СРБИЈЕ – НИВО ОБЛАСТИ

Апстракт

Продуктивност рада прерађивачке индустрије је важан фактор економског раста и конкурентности. Циљ истраживања јесте да укаже на значај ефикасног спровођења структурних и технолошких промена у прерађивачкој индустрији Републике Србије и испита њихов утицај на раст продуктивности рада. Технолошка структура испитана је према технолошком интензитету и методологији OECD-а. Проду-

ктивност рада анализирана је парцијалном мером продуктивности, додатом вредношћу по запосленом, а са аспекта утицаја различитих фактора на њен раст, „shift-share" анализом. Резултати истраживања показују да су стопе раста продуктивности рада прерађивачке индустрије високе и позитивне, да су веће од стопа раста бруто додате вредности (БДВ), што је резултат промене броја запослених. Раст продуктивности већи је у областима које припадају високом и средње високом технолошком нивоу и заснован је на унутарсекторском ефекту. Резултати овог истраживања су корисни креаторима индустријске политике приликом покретања структурних промена и реалокације фактора који утичу на продуктивност рада ка продуктивнијим областима прерађивачке индустрије.

Кључне речи: продуктивност рада, технолошке промене, структурне промене, прерађивачка индустрија.

INTRODUCTION

From the First to the emerging Fourth Industrial Revolution, industry has been a major driving force of economic development, dependent on technological progress and innovation, which influenced its continuous structural changes. Industry, in this context, refers to manufacturing industry, means processing and production, excludes mining and energy, creates value through the conversion of raw materials of different origins into products and services.

Development features and characteristics, especially the regularities of structural changes in developed EU economies, are based on changes in the industry structure, i.e. the relative share of new and technologically intensive industries. Theoretical and empirical arguments prove that manufacturing industry drives sustainable growth and employment, but also structural changes in national economies. Economic development theory refers to technological and structural economic changes as basic determinants of sustainable growth, but also of productivity and competitiveness growth.

Contemporary economic literature focuses on building a knowledge-based society and recommends it as a model for sustainable economic development, especially in countries with scarce resources. The creation of new technologies, significant investment in research activities, education and innovation are prerequisites for productivity growth. Productivity, as a measure of the efficient use of inputs in creating outputs, increases production efficiency and GDP. Productivity drives economic growth and development, thereby determining GDP growth per capita and contributing to rising living standards. Manufacturing industry, compared to other economic sectors, has a higher productivity level and growth, and due to spillover effects, its positive trends also affect the productivity growth of other industries. In addition to capital productivity, labor productivity is most commonly used to express and measure productivity.

In this regard, the subject of this paper is the technological structure and productivity of the manufacturing industry in the Republic

of Serbia. As productivity is a major driver of industry growth, its contribution to the dynamics of economic growth is indirectly determined. The main research objective is to point out the importance of effective implementation of structural and technological changes in Serbian manufacturing industry and examine their impact on labor productivity growth in the era of new digital technological innovations, which will follow the trends and achievements of the Fourth Industrial Revolution.

PRODUCTIVITY CONCEPT AND MEASUREMENT

The hypothesis of economic growth convergence explains higher growth rates in developing countries than in developed economies (Barro & Sala-i-Martin, 2004, p. 44), and empirical research confirms the existence of income convergence (Kang, 2011). According to the neoclassical model, GDP growth rate per capita is inversely related to its initial level (Barro & Sala-i-Martin, 1990, p. 2). If economies are similar in technology, less developed economies grow faster than developed economies. The inverse relationship between initial productivity levels and long-term productivity growth rates is due to the existence of a technological gap between developed and developing economies. Only those economies that have specific skills will be successful in using technology and moving closer to developed economies (Abramovitz, 1986, pp. 385-406). Social skills, in addition to education and institutions, include the ways in which knowledge and technology transfer takes place, the dynamics of structural change and investment. Technological innovations affect economic dynamics, above all, through the growth of productivity and new products (Pasinetti & Schefold, 1994, p. 1936).

Industrial revolutions result in radical economic change due to the application of new innovations, technologies and modes of production. The essence lies in productivity and resource efficiency growth, driven by technological innovation.

