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The Impact of Changes in Industrial Robots Supply on the Level of Employment in Selected European Countries

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Abstract: Europe is a region with the highest density of robots in industry. The aim of the article is to analyse the dynamics of annual robots supplies in five selected European countries and to identify a connection between the supplies and changes in employment. The one-way analysis of variance used in the study allowed concluding that the average increase of industrial robots supplies in Germany, Italy, France, Spain as well as in Great Britain differed significantly in particular years and depended primarily on the economic situation. A positive correlation between the supplies and annual changes in employment was observed, which may result from the fact that the robots are substitutes for tasks performed in given professions but they do not replace them completely.

Keywords: robots; industrial robots; employment

JEL Classification: J21; J24

1. Introduction

At the threshold of the third decade of the twenty-first century we are trying to consider the borders of automation and robotisation of business processes more frequently. Due to the automation of business processes we obtained a possibility of replacing work performed by a man by machine work, computer or its software work. On the other hand, defining the issues of robotisation of the business processes it may be observed that for its implementation in an automation process a programming robot is used. Therefore, although the terms robotisation and automation of processes are commonly alternatively used, it should be taken into account that robotisation is a part of automation or its special type. There are also cases of using robots that cannot be defined as automation.

The industrial robots play a particular role in robotisation of business processes. It should be noticed that in 2020 Europe will be a region with the highest density of using robots in industry. In almost every industry robotisation of production became necessary and it is considered as a standard of a competitive activity. Internationalisation of industry and globalisation of economy lead to implementation of the systems of production automation and consequently to supporting the effects regarding production scale. Interestingly, at the same time with a growing use of robots an increase in total employment may be noticed.

The most important achievements in automation and robotisation of business processes studies include the results of such researchers as Davenport Thomas and Kirby Julia (2015), Autor David (2015) and Sutherland Charles (2013). The studies concerning these problems were initiated in the early seventies of the last century in response to the increasing use of robots on production lines in the sixties.

The article deals with an increase in the use of industrial robots in selected European countries, including Germany, Italy, France, Spain and Great Britain, and focuses on the dynamics of their annual supplies. The data on the scale of the robotisation of processes in these countries indicate that the number of workplaces vulnerable to replacement by robots is big enough to propose a hypothesis proving the use of this type of technology as influencing a character of workplaces in the future. The main problem to solve in the presented article was to identify an impact of the increase in the use of robots on a level of employment. Dealing with the issue in more detail, the study tries to identify the links between annual

supplies of multi-functional industrial robots and changes in employment in five selected European countries.

2. Methods

In the course of analytical study on the dynamics of annual industrial robots supplies in five countries, including Germany, Italy, France and Great Britain, the one-way analysis of variance was used. The data concerning the increases of supplies in the years 2009-2020 (taking into account forecast data from the years 2018-2020) were obtained from the reports of the International Federation of Robotics. Subsequently, a correlation between estimated annual multi-functional industrial robots supplies and annual changes in total employment for the years 2009-2018 was calculated. Statistics on employment were obtained from the database provided by Eurostat.

3. Results and Discussion

In order to carry out the analytical study we should define the term an industrial robot, which is every automatically controlled, universal robotic system programmable on at least three axes, that are fixed or mobile and can be used in industrial automation (according to ISO Standard 8373: 2012). *This means that the robot (*International Federation of Robotics 2017*)*:

1. Performs tasks without any external commands during the process (automatically controlled);
2. Can change movements without changing the equipment (reprogrammable);
3. Is able to perform different operational activities after physical changes such as replacement of tools (universal).

From the sixties to the nineties of the last century the most of the robots and robotics were limited to an industrial use. (European Agency for Safety and Health at Work 2015) Although nowadays they are also used in other sectors, the industry is still one of their essential uses. The demand for industrial robots has started to increase significantly since 2010. The continuing tendency to automatization and technical innovations are the main reasons of this phenomenon. According to the data of the International Federation of Robotics, Europe was the second largest market of sale of industrial robots in 2018. The average annual growth rate in Europe was 10% in the years 2012-2017. The traditional industrial robots played a significant role in ensuring competitiveness of European production industry. Since the 1970s Europe has been competitive in terms of technical and trade considerations as regards robots, however they are unevenly used depending on the country. (Estolatan et al. 2018) Germany is the fifth largest robots markets in the world (after China, Japan, the Republic of Korea and the United States of America). The important market is also Italy. Whether in case of Germany or Italy it may be assumed that they have favourable solutions regarding the possibilities of automation of business processes and also institutions necessary in the robotics development6. Other countries with the significant growth of industrial robots sale are Spain, France and to a lesser degree Great Britain, however, France and Great Britain are facing the challenges that are posed by public opposition resulting from the potential of replacing human labour. The rest of West European countries, except for Austria and Portugal, also recorded an increase of sales but their position in the technological *landscape is less important.*

