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Deindustrialization and Implementation of Industry 4.0 - Case of The Republic of Croatia[1]

Abstract: The industrial sector of the Republic of Croatia is subject to deindustrialization, which was globally recognized as early as in the 1960s. Such a situation is a challenge in terms of implementing new sources of economic growth and industrial production, with a particular emphasis on investing in research and development, education and their products. Since 2011, special emphasis has been placed on the need to implement the concept of Industry 4.0. The problem surveyed in this research derives from insufficient readiness of the Republic of Croatia to implement Industry 4.0, mainly resulting from its major orientation towards traditional industrial sectors and a low share of high value added activities, which is particularly visible through the share of high technology products in total exports. However, the Republic of Croatia is characterized by low levels of scientific research and innovative activities, which greatly slows down this process. The aim of the conducted research is to present the theoretical aspects of the process of deindustrialization and Industry 4.0, to make projections of the key indicators of deindustrialization and Industry 4.0 until 2025, and to propose scientifically based measures to be taken in the direction of securing digital transformation of the Croatian industry. The purpose of the conducted research is to analyse trends in the industrial sector in the Republic of Croatia and to determine the current state of the (de)industrialization process and the level of implementation of Industry 4.0.

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The research has showed that the process of deindustrialization in the Republic of Croatia is characterized by a reduction in the share of employment in the primary sector, by a growing employment in the secondary sector, and by a relative increase in industrial production and labour productivity. However, since 2015 there has been an increase in employment in the secondary sector, which is in contrast to the theoretical concepts of deindustrialization and indicates a new trend in the industrial sector. This situation is a challenge concerning the implementation of Industry 4.0, which requires increased investment in research and development and the improvement of knowledge and the ability of the population and their implementation in the economic sector. By analysing this segment of the Croatian economy, some progress has been made. Also, it has also been found that in some segments it significantly lags behind the EU levels.

Keywords: deindustrialization, education, Industry 4.0, Republic of Croatia, research

JEL Classification: F00, L6

1. Introduction

Dynamic globalization trends in the global market impose new challenges on economic entities and entire economies in terms of digital transformation and the achievement of economic growth and competitiveness. These processes have also affected the industrial sector of the Republic of Croatia, which faced the need for digital transformation and orientation towards the implementation of the concept of Industry 4.0. This concept represents a relatively new and still insufficiently explored area of economics, which has emerged as a direct consequence of the global deindustrialization of the world economy.

Deindustrialization processes began in the 1950s and 1960s and they were first introduced in economic theory by Clark (1957) and Kaldor (1966). Due to its complexity and diversity of authors' approach, there is still no single theoretical approach to the definition of this concept. However, most authors agree that deindustrialization is a natural process, largely characteristic for developed countries, resulting from accelerated economic growth and changes in the sectoral structure of the economy (Baumol, 1967, Fuchs, 1968), with a particular emphasis on reducing the share of industry in GDP (Čavrak et al., 2011). However, the most recent research (Tomljanović and Grubišić, 2016, Kandžija et al., 2017, Popović, 2018, Tomljanović et al., 2018, Praščević and Ješić, 2019, Fabris, 2019, Luburić, 2019, Awdeh, 2019, Dumičić, 2019) emphasize the need for greater affirmation of investment in research and development, education and its products to increase the competitiveness of industry and face the challenges of deindustrialization and other contemporary challenges of globalization in all segments of doing business. Cairncross (1982) and Lever (1991) characterize deindustrialisation as a process that takes place in four key stages in which the economy starts from a de-

cline in production and/or employment in the industrial sector and an increasing orientation towards service activities by reducing the share of industrial products in foreign trade, which results in a failure to maintain trade balance. In such a situation the country can no longer provide sufficient quantities of imports necessary to maintain domestic production, thus slowing economic growth allowing for the domination of the negative effects of deindustrialization.

De-industrialization is the result of the action of internal and external factors. According to Rowthorn and Ramaswamy (1997), the most important internal factor of deindustrialization is the increase in labour productivity, with the finding that "*labour productivity growth is responsible for more than 60% of industry share reductions*" and that "on every *4.4 jobs lost in industry due to the competition of cheap imports, on average, one job is created in the industry due to the growth of exports of more sophisticated products*." Consideration of the importance of increasing labour productivity has continued with Rowthorn and Coutts (2004), who introduced the term deindustrialization, which indicates the situation of reducing employment in industry, but without reducing total industrial production. On the other hand, Družić et al. (2012), on the example of the Republic of Croatia, consider the situation of simultaneous reduction of industrial production and employment in the industrial sector, i.e. absolute deindustrialization.

Contemporary economic trends are increasingly focusing on the effects of international trade on the structure and characteristics of industrial sectors in individual countries. In such a situation, the industrial sector, primarily because of the increase in international competition, is oriented towards improving product and production processes and increasing production efficiency, through increasingly investing in research and development and continuous education and training of the workforce. Saeger (1997) states four concepts explaining the impact of change and inclusion in international trade flows on reducing industry's importance as follows: 1) Growing specialization in the service sector resulting from the shifting of comparative advantages in highly industrialized countries from factories to offices and/or distribution networks, 2) The appearance and pressure of new competitors characterized by low labour costs and poor legal regulation in the field of environmental protection. Such a situation results in the survival of the most productive enterprises, whose products do not have a substitute in cheap import. 3) Utilizing international cost differentials globally by opening branch offices in economically most cost-effective and most advantageous locations. 4) Orientation towards developing countries, which, as part of new developments in the international market, become new targeted markets for leading and competitive economic entities. Also, as an important external determinant of deindustrialization authors point out to foreign direct investment

(FDI). According to Alderson (1999), increase in FDI affects employment reductions in the industrial sector, primarily due to the shift of production facilities to new markets, i.e. developing countries, characterized by lower labour costs. The author also points out that FDI can have a positive effect on raising the marginal rate of return on domestic investment and thus initiate shifting investment from industrial to the service sector and ensure reorientation and shift from production investment.