We are at the beginning of the Fourth Industrial Revolution marked by the development of digital technologies. The concept of "Industry 4.0" is considered a major driver of the new industrial revolution, which aims to digitize the manufacturing industry. It is defined as "a comprehensive concept and new trend in the manufacturing industry, based on the integration of technologies that enable the ecosystem of intelligent, autonomous and decentralized factories and integrated products and services" (Stanković, Gupta, & Figueroa, 2017, pp. 8-9). It is a new industrial paradigm that embraces the application of modern technologies in industrial production (Pereira & Romero, 2017, pp. 1206-1214), such as: Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet of Services (IoS), Robotics, Additive Manufacturing or Industrial 3D Printing (Computer-Aided Design – CAD), Big Data Analytics, Cloud Computing, Augmented

Reality. The impact of “Industry 4.0 in industrial production will drive labor productivity growth” (Roblek, et al., 2017, pp. 1-11). New and modern industrial technologies will cause structural changes, labor productivity growth, and, thus, rise in income and investment. However, a number of factors determine the impact of technological and structural changes on industrial productivity (OECD, 2015; 5; Globerman, 2000, pp. 3-5).

The Fourth Industrial Revolution and economic changes have also influenced the development of the Global Competitiveness Index 4.0 (GCI 4.0). The focus of GCI 4.0 is on institutions, policies and factors that drive productivity. Productivity affects sustainable economic growth. GCI 4.0 “assesses factors that together affect productivity and determine productivity levels, as the most important driver of long-term improvement in living standards” (Schwab, 2017, pp. 37-38).

The concept of productivity is applied in economic theory and practice with different goals and at different levels. In this case, it is the productivity of the manufacturing industry. “Productivity is an important factor driving production activities” (Singh et al., 2000). It represents resource efficiency, i.e. the efficiency with which industry converts production factors into finished products. Productivity “is the ratio of the measure of output and input, so it is a relative concept" (Productivity & Manual, 2001, p. 18).

The basic characteristic of productivity is that it “influences value creation because inputs in the production process add value to outputs” (Tangen, 2002, 18-20). It is possible to evaluate the level and rate of productivity growth. A high level of productivity has a positive effect on production costs and competitiveness growth, but also on employment, investment and technological change. Productivity levels demonstrate the efficiency of using inputs as well as the rate of return on the investment, while high productivity growth rates indicate that industry has growth potential (Ketteni, et al., 2017, pp. 3-18).

Improving company productivity affects industry productivity growth, but industry-level productivity is higher than company productivity. The reason is market competition and the spillover effect. Industry productivity growth may be due to the improvements in production efficiency with existing knowledge and technology levels or due to the development of new production methods and advances in technology. Productivity growth occurs as a result of better production organization or technological change. In practice, the two processes are simultaneous. Industries below their production capabilities can achieve rapid productivity growth in the process of reaching their production potential, as demonstrated by the practices of industries exposed to international competition. When the industry reaches the limit of production capabilities, productivity can increase technological and organizational change. Productivity growth is largely dependent on a combination of factors such as institutions, quality of workforce, capital and

investment, changes in the business environment, knowledge, technological change, innovation, and the way of diffusion of innovation (Gordon, Zhao & Gretton, 2015, p. 4).

One of the key questions is why industries or sectors differ in productivity levels. At the economic level, it is determined by company performance, market and institutional conditions. In industry, productivity growth is the result of a different combination of company productivity growth, changes in market share, market entry and exit (Scarpetta et al., 2002). Productivity growth in companies depends on changes in the efficiency of inputs used in production. Changes in market share affect the reallocation of resources and productivity due to changes in the market share of high- or low-productivity firms. The process of market entry and exit is a kind of reallocation that contributes to productivity growth, as more productive businesses replace less productive ones. The contribution of reallocation to productivity growth is seen as a process of market competition, driven by changes in institutional conditions and technological progress (Mai & Warmke, 2012, pp. 5-7).

Productivity shows how effectively inputs are used in output creation. The general form of productivity measurement is the ratio between output volume and input volume. Productivity analysis aims to show how and how much production factors contribute to output growth. The goals of productivity measurement are to monitor technological change, increase efficiency, reduce costs, compare production processes, and evaluate living standards (Productivity & Manual, 2001).