In recent years, the above-mentioned countries have launched the programs, aimed at development of robotics, that are often a part of the campaign for Industry 4.0. These are initiatives involving universities as well as domestic companies, mainly in a form of public-private partnerships. It is presented in figure 1 where estimated annual supplies of multi-functional industrial robots in the analysed countries, Germany, Italy, Spain, France and Great Britain, can be found. A slow but constant growth of the estimated supplies may be observed in all the countries except for Great Britain where there were slight fluctuations on their level in 2015. Germany has been an undisputed leader and in 2017 with the number 21404 it exceeded the sum of supplies acquired in other analysed countries (19,124 in total).

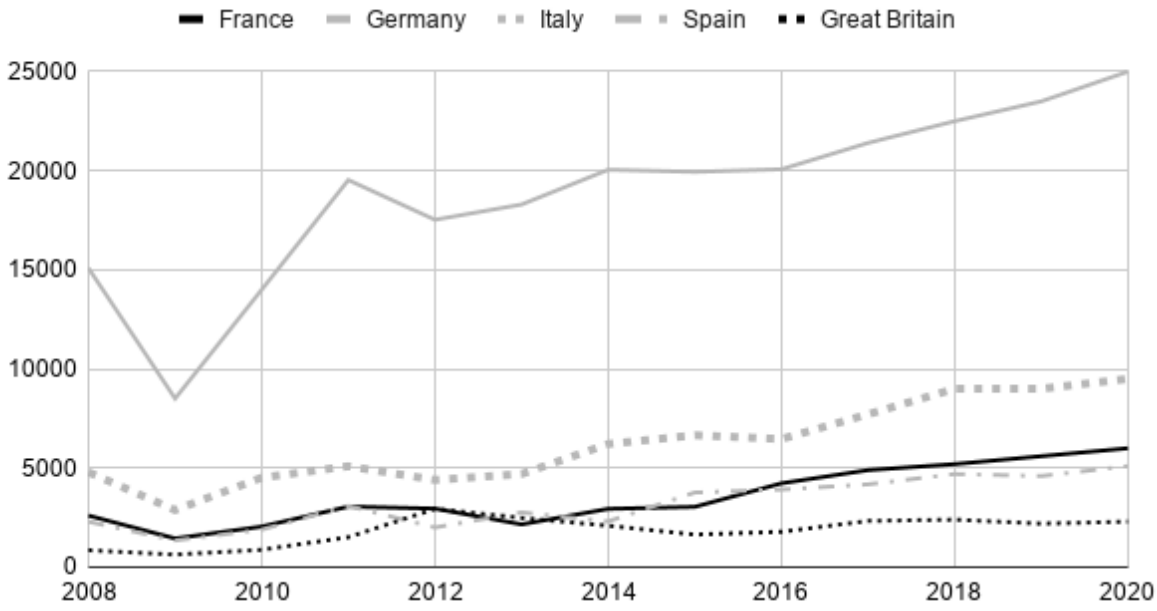

Figure 1. The estimated annual supplies of multi-functional industrial robots in selected European countries, 2008-2020 (forecasting data for the years 2018-2020), own study based on: International Federation of Robotics (2017), World Robotics Industrial Robots, https://ifr.org/, [accessed on 27 October 2019].

The idea of a future industrial revolution is connected with the achievements of German production both by scientists and industry analysts. (Kagermann et al. 2013) The great interest in this topic is related to an expected increase in productivity. It is worth emphasizing that Germany is not only a user but also an important engineer of industrial robots. The German robotics industry consists of about 500 companies including a few big players and a large number of small and medium-sized enterprises specializing in specific areas of use. Most of these companies are owned by stable networks, Original Equipment Manufacturers (OEMs) and leading suppliers. (GTAI 2018) In addition, Germany has a strong scientific base specialising in various sub-areas of robotics. It is estimated that 57% of German robotics is exported and the biggest export markets remain China (10%) and North America (9%). Moreover, the foreign demand is expected to grow.

Italy is another leading producer of robots in Europe. Italy has the second largest market in the region and supports industrial automation in production. The statistics show that the industry is export-oriented and the country is a significant player in the global industrial landscape. The domestic sector consists in 75% of big companies and in 25% of small and medium-sized enterprises. (Estolatan et al. 2018) Most of them is located in the north of Italy, especially in Lombardy and Piedmont. In 2016 the national plan, 'Industry 4.0' was introduced, which aimed at supporting development of the industry. This long-term strategic document ensures funds, 18 billion euro in total, for research and technological innovations.