A special segment of exploring deindustrialization is also the way it occurs in the former socialist countries and Western Balkans, where most of the economic activities and reforms implemented in the past emerged as a result of political decisions (Krstevska and Petrovska, 2012). Therefore, analysing the situation in this group of countries Mickiewicz and Zalewska (2001, 2002, 2006) introduce the concept of forced deindustrialization. Also, this group of countries is characterized by the notion of premature deindustrialization, which started in a situation where the economies have not yet reached high levels of industrial production (Priewe (1993) and Dasgupta and Singh (2009).

The research problem arises from the insufficient readiness of the Republic of Croatia to implement Industry 4.0, largely resulting from still high orientation towards traditional industrial sectors and a low share of high value added activities, which is particularly visible through the share of high technology products in total exports. Also, the Republic of Croatia is characterized by low levels of scientific research and innovative activities, which greatly slows down this process. The aim of the conducted research is to present the theoretical aspects of the deindustrialization process and Industry 4.0, to predict key indicators of deindustrialization and Industry 4.0 to 2025, and to propose scientifically based measures to be taken in the direction of securing the digital transformation of the Croatian industry. The purpose of the research is to analyse the trends in the industrial sector in the Republic of Croatia and to determine the current state of the industrialization process and the level of implementation of Industry 4.0. By looking into the relevant literature, it can be said that that problem has not been sufficiently researched in the Republic of Croatia nor has it been explored in other countries of the world. Namely, in the situation of an increasing digital transformation of industrial production and the overall economy, the exploration of this topic is inevitable. Therefore, its theoretical and practical justifications are derived from it.

The paper consists of six interrelated chapters. After introductory considerations introducing the key elements of research and the theoretical framework of deindustrialization, we present the research methodology used in the work. The

research was continued with a detailed analysis of the deindustrialization process and elements of Industry 4.0 in the Republic of Croatia. Based on the research results the perspectives of the development of the industrial sector of the Republic of Croatia are determined, grounded on the existing strategic documents, and the projection was made of key indicators of deindustrialization and Industry 4.0 to 2025. The paper ends with a conclusion, which represents the synthesis of the key findings that the authors came up with during the research.

2. Research methodology

The paper presents a descriptive analysis of the deindustrialization process in the Republic of Croatia. The analysis was conducted by examining the following indicators: 1) GDP per capita (in US dollars), 2) Sectoral structure of the economy (primary, secondary and tertiary sector) (% of GDP), 3) Industrial production index, 4) growth rates of industrial production (%), 5) labour productivity (index, 2010=100), 6) rate of employment (percentage of total population, 25-64 years), 7) sectoral structure of employment (share of primary, secondary and tertiary sector) (% of total employment) and 8) direct foreign investment (% of GDP).

Based on the insight into the deindustrialization process, the implementation of Industry 4.0 has been analysed using the following indicators: 1) Investments in research and development (% of GDP), 2) Sectoral structure of investment in research and development (% of total investment), 3) export of high technology products (% of total export), 4) employment in high technology sectors (% of total employment), 5) employment in research and development activities (% of active population, 25-64 years), and 6) participation of persons 25-64 years (%) in lifelong learning programs. The analysis covered (depending on the availability of data) the period from 2000 to 2017. Data were collected from the World Bank's Secondary Statistics Base and Eurostat.

Taking into consideration theoretical background that emphasizes the importance of investing in research and development in the context of the implementation of Industry 4.0, the projection of the key indicators was made until the year 2025. The projection was made using the exponential smoothing method, which is commonly used in time series. By using this method, the forecast for the period is obtained as a weighted average of the actual and projected time series value in t period. The real value of the time series in the period is associated with the weight w (smoothing constant), which takes the value between 0 and 1, while the forecast t is added the weight. The higher the value of the parameter, the greater the weight attached to the previous period (Winters, 1960).

The Holt-Winters method uses a triple smoothing and has three smoothing constants:

1. the constant used for each exponential smoothing (overall smoothing),
2. constant used in determining trend (trend smoothing)
3. the constant used to determine periodic smoothing (seasonal smoothing)

The forecast is calculated based on the following formulas:

$$St= \alpha\ yt/It-L+(1- \alpha)(St-1+bt-1) \quad (1)$$

$$bt=y(St- St-1) +(1-y)\ bt-1 \quad (2)$$

$$It= \beta\ yt/St + (1- \beta)\ It-L \quad (3)$$

$$Ft+m=(St+mbt)\ It-L+m, \text{ where} \quad (4)$$

y= the observed values

S= smoothed values

b= value trend factor

I= periodic value index

f= the forecast for m period in advance

t= index determining the time period

3. Theoretical background of the industry 4.0

Deindustrialization and other global trends and challenges faced by the industrial sector of the Republic of Croatia and globally have emerged as a direct consequence of changes initiated within the third and fourth industrial revolution. The third industrial revolution began in the 1960s and was based on the implementation of digital computers and communications technology, in order to improve the performance of production processes and the daily life and work of the population. The continuation of this process is the fourth industrial revolution marked by the creation of a large number of technological innovations and the development of robotics, nanotechnology, artificial intelligence, internet, 3D printing and autonomous vehicles, with a view to achieving economic growth

and increasing competitiveness of the economy. In the context of the fourth industrial revolution, the term Industry 4.0 appears, for which the authors agree that it represents its most important driver and element. The term Industry 4.0 was developed in 2011 in Germany (Hanover) by the Federal Ministry of Education and Research and is increasingly widespread in contemporary economic terminology.

In general, exploration and consideration of the Industry 4.0 can be started with the view that it represents *the organization of production processes based on technology and devices for autonomous communication*. Furthermore, Industry 4.0 embraces *the concept of modern / smart future factories, in which computer systems manage and monitor physical processes and thus create a copy of the physical world and make decentralized decisions based on self-organization mechanisms*. However, when considering this concept, emphasis should be placed on the growing computerization of production, which implies the integration of physical objects with the information network (Matejak, 2017).