Productivity is most often measured using indices or ratios (Schreyer & Pilat, 2001, 127-170). Indices can be either single-factor or multifactor. Labor productivity and capital productivity are one-factor or partial measures of productivity. Multifactor productivity takes into account labor and capital inputs, as well as the substitution between them. Productivity measures also differ in how the output is expressed. There are measures that take into account the total output as well as those that apply the concept of value added.

Labor productivity is obtained as the ratio of the output measure and the measure of labor input. As labor represents only one factor of production, labor productivity also depends on changes that occur in the composition of other factors of production. It shows how productively the work is used to create output or added value. Changes in productivity levels reflect the impact of changes in capital, indirect inputs, efficiency, technical and organizational changes, economies of scale and capacity utilization. Labor productivity growth, based on value added, is less dependent on changes in the relationship between indirect inputs and labor and on the level of integration. Viewed at the macro level, labor productivity, calculated on the basis of value added, is the direct link to GDP per capita, as a measure of living standards (OECD, 2001, p. 11).

Capital productivity can also be calculated as a ratio of outputs or value added and capital inputs. Multifactor productivity or total factor productivity puts the output level in relation to the sum of all inputs. It is an indicator that shows an overall improvement in the economic efficiency in the process of converting inputs to outputs. It also demonstrates the contribution of technology and innovation to economic growth (Syverson, 2011, pp. 326-365). In multifactor productivity, "embodied" and "disembodied" technological changes imply improvements in the quality of capital goods, as well as knowledge and organizational change (OECD, 2001, pp. 11-12).

In addition to using indices, productivity is also measured using econometrics and linear programming methods (Del Gatto, et al., 2011, p. 952). The use of linear programming methods involves assessing the contribution of each production factor to the achieved volume of production, based on the production function. This approach does not require input and product pricing data but quantities. The most commonly used technique is the "Data Envelopment Analysis" (Singh, Motwani, & Kumar, 2000, 234-241).

One of the methods most commonly used in literature for measuring and analyzing productivity, from the point of view of the influence of various factors on its growth, is the shift-share analysis. It breaks down productivity growth into elements that affect changes within and between sectors or industries and productivity growth. The result of changes in labor productivity within an individual sector is called within-sector effect. By combining employment and interaction effects, a between-sector or structural change effect is obtained, which speaks of the contribution of structural change between economic sectors to labor productivity growth (Fagerberg, 2000, 393-411). Shift-share analysis of labor productivity has been applied in numerous empirical studies of structural change (Marouani & Mouelhi, 2015).

RESEARCH METHODOLOGY AND HYPOTHESES

The paper uses the comparative method to compare indicators of structural and technological change and labor productivity indicators. Technological changes and innovations are diverse and dominantly shape virtually all production areas. The connections and relationships between innovation and industry development are complex. The analysis of the results of structural changes is particularly important from the perspective of technological criteria. Therefore, the technological structure of the economy and industry of the Republic of Serbia will be examined based on the OECD technological classification of manufacturing industry by technology intensity (Galindo-Rueda & Verger, 2016, pp. 5-15). Technological effort or intensity relative to their gross value added (GVA) is

an important determinant of labor productivity and industry competitiveness (OECD, 2003, pp. 136-138). The technology-based classification is aligned with the United Nations Industrial Development Organization's Competitive Industrial Performance Index (CIP) (ISIC, 2011, p. 3).

To cover sectors, in particular the manufacturing industry activities, the paper uses industry definition according to the NACE Revision Statistical Classification (22 sectors and 64 activities). The research relies on secondary data of the Statistical Office of the Republic of Serbia (SORS). The general trend and dynamics of manufacturing industry's technological development are analyzed on the basis of value added and number of employees in this industry. According to the methodology applied in the EU, the basic indicator for measuring labor productivity is value added per employee. It is calculated by dividing the GVA of an activity by the number of employees.