France also has a program supporting enterprises in implementation of digital technologies and production modernisation: 'Industrie du Futur'. (European Commission 2017a) In 2008-2017 there was 88% growth in annual supplies of multi-functional industrial robots in France (from 2,605 to 4,897). The Franche-Comté region is considered to be the most vulnerable to robotisation as it is the strongest manufacturing region in the country. (Oxford Economics 2019)

The number of robots supplies in Spain was slightly smaller than statistics in France in the analysed period. The increase in the years 2008-2017 reached 82% and in the last year amounted to 4,180. The Spanish strategy of supporting robotisation is included in the strategy 'Industria Conectada 4.0'. (European Commission 2017b) It should be noted, that although the total number of industrial robots supplies in Spain is much smaller than in Germany, relatively more companies use the

industrial robots. This is a consequence of the fact that the percentage of the enterprises using robots remains low in Germany but the companies that use them do it to a greater extent. (Jäger et al. 2015)

Robotics and autonomous systems (RAS) were recognised as one of the eight technologies supporting British industrial strategy in 2012 by the British government. They are treated as a chance to restore a balance in economy as well as growth and jobs creation. The strength of Great Britain in robotics is considered a large number of experts in the research community and in business. In accordance with the assumptions of the RAS 2020 strategy this kind of base in connection with proper investment is to create ecosystem generating new products, services and business. (UK-RAS Network 2019) In the years 2008-2017 Great Britain recorded an increase in annual supplies of industrial robots at the level of 177%, however, it continues to lag behind other analysed countries.

The one-way analysis of variance of annual supplies of multi-functional industrial robots in five analysed countries allows for the conclusion that the average increases for individual years significantly differ.

Table 1. The one-way analysis of variance of annual supplies of multi-functional industrial robots in selected European countries, own calculations based on: International Federation of Robotics (2017), World Robotics Industrial Robots, [accessed 27 October 2019].

	Df	**Sum Sq**	**Mean Sq**	**F value**	**p value**
Year	11	2.744	0.24947	5.006	3.82e-05 ***

The average growth of annual supplies of robots was not stable and, as in the case of the countries with higher intensity of supplies as well as lower statistics, depended on an economic situation. There is a clearly perceived decrease in supplies after the financial crisis in 2007 and then their increase. Since 2012 a demand for industrial robots has increased due to a continuing trend towards automation and constant technical innovations of robots. In 2012 there was another drop and the sale of industrial robots in Europe fell by 6% compared to the previous year. After substantial investments of the automotive industry in 2011 the installment of robots decreased in this sector, while robots were still purchased by most of the other industries. Although in 2012 the sale of robots decreased in most of the countries, in Great Britain it increased to record levels. During the next years the sale of robots began to rise due to relaunching investment in automotive industry. In the years 2013-2018 installations of robots grew by 19% a year. The average number of robots on 10000 of employees in the manufacturing industry was 99 in 2018 in the world and 114 in Europe. Europe is a region with the highest density of robots. (International Federation of Robotics. 2017)

The development of robotics has been an area of particular interest due to its potential to improving quality of life and workplaces as well as the possible impact on employment and wages. According to the International Federation of Robotics, robots are substitutes for tasks performed in many different jobs, however, they are not replacing labour. The increase of their use has resulted in increased demand for work and has had a positive impact on wages so far. (International Federation of Robotics. 2017)

It is believed that in all analysed countries the number of workplaces vulnerable to substitution by robots is so large that we may be sure that this technology will be shaping a character and number of available workplaces in the future. (Lordan 2018)

The following table provides the correlation between estimated annual supplies of multi-functional industrial robots and annual changes in total employment in the analysed countries in the years 2009-2018. The results for all countries except for Great Britain are statistically significant. The positive correlation is noted, which may indicate a positive impact of robots supplies on employment in France, Spain, Germany and Italy.

Table 2. The one-way analysis of variance of annual supplies of multi-functional industrial robots in selected European countries, own calculations based on: International Federation of Robotics (2018), World Robotics Industrial Robots, [accessed: 27 October 2019].