Industry 4.0 is determined by trends, elements and priorities (Table 1).

Table 1: Trends, elements and priorities of Industry 4.0

Trends	Elements	Priorities
Interoperability	Internet of Things	Standardization and referential architecture
Virtualization	Internet services	Managing complex systems
Decentralization	Big Data	Broadband Internet
Capabilities of real time	Cloud Computing	Safety and protection
Orientation towards services	Robotics	Organization and labour design
Modularity	Artificial intelligence	Education and knowledge improvement, life-long learning
	Autonomous vehicle	Regulatory framework
	3D printing	Efficiency of resources
	Nanotechnology	
	Biotechnology	
	Industrial Internet	
	Advanced production	
	Cyber-physical production systems (CPPS)	
	Smart factory	

Source: developed by the authors based on Kutil (2015), Smit et al. (2016) and Kagermann et al. (2013)

Kutil (2015) points out that the foundation of Industry 4.0 connects workers and smart factories and provides their mutual communication via cyber-physical systems, whereby the virtual copy of the factory is created by linking sensor data to a virtual factory model and simulation model. In addition, cyber-physical systems independently make decisions using advanced technologies, with the ability to make decisions and analyse data in real time. In line with modern economic trends, Industry 4.0 implies *high service orientation and adaptation of smart factories to a dynamic environment*.

Elements related to the realization of Industry 4.0 reflect the orientation of modern business processes on information and communication technologies, created as a direct product of investing in research and development (Smit et al., 2016). The main emphasis should be placed on elements related to industrial production, namely industrial Internet (implementation of the Internet in all aspects of business), advanced technology (use of technological innovations in order to improve production processes), cyber-physical production systems (CPPS) (advanced systems that independently exchange information, trigger actions, and carry out independent controls) and smart factories (implementation of information communication technologies in the manufacturing process). According to Kagermann et al. (2013), Industry 4.0 priorities include connecting and integrating companies through value networks, whose production systems are becoming more complex, with the emphasis on equipment and planning. Also, this concept requires the presence of broadband Internet networks, with the necessity of erasing all potential risks for process participants. Organization and new methods of labour require adaptation to the changes that are largely reflected in the new labour market demands, which place the emphasis on the need for continuous education of the workforce, primarily through lifelong education and training programs. Industry 4.0 puts new challenges ahead of the legislative system in terms of intensified protection of all forms of intellectual property and data protection among affiliated companies.

According to the viewpoint that Industry 4.0 is based on innovation, study of Delloite (2015) identifies the most important innovations developed within this concept: vertical networks of smart production systems, horizontal integration through new global value chain networks, crosslinked engineering within the whole chain, and acceleration of growth through exponential technology.

Furthermore, Kagermann et al. (2013) determine the key preconditions and challenges of Industry 4.0. The authors, based on a survey carried out on a sample of 278 companies, as industry`s most important preconditions/challenges, highlight the standardization of production, work organization, product availability, and

the development of new business models. Also, as relevant prerequisites/challenges security and protection are recognized, as are a lack of professional staff, research, the necessity of continuous education and training, and the regulatory framework. The implementation of technological solutions to modern companies raises the question about their impact on business operations. According to Smit et al. (2016), 90% of German industrialists recognize the benefits of this process. However, only 12% feel ready for transformation. According to Deloitte (2015), Swiss industrialists point out the pressures and potential costs of digital transformation to research and development, production and procurement Considering the potential future effects of Industry 4.0 and digital transformation, Buhr (2015) points out that the implementation of these processes can result in 1) large opportunities and cost cutting, 2) large companies more seriously approaching digital transformation, 3) changing the need for high technology skills, 4) increasing the need for exponential technologies, which will ultimately result in 5) increasing competitiveness and creating new jobs.

Furthermore, Buhr (2015) considers the potential effects of Industry 4.0 on companies and the overall economy and identifies three key directions: *Breaking up, Progress, and Destruction*. According to the Breaking up concept, Industry 4.0 will, by orienting itself to new business models and processes, gradually result in the replacement and extinction of old technologies. The Progress concept highlights the *solution of the present problems with future technologies*. On the other hand, the Destruction concept points out that Industry 4.0 is not new, i.e. there is no innovative approach. The choice of the concept and its potential effects in a particular country will depend primarily on the ability of economic and political authorities to stimulate the digital transformation of economy through thorough and comprehensive structural changes and their dynamic management.

Digital transformation as a major challenge highlights the problem of digital security, i.e. the need for data protection. Namely, in modern business conditions where information is the key to achieving successful business results and achieving competitive advantage, public disclosure or pilfering data may be a serious blow to businesses. Smit et al. (2016) point to categories that are largely exposed to security risks: intellectual property, privacy, operability, environmental protection, and health and safety. Furthermore, Geissbauer et al. (2015) identify the most important aspects of alienation of information and other forms of digital security disturbance, and put special emphasis on manufacturing hacking attacks, risk of data loss and potential damage to corporate reputation and loss of trust between partners and clients. The overall development of Industry 4.0 also depends largely on scientific research activities, with a high emphasis on the combination of information-communication technologies and automation.

Kagermann et al. (2013) point out that research and development must focus on existing production processes and their transition to cyber-physical systems, which is the foundation for the development of smart factory models. In addition, Brettel et al. (2014) state the key areas which future research should focus on: individualization of production, end-to-end engineering[2] in a virtual process chain and horizontal integration in collaboration networks.

Industry 4.0 and its related processes (convergence of information-communication technologies, manufacturing, technology and software) require development of new skills by contemporary workers. Smit et. al (2016) stipulate the four key areas, which will in the future create a competitive and adaptable workforce. These areas are referred to by the common name STEM, consisting of science, technology, engineering and mathematics. Also, the authors state that the benefits of the labour market and modern business processes will be achieved by those workers who successfully connect as much knowledge as possible from several different areas.