Using shift-share analysis, we decompose labor productivity growth into within-sector and between-sector effect. Labor productivity can be expressed by the equation (Fagerberg, 2000¸ 393-411):

$$\Delta P = \Sigma_i \left[\frac{P_{io} \Delta S_i}{P_o} + \frac{\Delta P_i \Delta S_i}{P_o} + \frac{S_{io} \Delta P_i}{P_o} \right]$$

The fractions in the equation show three different types of contributions to productivity growth. The first section presents the contribution to labor productivity that results from the reallocation of labor between sectors, i.e. employment effect. This ratio is positive in an economy when labor shifts from the low-tech to the high-tech sector. The second fraction calculates the interaction between productivity changes in individual sectors and changes in labor reallocation between sectors. It is called the interaction effect and is positive if, in addition to productivity growth, a sector also registers an increase in employment. The third fraction indicates the contribution to labor productivity growth, which is the result of changes in labor productivity within the sector, i.e. within-sector effect (Fagerberg, 2000, 393-411). Labor productivity growth can occur as a result of a within-sector effect through capital accumulation, technological change and various advancements, and a between-sector effect that results from structural changes, i.e. labor shift from lower-productivity sectors or industries to higher-productivity ones (McMillan & Rodrik, 2011).

In accordance with the defined subject and objective, the paper tests the following research hypotheses:

Hypothesis 1: Labor productivity growth of the manufacturing industry in the Republic of Serbia is higher in medium-low and medium-high technology sectors.

Hypothesis 2: Labor productivity growth of the manufacturing industry in the Republic of Serbia is based on the within-sector effect.

RESEARCH RESULTS AND DISCUSSION

With reference to the technology level and OECD industry classification, it is possible to analyze the technological structure of the manufacturing industry of the Republic of Serbia (Table 1). The manufacturing industry is characterized by rather low-productivity, labor-intensive and inadequate technological structure, at a time of rapid development of "Industries 4.0". In 2018, 80% of manufacturing companies operated at L-T (low-technology) and M-L-T (medium-low-technology) levels, created about 75.5% of GVA and employed 78% of workers.

Table 1. Manufacturing industry technological structure in 2018

	Number of companies	GVA	Employment
H-T	5.7	4.5	2.8
M-H-T	14.3	19.9	19.2
M-L-T	25.1	32.2	27.3
L-T	54.9	43.4	50.7

Source: Author calculation based on SORS data, 2020

With reference to the share in GVA structure, from 2001 to 2018, low-tech and medium-low-tech industries dominated the manufacturing industry structure, with low share of medium-high-tech (MHT) industries, especially the high-tech (H-T) level, characterized by higher and high technological intensity, but also labor productivity (Table 2). This is due to low investment, as well as limited application of R&D and production innovation, but also a small transfer of the latest, especially digital technologies.

Table 2. Manufacturing industry GVA 2001-2018, Technology intensity %

	H-T	M-H-T	M-L-T	L-T
2001	4.8	16.4	30.7	48.2
2010	6.5	11.3	34.1	48.1
2018	4.2	19.5	34.4	42.0
Δ2001	-0.6	3.2	3.7	-6.2
Δ2010	-2.3	8.2	0.2	-6.1
Mean	6.1	15.4	33.1	45.4
Min	4.2	11.3	30.6	42.0
Max	8.1	20.3	36.6	48.7
Standard deviation	1.4	3.0	1.8	2.1

Source: Author calculation based on SORS data, 2020.

Since 2001, there have been structural changes, but not intense enough. Standard deviation shows the magnitude of the structural change between sector groups. Rather than affecting the rise in the share of high-tech sectors, structural changes saw a decrease by about 2.3 percentage

points in 2018, compared to 2010, while the share of M-H-T levels has increased by 8.2 percentage points. At the same time, the share of the medium-high tech level fell by only 0.2 percentage points, while the high-tech level recorded a decrease of about 6.1 percentage points. Sectors at a low-technology level are the most significant part of the manufacturing industry, according to GVA created. This is due to the high share of food production (C10) and beverage production (C11), which are part of the low-technology group. The share of these two sectors in the manufacturing sector GVA in 2018 was 22.3% of the manufacturing industry GVA, which is slightly lower than in 2010, when the share of these sectors was 26.5%. This is due to slow structural changes, which affects the productivity level and the growth of the manufacturing industry.

The ratio of GVA, expressed in millions of dinars (at constant prices), and the number of employees gives labor productivity in the manufacturing industry sectors, i.e. activities (Table 3).