Analysing the current research in the subject matter, it is possible to see that Industry 4.0 is a complex process that requires the implementation of a large number of research and knowledge-based elements. Therefore, the authors of this paper define Industry 4.0 as *a process, resulting from deindustrialization, which implies the advancement of industrial production and its close connection with information and communication technologies. Such an approach requires increased research and development activities, labour force training in key areas, which will ultimately result in the production of a large number of high value products. By this approach, it is possible to ensure long-term economic growth and export competitiveness of the economy.*

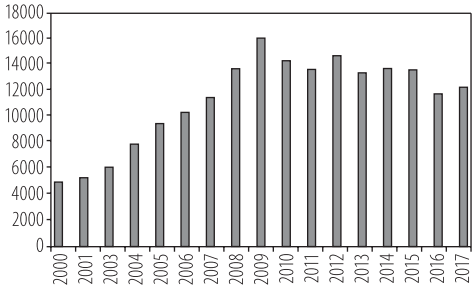
[2] Progress in integrated engineering within the value chain by using advanced communication methods and virtualization

4. Deindustrialization and Industry 4.0 in the Republic of Croatia

In the observed period, the Republic of Croatia consistently increased the level of GDP per capita by the year 2008, when, to a large extent due to the negative effects of the economic crisis, the economy slowed and stagnated. Nevertheless, growth picked up in 2017, indicating some progress in the economy (Figure 1).

In order to obtain a concrete picture of economic trends and factors of economic growth, the analysis of the fluctuation of the share of the individual sectors (primary, secondary and tertiary) in the total added value (Table 1) has been analysed below.

Figure 1. Trend of GDP per capita of the Republic of Croatia in the period 2000-2017 (in US dollars)



Source: developed by the authors based on the World Bank (1), 2019

Table 1: Sectoral structure of economy of the Republic of Croatia in the period 2000-2017 (% GDP)

Year/ Sector	Value added of the primary sector (% GDP)	Value added of industrial sector (% GDP)	Value added of services sector (% GDP)
2000	6.41	29.08	64.27
2001	6.42	29.33	64.71
2003	6.31	28.87	65.39
2004	5.18	28.30	65.96
2005	5.54	28.87	64.59
2006	5.00	29.87	65.95
2007	5.14	29.04	66.13
2008	4.83	28.73	67.07
2009	4.96	28.10	67.14
2010	5.05	27.90	67.28
2011	4.87	27.68	68.07
2012	4.67	27.06	68.31
2013	4.47	27.02	68.45
2014	4.39	27.07	68.99
2015	4.14	26.61	69.23
2016	4.20	26.62	69.40
2017	3.96	26.40	69.76
EU	1.55	24.53	73.90

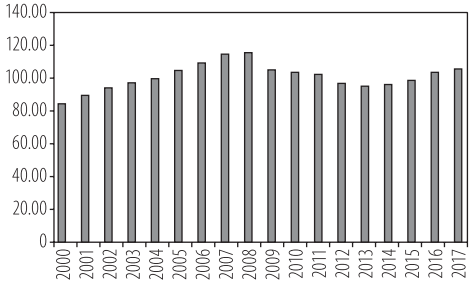
Source: developed by the authors based on the World Bank (2), World Bank (3), and World Bank (4), 2019

Data in Table 1 indicate that the Republic of Croatia decreased the primary and secondary sector's share in GDP in the observed period while the share of services increased. However, it is evident that the Republic of Croatia still has a nearly three times higher share of the primary sector in GDP than the EU average, while the share of services, despite the increase, is below the EU average. A special case is the industrial sector, whose share is close to the EU average. However, the industrial sector of the Republic of Croatia is still insufficiently innovative and is oriented towards traditional production segments. Such a situation cannot have long-term positive effects on economic growth and competitiveness of the Croatian economy.

The industrial production index of the Republic of Croatia was increasing until the year 2008, when due to the negative effects of the global economic crisis it started to decline, which lasted, with some exceptions, until the year 2015. After 2015, the industrial production started to grow again (Figure 2).

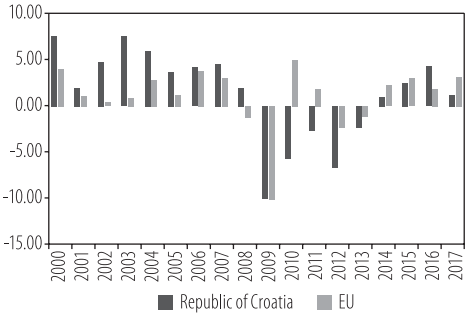
Industrial production in the Republic of Croatia in the period 2000 - 2017 increased on average 1.34% per annum, leading to a faster growth than the EU average (1.13%). The available data suggest that the global economic crisis has had a significant impact on the growth rate of industrial production, resulting in a significant overall industrial production decline in the period 2009-2014. Relative stability was achieved in 2014. Since then, positive growth rates of industrial production have been achieved (Figure 3).

Figure 2: Trends in the industrial production index (2015=100) of the Republic of Croatia in the period 2000 - 2017



Source: developed by the authors based on Eurostat (1), 2018

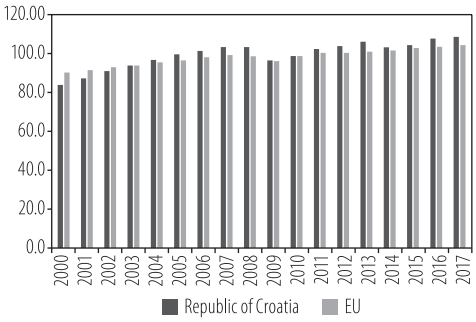
Figure 3: Growth rates of industrial production in the Republic of Croatia in the period 2000-2017 (%)



Source: developed by the authors based on Eurostat (1), 2019

The effects and state of deindustrialization in a given country can also be estimated on the basis of the trends in labour productivity index. The data from Figure 4 indicate that the Republic of Croatia achieved, with certain exceptions in 2008, 2009 and 2014, an increase in labour productivity, which continued in 2017 (Figure 4).

Figure 4: Labour productivity trends (index, 2010 = 100) in the Republic of Croatia and the EU in the period 2000-2017

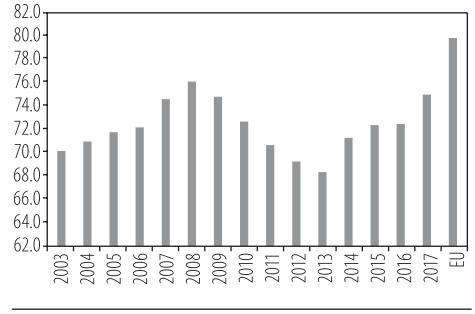


Source: developed by the authors based on Eurostat (8), 2019

The previously presented data indicate that the economic growth of the Republic of Croatia in the previous period was accompanied by a reduction in the share of primary and secondary sectors in GDP, bringing about an increase in the importance of the service sector. Furthermore, the Republic of Croatia has achieved an increase in labour productivity, which is in line with works of Rowthorn and Ramaswamy (1997), which recognize the increase in labour productivity as the most important characteristic of the deindustrialization process. Such findings point to the fact that the Republic of Croatia followed the development paths characteristic for developed countries in this segment.

Indicators of total employment and the change in its sectoral structure are analysed below.

Figure 5: Employment trends (% of total population, 25-64 years) in the Republic of Croatia in the period 2003-2017



Source: developed by the authors based on Eurostat (9), 2019

By 2009, the Republic of Croatia increased employment, when, due to the negative effects of the economic crisis, the employment began to decline. This fall lasted until 2013. In the forthcoming period, total employment would begin to rise again, reaching a level of 74.9% in 2017. With such values, the Republic of Croatia was still below the EU average (79.7%), but with the tendency to reduce the existing lags (Figure 5).

The trends in total employment in the Republic of Croatia were also followed by changes in its sectoral structure (Table 2).

Table 2: Sectoral structure of employment in the Republic of Croatia in the period 2000-2017 (% of total employment)

Year/Sector	Primary sector	Secondary sector	Tertiary sector
2000	14.52	28.88	56.60
2001	15.58	30.04	54.38
2002	15.55	29.82	54.63
2003	16.86	30.25	52.88
2004	16.97	29.64	53.40
2005	17.30	28.63	54.07
2006	14.25	29.35	56.40
2007	12.35	30.64	57.00
2008	12.82	30.85	56.33
2009	13.32	29.01	57.67
2010	14.25	27.45	58.29
2011	14.59	27.95	57.46
2012	12.25	27.91	59.83
2013	10.79	27.63	61.59
2014	9.52	26.98	63.50
2015	9.23	26.71	64.06
2016	7.60	26.97	65.42
2017	7.54	27.04	65.41
EU	**4.24**	**23.95**	**71.79**

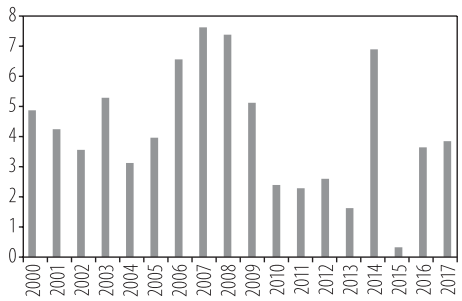
Source: developed by the authors based on the World Bank (5), World Bank (6), and World Bank (7), 2019

Data in Table 2 show that, compared to the beginning of the period, the Republic of Croatia achieved a total reduction of employment in the primary and secondary sector (however, its value has slightly increased since 2015), while employment in the tertiary sector has increased. However, as well as in the sectoral structure of economy, there is still higher employment in the primary sector than the EU average, as well as a decline in employment in the service sector. Also, observing the period after 2015, it is clear that the Republic of Croatia has achieved an increase in labour productivity, relative growth of industrial production and an increase (though not significant) in employment in the industrial sector. These results point to a certain turn in relation to the previous period, marked by absolute deindustrialization, which is recognized by Družić et al. (2012).

Contemporary global trends are increasingly focusing on the significance of FDI for the overall process of deindustrialization (Figure 6).

Foreign direct investment fluctuated during the observed period, with the largest growth being achieved between 2003 and 2007, after which FDI began to decline until 2013. After 2015, growth picked up and this continued throughout 2016 and 2017. In the example of the Republic of Croatia, especially after 2015, there is an increase in the level of FDI, with an increase in employment in the secondary sector.This situation contradicts the Alderson`s assumptions (1999) on the link between FDI increase and employment reduction in the industrial sector.

Figure 6: Foreign direct investments in the Republic of Croatia in the period 2000-2017 (% of GDP)



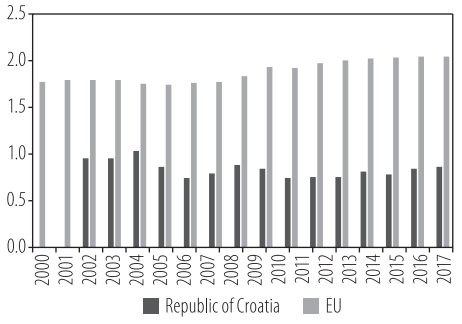
Source: developed by the authors based on the World Bank (8), 2019

Based on the data presented above, it is possible to conclude that the process of deindustrialization in the Republic of Croatia is characterized by a reduction of the share of employment in the primary sector, by increasing employment in the secondary sector, and by a relative increase in industrial production and labour productivity. Although reduced in comparison to the beginning of the period, employment in the industrial sector has increased since 2015, which is in contrast to the theoretical notions of deindustrialization and marks a new trend in the industrial sector in the Republic of Croatia. Such situation shows a (possible) shift of this sector of the Croatian economy towards the demands of the modern economy, with the emphasis being put on the implementation of the Industry 4.0 concept.