Table 3. Labor productivity – manufacturing industry sectors in the Republic of Serbia, 2001-2018

	2001	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
C	0.13	0.84	0.99	1.08	1.36	1.52	1.65	1.64	1.64	1.67	1.64
C10	0.17	0.96	1.06	1.16	1.48	1.58	1.77	1.50	1.60	1.59	1.54
C11	0.25	1.86	2.16	2.18	2.57	2.65	2.83	3.74	4.89	4.07	4.11
C12	0.38	2.45	3.46	2.17	1.98	2.03	2.24	3.73	6.00	7.49	6.85
C13	0.08	0.30	0.61	0.56	0.63	0.81	0.72	0.69	0.58	1.25	1.07
C14	0.05	0.40	0.49	0.57	0.71	0.75	0.88	0.82	0.80	0.81	0.79
C15	0.10	0.49	0.61	0.66	0.67	0.86	1.05	0.78	0.63	0.72	0.72
C16	0.09	0.49	0.60	0.68	0.86	0.92	1.01	0.93	0.93	1.07	1.04
C17	0.12	1.26	1.29	1.30	1.70	1.85	2.03	2.25	2.30	2.73	2.83
C18	0.11	0.86	0.95	0.94	1.09	1.15	1.24	1.55	1.30	1.27	0.99
C19	1.18	5.83	12.42	11.24	21.36	36.99	40.54	38.87	16.48	12.50	17.29
C20	0.15	0.57	0.57	0.88	1.35	1.52	1.38	2.37	3.36	3.28	3.41
C21	0.41	2.70	2.47	2.14	2.35	2.50	3.04	4.26	2.71	3.72	3.92
C22	0.13	1.04	1.21	1.22	1.59	1.70	1.99	1.91	2.15	2.27	2.23
C23	0.16	1.05	1.24	1.21	1.32	1.39	1.70	1.90	2.01	2.07	2.28
C24	0.09	0.57	0.37	0.65	0.70	0.69	0.88	0.46	1.13	0.57	0.62
C25	0.08	0.72	0.85	0.95	1.23	1.34	1.14	1.24	1.17	1.69	1.61
C26	0.08	0.87	0.98	1.16	1.22	1.30	1.70	1.82	2.13	2.05	1.79
C27	0.13	0.65	0.78	0.84	0.92	1.03	1.12	1.22	1.07	1.32	1.10
C28	0.09	0.62	0.73	0.93	1.05	1.00	1.38	1.74	1.77	1.90	2.02
C29	0.07	0.34	0.41	0.44	0.69	1.41	1.60	1.72	1.58	1.29	0.97
C30	0.03	0.55	0.44	0.46	0.58	0.65	0.68	0.57	1.25	1.25	1.48
C31	0.10	0.57	0.63	0.68	0.85	0.89	1.06	0.86	0.92	0.97	0.98
C32	0.10	0.69	0.85	0.95	1.03	1.22	1.27	1.31	1.25	1.34	1.58
C33	0.06	0.79	0.93	0.84	1.00	1.16	1.37	1.69	0.89	0.83	1.03

Source: Author calculation based on SORS data, 2020

The manufacturing industry labor productivity has been steadily increasing over the observed period. In addition, value added per worker ranged from 13,000 dinars in 2001 to 1,670,000 dinars in 2017. The differences and variations per sector are much greater, especially in vehicle production (C-30), coke and petroleum products (C-19), base metals (C-24) and chemicals (C-20). The amount of GVA, expressed in millions of dinars per employee, as well as the intensity of changes in these areas, has been under the influence of the investment level in these sectors, in particular the reduction or increase in the number of employees.

In the manufacturing industry of the Republic of Serbia, labor productivity growth is for the most part the result of a continuous decrease in the number of employees and much less of the rise in value added. In the observed period, labor productivity growth rates were higher than GVA growth rates. Labor productivity growth rates, i.e. their mean, minimum and maximum values confirm this (Table 4).