Realization of the Industry 4.0 concept requires a continuous increase in investment in research and development and the improvement of knowledge and capacities of people and their implementation in economy.

In 2016, the Republic of Croatia has reached a level of investment in research and development of 0.86% of GDP, which was the continuation of

Figure 7: Investments in research and development (% of GDP) in the Republic of Croatia and the EU in 2000-2016



Source: developed by the authors based on Eurostat (2), 2019

an increasing trend that started in 2010 (with the exception of 2014). However, increasing investment in research and development is still relatively modest, especially compared to the EU average (2.04% of GDP in 2016) (Figure 7).

It is also necessary to analyse the structure of investment in research and development, i.e. contributions of particular sectors (public sector, business sector, higher education sector, private non-profit sector and foreign investment) (Table 3). The available data indicate that the largest share of total investment in research and development in the Republic of Croatia is realized by the business sector, followed by public sector investment and foreign investment. Also, data suggest that the Republic of Croatia has slightly increased the level of business sector investment compared to the beginning of the period but it is still below the EU average.

Table 3: Sectoral structure of investment in research and development (% of total investment) in the Republic of Croatia and EU in the period 2002-2015

Year	Business sector	Public sector	Higher education sector	Private non-profit sector	Foreign investment
2002	45.7	46.4	6.4	-	1.5
2003	42	55.9	-	-	2.2
2004	43	46.6	7.9	-	2.6
2005	34.3	58.1	4.9	0	2.6
2006	34.6	55.8	2.5	0.2	6.8
2007	35.5	50.4	3	0.2	10.9
2008	40.8	49.3	1.9	0.2	7.9
2009	39.8	51.2	1.9	0.1	7
2010	38.8	49.2	2	0.2	9.9
2011	38.2	48.2	1.7	0.2	11.6
2012	38.2	45.5	1.7	0.3	14.4
2013	42.8	39.7	1.7	0.3	15.5
2014	42.9	41.7	2.1	0.5	12.8
2015	**46.6**	**36.4**	**2**	**0.5**	**14.5**
EU	**55.3**	**31.3**	**0.9**	**1.7**	**10.8**

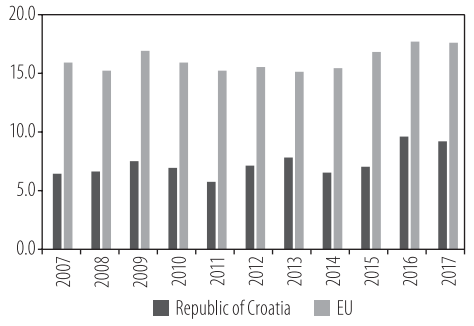
Source: developed by the authors based on Eurostat (3), 2019

Further increase in the level of investment in research and development of the business sector is one of the key challenges of Croatian economy in the process of achieving international competitiveness and taking a more significant share in the international market. Scientific research activities undertaken at enterprise

and industry level have a crucial impact on increasing the level of share of high-tech products in total exports.

Data from Figure 8 show that the exports of high technology products account for 9.3% of total Croatian exports, which is an increase compared to the beginning of the year (2007), but also a slight decrease compared to 2016. Nevertheless, it is evident that increasing overall investment in research and development and increased business sector engagement also result in positive effects on increased exports of high technology. However, the Republic of Croatia is also far below the EU average in this segment (17.8% in 2017).

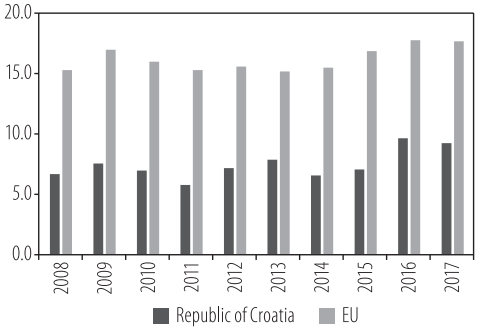
Figure 8: Exports of high technology products (% of total exports) in the Republic of Croatia and EU in the period 2007-2017



Source: developed by the authors based on Eurostat (4), 2019

Furthermore, the Republic of Croatia has also achieved an increase in the level of employment in high technology sectors, which is particularly notable since 2014. The latest available data indicate that employment in high technology sectors accounts for about 9.3% of total employment (Figure 9).

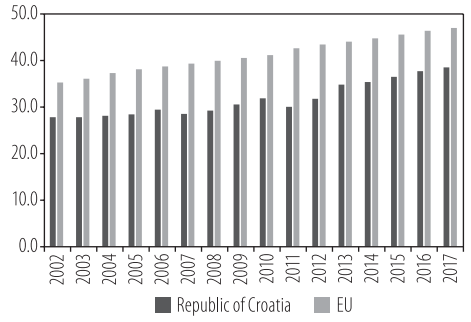
Figure 9: Employment in high-tech sector (% of total employment) in the Republic of Croatia and EU in 2008-2017



Source: developed by the authors based on Eurostat (5), 2019

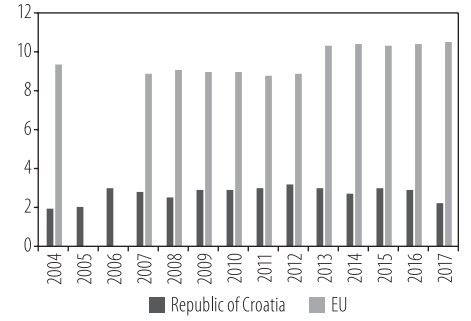
However, according to this indicator, despite some progress, the Republic of Croatia still lags significantly behind the EU average (17.8% in 2017). Increasing the level of employment in high technology sectors requires economic policy holders in the Republic of Croatia to respond to challenges of engaging a larger proportion of the active population in research and development activities. The Republic of Croatia has recorded positive trends in this segment, which

Figure 10: Employment in science and technology (% of active population, 25-64 years) in the Republic of Croatia and EU in the period 2002 -2017



Source: developed by the authors based on Eurostat (6), 2019

Figure 11: Participation of people aged 25-64 years (%) in lifelong learning programs in the Republic of Croatia and EU in 2004-2017



Source: developed by the authors based on Eurostat (7), 2019

have been particularly notable since 2010. The latest available data indicate that 38.2% of the active population aged 25-64 in the Republic of Croatia has been engaged in science and technology (Figure 10). Trends in this area turn to be close to the EU average (46.6% in 2017).

Volatile and dynamic conditions in the labour market and the ubiquitous digital transformation of society require modern workforce to consistently improve their knowledge and skills through higher education institutions and lifelong learning programs, which is also prioritized by key EU development strategies (e.g. EUROPA 2020). In the Republic of Croatia in the year 2017, only 2.3% of the population aged 25-64 were included in lifelong learning programs, which is almost 5 times lower than the EU average (Figure 11).

Presented data on investments in research and development indicate that the Republic of Croatia has made some progress, with a particular emphasis on the engagement of the business sector in research and development activities and increasing employment in high scientific intensity sectors. Nevertheless, the Republic of Croatia is still significantly below the EU average according to all indicators, which is a major challenge in the future. In order to adapt to the requirements of Industry 4.0 and to generally implement the knowledge economy and the realization of digital transformation, it is necessary to greatly improve the level of workforce capability, which in modern business conditions is a key element of long-term development and competitiveness, and which is particularly significant in the context of the latest developments in the industrial sector.

The results of the research conducted by Veža (2017) speak in favour of these conclusions. Having analysed 161 industrial enterprises, it was found that *Croatian industrial companies are at Industrial level 2.15, which represents a big difference compared to the German model of Industry 4.0.* Also, as the largest constraints of the observed companies the following have been identified 1) the inability of workers to adapt and monitor the progress of technology and organization, 2) the small number of companies whose employees spend more than 5 days a year on training, and 3) the lack of systematic vocational retraining of employees (95% of companies). The author of this research agrees that the Republic of Croatia must develop *the original Croatian model of a smart company.*

5. Perspectives of industry 4. 0 in The Republic of Croatia

As a full member of the EU, the Republic of Croatia has to direct industry trends in accordance with the EU industry principles and policies, with particular emphasis on securing industrial growth, full employment, financial stability and efficiency, with the ultimate goal of achieving economic growth, competitiveness and increasing living standard. The Croatian industry, in accordance with the requirements of Industry 4.0, also has to act in the direction of achieving the objectives of the European research and development policy. This policy is governed by Articles 179-190 of the Treaty on the Functioning of the EU and *provides for the need to strengthen the scientific and technological bases of the Union industry and to favour the development of international competitiveness based on the framework of multi-annual research programs that determine the scientific and technological objectives.*

Furthermore, the EUROPA 2020 strategy, defined in 2010, requires the EU and its Member States to achieve smart, sustainable, and inclusive growth by 2020. Also, the Strategy is oriented towards the realization of five key objectives, namely: 1) increasing employment rates to 75%, 2) achieving research and development investment of at least 3% of GDP, 3) reducing greenhouse gas emissions by 20%, increase energy efficiency by 20% and the share of renewable energy sources by 20%, 4) achievement of early school leaving rate of less than 10%, and having the share of highly educated population aged 30-34 years at least at 40%, and 5) reduction of the proportion of poor people or people living on the edge of poverty by 20 million (European Commission (1), 2019).

The strategy envisages the achievement of the priorities and the set goals through seven key initiatives, four of which are aimed at securing further industry progress such as *the Union of Innovation, Digital Program for Europe, the Industrial*

Policy for Global Age, and New Skills for Workplace. A special contribution to strengthening the role of industrial policy has the initiative „Industrial Policy for the Globalization Age", which proposed 10 measures for the progress of the EU industry.

The primary objective of the aforesaid initiative is to ensure the improvement of the business environment (especially for small and medium-sized enterprises) and to encourage the development of a strong and sustainable industrial base. In addition to this initiative, the Union of Innovation initiative is particularly important, with a targeted focus on improving the business environment and access to finance for research and innovation development activities. By boosting entrepreneurship's innovation, economic growth and job creation are achieved, which is particularly important for the European industry (European Commission (2), 2019). These two initiatives are perceived as leading initiatives of the Europe 2020 strategy in the industrial sector as well as the bearers of the new industrial revolution, which has brought industrial policy as a key element for the future development of the Union.

The strengthening of industrial policy in years after the adoption and enforcement of the Europe 2020 strategy has been marked by defining several **communications**. Communication „Industrial Policy: Strengthening Competitiveness", issued in 2011, highlights the importance of launching structural change and coherence and harmonization of policies in the Member States with the aim of boosting economic and industrial competitiveness and sustainable growth in the EU. In 2012, Communication referred to as „Strong European Industry for Growth and Economic Recovery" was adopted with the aim to create and implement measures in order to foster investment in innovations within the industrial sector. In 2014, a new communication called "For the European Industrial Revival" (European Commission (3), 2019) was adopted as a result of a series of weaknesses and obstacles to the development of the European industry, despite its excellent "performance". It is recognized that in the future these barriers may threaten the competitiveness of the European industry.

In the last few years, several Strategies aimed at strengthening the scientific-technological foundations of the economy have been defined in the Republic of Croatia.

The Strategy for innovation encouragement of the Republic of Croatia 2014-2020 was accepted in 2014 *in order to build an efficient innovation system that will direct the Croatian economy to knowledge-based activities but also to exploit the potential of Croatia in terms of its territorial position, resources and tradition in industrial*

production, but also innovativeness and creativeness as the basic driving factors of the economy. As the most important goals of the Strategy, whose implementation is planned by 2020, the following were stated: 1) *investment in research of 1.4% of GDP*, 2) *investment of business sector in research and development activities of 0.7% of GDP*, 3) *directing 33% of total scientific research investments into investment projects*, 4) *increasing the number of patent applications per million inhabitants to 25*, 5) *25% of foreign investor contribution to investment in the business sector*, and 6) *increasing the number of researchers in the total number of employees in the economy to 1571* (Ministry of Economy, Entrepreneurship and Crafts of the Republic of Croatia (1), 2017).