Table 4. Labor productivity growth rates – manufacturing industry sectors, 2001-2018

	2001	2018	Mean	Min	Max	Standard deviation
C	69.0	-2.0	22.0	-2.0	106.9	27.3
C10	73.8	-2.7	20.4	-15.2	108.1	28.9
C11	63.0	1.0	27.2	-12.0	112.8	31.2
C12	75.7	-8.5	31.1	-37.3	178.6	61.8
C13	46.3	-14.7	15.0	-53.6	103.7	33.9
C14	136.0	-2.5	26.3	-7.4	136.0	32.6
C15	92.1	1.0	17.8	-25.4	92.1	25.9
C16	52.2	-3.3	18.8	-13.5	70.8	22.4
C17	45.8	3.6	22.6	-15.6	73.0	23.1
C18	51.9	-22.0	20.6	-16.0	98.7	25.0
C19	336.6	38.4	47.7	-57.6	336.6	90.5
C20	29.2	3.9	27.7	-36.1	93.8	36.8
C21	68.3	5.2	20.9	-36.4	214.7	55.4
C22	45.7	-1.9	22.4	-5.3	107.1	26.3
C23	84.8	10.3	22.7	-3.5	95.4	28.2
C24	36.4	9.7	33.8	-47.4	144.8	54.7
C25	89.1	-4.7	23.1	-31.0	124.3	36.6
C26	22.3	-12.5	27.7	-0.5	192.6	44.1
C27	66.0	-16.6	18.1	-19.3	101.3	29.0
C28	67.5	6.5	25.1	-20.7	84.6	28.8
C29	35.6	-24.7	33.1	-21.2	188.5	57.9
C30	63.2	18.6	34.7	-20.3	129.2	46.9
C31	-12.0	0.9	15.6	-18.7	80.1	27.5
C32	132.0	18.2	26.7	-6.4	142.2	43.2
C33	149.8	23.6	30.1	-47.4	149.8	43.8

Source: Author calculation based on SORS data, 2020

Sector-level analysis shows that greater dispersion of labor productivity growth rates suits greater structural changes between sectors, as measured by changes in GVA. Standard deviation of labor productivity trends by sector since 2001 confirms this. Higher dispersion means higher standard deviation of labor productivity. Sectors whose growth rates have higher deviation record high labor productivity. Labor productivity growth rates confirm the industrial development experience, where dynamic labor productivity growth in the manufacturing sector precedes and influences the creation of a modern production structure. Previous studies of structural changes in the manufacturing sector of the Republic of Serbia confirm this finding (Savić, et al., 2015, pp. 25-45).

Labor productivity growth was recorded at all technology levels in the period 2001-2018. In 2018, the highest productivity level was in high-tech sectors and the lowest in low-tech sectors, which is also correlated with the GVA, generated at these levels (Table 5).

Table 5. Labor productivity 2001-2018

	Sector C	H-T	M-H-T	M-L-T	L-T
2001	0.13	0.16	0.10	0.14	0.12
2002	0.26	0.49	0.21	0.31	0.24
2003	0.31	0.56	0.25	0.35	0.29
2004	0.37	0.67	0.32	0.43	0.33
2005	0.38	0.74	0.26	0.47	0.36
2006	0.49	0.85	0.28	0.63	0.46
2007	0.62	1.07	0.39	0.77	0.59
2008	0.71	1.33	0.50	0.85	0.66
2009	0.84	1.47	0.54	0.98	0.82
2010	0.99	1.46	0.61	1.26	0.94
2011	1.08	1.52	0.74	1.40	1.00
2012	1.36	1.63	0.95	1.85	1.23
2013	1.52	1.75	1.23	2.07	1.31
2014	1.65	2.19	1.37	2.19	1.45
2015	1.64	2.64	1.66	2.11	1.35
2016	1.64	2.37	1.80	1.92	1.39
2017	1.67	2.36	1.63	1.80	1.33
2018	1.64	2.36	1.42	1.69	1.28

Source: Author calculation based on SORS data, 2020.

Average labor productivity growth rates of technology levels in the 2001-2018 manufacturing industry show that they were approximately equal (Table 6).