In 2016, the Government of the Republic of Croatia adopted the Strategy for Smart Specialisation for the period 2016-2020, which provides access to European Structural and Investment Funds for the purpose of strengthening research, technological development and innovation (Topic Objective 1) amounting to EUR 664 million. The aim of the implementation of these programs is to further strengthen and advance the competitiveness of the Croatian economy, through research, innovation and technological development. The priority thematic areas of the Strategy are: 1) Health and quality of life, 2) Energy and sustainable environment, 3) Transport and mobility, 4) Security, and 5) Food and bioeconomy. Also, the main aims of the Strategy are *the achievement of economic growth, the promotion of business sector investment in research and development activities, and the creation of new highly qualified jobs, as well as the strengthening of cooperation between the scientific and research sector* (Ministry of Economy, Entrepreneurship and Crafts of the Republic of Croatia (2), 2017).

The Strategy, with the stipulated descriptive goals, determines a large number of quantitative goals, among which it is necessary to distinguish the following: 1) *increase the investment of the business sector in research and development activities to 0.7% of GDP by 2023*, 2) *increase the number of innovative small and medium-sized enterprises in the total number of small and medium-sized enterprises of 35%*; and 4) *export of medium and high technology products (% of total export of products) from 41.36% by 2023*.

Applying the exponential smoothing method, a projection of key indicators related to deindustrialization and implementation of Industry 4.0 is presented below (Table 4).

Table 4: Projections of key deindustrialization and Industry 4.0 indicators until the year 2025

Year/ Indicator	Share of industry in GDP	Employment in industry (% in total employment)	Employment in high technology sectors (% in total employment)	Employment in research and development activities (% of active population aged 25-64)	Participation of people aged 25-64 (%) in life-long learning programs
2000	24.42	28.88	-	-	-
2001	24.03	30.04	-	-	-
2002	23.56	29.82	-	27.6	-
2003	24.16	30.25	-	27.6	-
2004	25.24	29.64	-	27.9	2.0
2005	24.58	28.63	-	28.2	2.1
2006	24.31	29.35	-	29.2	3.1
2007	23.91	30.64	-	28.3	2.9
2008	23.82	30.85	6.7	29.0	2.6
2009	23.89	29.01	7.6	30.3	3.0
2010	23.14	27.45	7.0	31.6	3.0
2011	23.28	27.95	5.8	29.8	3.1
2012	22.98	27.91	7.2	31.5	3.3
2013	22.46	27.63	7.9	34.5	3.1
2014	22.50	26.98	6.6	35.1	2.8
2015	22.34	26.71	7.1	36.2	3.1
2016	22.14	26.97	9.7	37.4	3.0
2017	21.76	27.04	9.3	38.2	2.3
2018	21.99	26.74	8.9	37.6	3.1
2019	21.84	26.54	9.1	38.3	3.1
2020	21.68	26.34	9.4	39.1	3.2
2021	21.52	26.14	9.6	39.8	3.2
2022	21.37	25.94	9.9	40.5	3.2
2023	21.21	25.73	10.1	41.3	3.3
2024	21.06	25.53	10.4	42.0	3.3
2025	20.90	25.33	10.6	42.7	3.3

Source: authors` calculations

The projection results indicate that the Republic of Croatia will continue to reduce its secondary sector share in GDP and reach a level of 20.9% of GDP in 2020. On the other hand, the results indicate that employment in the industrial sector,

despite a slight increase in recent years, will continue to decline and is expected to reach 25.33% in 2025. Concerning the education of population, predictions of continuous increase of all observed indicators is particularly encouraging. With such developments, the Republic of Croatia is on its way to creating a good human resource base to implement the knowledge economy, addressing the challenges of digital transformation and other processes present in modern business conditions. However, projection results need to be taken with a certain amount of reserve. Namely, actual results will nevertheless come as a result of measures and policies designed by the economic and social authorities. Future developments will also depend on the new strategic commitments of the EU, given the completion of the implementation of the EUROPA 2020 strategy and the questionable success of its implementation.

6. Conclusion

The research has shown that the process of deindustrialization in the Republic of Croatia, especially in the last few years, has been characterized by a reduction in the share of employment in the primary sector, a growing employment in the secondary sector, and a relative increase in industrial production and labour productivity. However, since 2015 there has been an increase in employment in the secondary sector, which is in contrast to the theoretical deindustrialization and marks a new trend in the industrial sector in the Republic. This situation is a challenge from the aspect of implementation of Industry 4.0, which requires increased investment in research and development and the improvement of knowledge and ability of the population and their implementation in the economic sector. Analysing this segment of the Croatian economy leads to a conclusion that some progress has been made, as well as that there are significant lags behind the EU levels. The following have been recognized as the major limitations: insufficient levels of investment in research and development and unfavourable educational structure of population. Namely, in accordance with modern development directions, educated and skilled labour is the key factor in achieving economic growth and competitiveness, which is particularly significant in the context of the latest developments in the industrial sector. The future trends of the Croatian industrial sector and the success of the implementation of Industry 4.0 will largely depend on the readiness of economic and political authorities to prepare and implement quality development plans, which will provide the basis for the implementation of quality structural reforms. Furthermore, the future of the industrial sector and the achievement of competitiveness will be determined by adjustments to the EU development directions. Scientific contribution of this research is based on considerations stipulated above. Also,

its scientific contribution derives from the considerations of theoretical aspects of Industry 4.0 and the analysis of its implementation in the Republic of Croatia. Although it has increasingly attracted attention of economic theorists, it is still an insufficiently explored area. The conducted research should be the basis for future research on this topic which should primarily focus on quantifying the effects of the deindustrialization process and the implementation of Industry 4.0 in the developmental results and performance of the Croatian economy.

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