Table 6. Average rates of change in labor productivity, 2001-2018

Labor productivity	2001-2010	2010-2018	2001-2018
Sector C	29.4	7.8	21.3
H-T	36.8	7.5	21.3
M-H-T	27.6	17.4	22.4
M-L-T	36.1	10.8	22.8
L-T	31.1	9.8	20.0

Source: Author calculation based on SORS data, 2020

If labor productivity growth rates are observed in two periods, the conclusion is different. In the 2001-2010 period, the average labor productivity growth of the manufacturing sector was 29.4%, while in the period 2010-2018 it decreased over 3.7 times. This is due to a much larger drop in the number of employees in the period 2001-2010 than in the period 2010-2018. In the period 2010-2018, the medium-high-tech group was in the lead by the 17.4% growth rate, followed by the medium-low-tech group, with 10.8%. We can say that higher GVA generation was due to greater investment in certain medium-high-tech sectors and new technologies. The results in Table 6 confirm the first hypothesis, that the manufacturing industry productivity growth in the Republic of Serbia is higher in both medium-high- and medium-low-tech sectors.

Using the shift-share analysis, we perform the breakdown of labor productivity growth in the manufacturing industry, as well as in certain groups of sectors of the Serbian economy. Using employment and GVA data, we calculate employment effect, interaction effect and within-sector effect and total results as the sum of all employment and interaction effects (Table 7).

Table 7. Labor productivity growth by sector in 2001-2018

	Between-sector effect		Within-sector effect	Total
	Employment effect	Interaction effect		
Agriculture	-0.15	-0.31	0.51	0.05
Industry	-0.09	-0.59	3.15	2.46
Manufacturing industry	-0.04	-0.46	2.42	1.92
Services	0.13	1.48	5.39	7.00

Source: Author calculation based on SORS data, 2020

The obtained results indicate that labor productivity growth in the Serbian economy in the 2001-2018 period was largely the result of within-sector profit or effect, i.e. the use of factors and resources, as other studies confirm (Jakopin, 2012). In most sectors, including the manufacturing industry, the greatest impact of the within-sector effect is the result of a drop in the number of employees. The employment effect and resource

shift from low-productivity to high-productivity activities had a slight, mainly negative impact on labor productivity growth in three industrial sectors. The interaction effect had greater significance, but also a negative impact in industrial sectors, especially in the manufacturing industry. The between-sector effect was very low in all sectors and had a negative impact on productivity growth. In service sectors (G-S), the between-sector effect had a positive impact on labor productivity, so services dominate the economy in generating total GVA. Thus, the results confirm the second hypothesis that labor productivity growth of the manufacturing industry in Serbia rests on within-sector profit or effect, which is due to insufficiently efficient structural changes. The downside is the negative employment effect, which means a labor shift from low- to medium-and high-tech sectors. Also, the low negative values of the interaction effect mean that there has been no noticeable increase in the number of employees in the manufacturing industry, despite a slowdown in decline intensity since 2015, which has lasted for almost twenty years.

CONCLUSION

Technology intensity shows very low improvement in the manufacturing industry technology level and slow intensity of changes. The reasons are inadequate structural and technological changes, low investment and insufficient domestic technological innovation, as well as insufficiently developed mechanisms for the transfer of modern technology from abroad, foreign and domestic companies.

An important finding of the analysis is that labor productivity growth rates of the manufacturing industry are high and positive, but higher than GVA growth rates, more due to drop in the number of employees than increase in production. It is clear that increasing labor productivity, based on the reduction in the number of employees, cannot be a long-term strategy for overall productivity growth, and, thus, for industrial growth. New technology, its transfer from abroad, greater investment in R&D are needed to increase production volumes in mid-high- and high-tech sectors. The current manufacturing industry structure, where low-tech production is dominant, does not have the capacity to provide, in the long run, more productive growth in labor productivity and higher growth rates in the manufacturing industry as a whole.

The average labor productivity growth rates, according to different technology levels, confirm the first hypothesis that manufacturing industry productivity growth in the Republic of Serbia is higher in high- and medium-high-tech sectors than in medium-low- and low-tech sectors. This fact points to the legality of higher labor productivity growth at higher technology levels than at lower levels.

The shift-share analysis finds that the manufacturing industry productivity growth, as well as that of other sectors, is the result of within-sector profit, i.e. the result of resource use. Shifting resources and production factors from low-productivity activities to high-productivity activities does not have a significant impact on labor productivity growth, thus confirming the second research hypothesis that manufacturing industry productivity growth is based on within-sector profit or effect.

The research conducted has some limitations. Only the manufacturing industry productivity has been analyzed, due to the lack of comparable data that would allow the calculation of factor productivity. For the same reason, no comparison with other countries' manufacturing industries has been made. Given these limitations, this research opens up opportunities for new analyses to eliminate them.

Finally, labor productivity growth does not rely on resource reallocation between sectors. The characteristics of structural change indicate the directions which future industrial policy should take. The results of this research are useful to industrial policy makers as they indicate that reallocation of labor productivity growth factors must focus on structural changes in the more productive manufacturing industry sectors.

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ТЕХНОЛОШКА СТРУКТУРА И ПРОДУКТИВНОСТ РАДА ПРЕРАЂИВАЧКЕ ИНДУСТРИЈЕ РЕПУБЛИКЕ СРБИЈЕ – НИВО ОБЛАСТИ

Владимир Мићић[1], Љубодраг Савић[2], Горица Бошковић[3]
[1]Универзитет у Крагујевцу, Економски факултет, Крагујевац, Србија
[2]Универзитет у Београду, Економски факултет, Београд, Србија
[3]Универзитет у Нишу, Економски факултет, Ниш, Србија

Резиме

Продуктивност рада прерађивачке индустрије важан је фактор економског раста. На раст продуктивности рада овог сектора утичу интензитет и правац технолошких и структурних промена.

Промена структуре ка пропулзивнијим активностима, које су интензивне технологијом и које стварају већу додату вредност, детерминише раст БДП-а per capita и утиче на повећање животног стандарда. Технолошке промене и иновације су разноврсне и доминантно обликују све области производње. Наведено посебно важи у време Четврте индустријске револуције, која је обележена динамичним развојем дигиталних технологија, а чија је главна карактеристика висок технолошки ниво.

Повезаност и релације између иновација и развоја индустрије су сложене природе. Анализа резултата структурних промена посебно је значајна са аспекта технолошких критеријума.

Предмет истраживања овог рада јесте технолошка структура и продуктивност рада прерађивачке индустрије Републике Србије. Специфичност истраживања је у томе што се бави анализом структурних промена, технолошким нивоом и продуктивношћу рада на нивоу области прерађивачке индустрије. Циљ истраживања јесте да укаже на значај ефикасног спровођења структурних и технолошких промена у прерађивачкој индустрији Републике Србије и испита њихов утицај на раст продуктивности рада. Технолошка структура испитана је према технолошком интензитету и методологији OECD-a. Продуктивност рада анализирана је парцијалном мером продуктивности, додатом вредношћу по запосленом, а са аспекта утицаја различитих фактора на њен раст, „shift-share" анализом. Она показује различите ефекте фактора као, на пример, реалокацију радне снаге између сектора и унутар њих, који су посебно важни када структурне промене иду у правцу померања радне снаге из нискотехнолошких у високотехнолошке области, односно од области са нижом продуктивношћу ка областима са вишом продуктивношћу рада. Овом анализом утврђено је да је раст продуктивности рада прерађивачке индустрије резултат унутарсекторске добити, то јест резултат употребе ресурса. Померање ресурса и производних фактора из активности са ниском продуктивношћу у активности са високом продуктивношћу – није имало значајан утицај на раст продуктивности рада.

Резултати истраживања показују, такође, да су стопе раста продуктивности рада прерађивачке индустрије Републике Србије високе и позитивне, да су веће од стопа раста бруто додате вредности, али је то резултат смањења броја запослених, што не може бити дугорочна стратегија укупног раста продуктивности, а тиме ни индустријског раста. Дакле, раст продуктивности прерађивачке индустрије већи је у областима које припадају високом и средње високом технолошком нивоу, највећим делом потиче од унутарсекторског ефекта и није се заснивао на реалокацији ресурса између сектора. Имајући у виду да карактеристике структурних промена указују на правце у којима треба да делује будућа индустријска политика, резултати овог истраживања су корисни креаторима индустријске политике приликом покретања структурних промена, односно реалокације фактора који утичу на продуктивност рада ка продуктивнијим областима прерађивачке индустрије.