France	Spain	Germany	Great	Italy
0.8977035	0.775204	0.9587835	0.343092	0.7268532
(0.001019)	(0.01412)	(4.495e-05)	(0.366)	(0.02652)

Dauth, Findeisen, Südekum and Wößner found no evidence that robots are responsible for the total loss of jobs in Germany but they rather influence on the structure of employment. According to their results, each robot destroys two production sites, representing 23% of the overall decrease in manufacturing industry in Germany in the years 1994-2014. However, the losses were compensated due to additional workplaces in the service sector. (Dauth et al. 2017) Similarly, Graetz and Michaels while analysing the periods of emerging from a recession since 1980s checked if they were characterized by a lower increase in employment due to technological changes. According to the results for 17 countries, including Germany, Italy, France, Spain and Great Britain, although GDP grew slower after the last recessions in case of emloyment, no similar change can be observed. Industries use routine tasks to a greater degree and those more vulnerable to robotisation did not experience slower increase in employment. The results suggest that technology does not has an influence on a slower increase of employment after recessions in the developed countries, except for the United States where it is particularly evident. (Graetz and Michaels 2017) Meanwhile, Backer, DeStefano, Menon and Suh have shown that there is a positive relationship between employment in international enterprises in the developed countries and investments in robots. They discovered that a negative impact is visible only in case of offshoring, that is robotics seems to decrease a need to move a part of the activity from developed economies. (Backer et al. 2018) Similarly, Carbonero, Ernst and Weber presented the evidence that the impact of robots on employment in the developed countries is not significant and what is more the robots influence on a decrease of offshoring, which is benefitial for employment of the emerging economies. (Carbonero et al. 2015) Additionally, Jäger, Moll, Som, Zanker, Kinkel and Lichtner argue that differences in use of robots cannot be linked with the level of employment and wages in the countries as a pressure factor for replacing labour by capital. There are examples that the countries with a relatively low wages, such as Spain, have higher percentage of companies using robots than countries with high wages, such as Switzerland. (Jäger et al. 2015)

At the same time, the results obtained by Chiacchio, Petropoulos and Pichler suggest that one additional robot for one thousand employees causes a decrease in employment by 0.16-0.2 percentage points. The calculations were performed with the use of the data for the countries analysed also in this article, except for Great Britain. Additionally, Finland and Sweden were taken into account. (Chiacchio et al. 2018) Comparing the employment on positions vulnerable to automation in the three decades it was stated that there is no significant evidence of continuation of automation in all the analysed countries (Germany, Italy, France, Great Britain, Spain). (Lordan 2018) This may suggest that the analysed countries reorganised work in other way than the countries with a significant employment decrease.

4. Conclusions

The conducted studies, both theoretical and analytical, proved that the implementation of the increasingly modern robots is a constant and unstoppable process in the analysed countries. Robotisation of the industrial production is facilitated by a good economic situation and above all omnipresent, not only in European countries but also worldwide, production standarization. The conducted analysis of the dynamics of annual supplies of industrial robots as well as their impact on employment allowed to draw a few significant conclusions regarding the assessment of the state of robotisation and its future in Europe.

1. Robotisation of the global and European production is regarded as a continuous and necessary process both in a growth and economic development of countries in the world. This thesis is accepted by theoreticians, researchers and practitioners of the economic life.
2. During the last decade the increasing interest in industrial robots is noticeable in Europe, which remains the second largest market for their sale. This tendency is clearly visible in the statistics regarding the annual supplies of robots in the analysed European countries. This is reflected in a slow but constant increase of estimated supplies in all countries, except for Great Britain where since 2015 there have been slight fluctuations in their level.
3. The average increases in the industrial robots supplies in Europe for the individual years differed significantly in the countries with high intensity of supplies as well as with lower statistics. One-way analysis of variance of the annual supplies allows to conclude that they depended on the economic situation.
4. The conducted studies and their results proved that there was a positive correlation between estimated annual supplies of multi-functional industrial robots and annual changes in the total employment in the analysed countries in the years 2009-2018. This is confirmed by the statistically significant results for all countries except for Great Britain. This may result from the fact that robots are substitutes for tasks performed within given jobs but do not replace them completely, which means that the differences in use of robots should not be linked only with the level of employment as a pressure factor for work replacement.

References

Autor David. 2015. Why Are There Still So Many Jobs? The History and Future of Workplace Automation. *Journal of Economic Perspectives*: 29(3), 3-30.

Backer Koen, DeStefano Timothy, Menon Carlo, and Suh Jung Ran. 2018. Industrial robotics and the global organisation of production. *Technology and Industry Working Papers*: 3, 3-43. https://doi.org/10.1787/18151965.

Carbonero Francesco, Ernst Ekkehard, and Weber Enzo. 2018. Robots worldwide: The impact of automation on employment and trade. Research Department Working Paper: 36, 1-14.

Chiacchio Francesco, Petropoulos Georgios, and Pichler David. 2018. *The impact of industrial robots on EU employment and wages.* Working Paper No. 2. Available online: https://bruegel.org/wp-content/uploads/2018/04/Working-Paper-AB_25042018.pdf (accessed on 12 December 2019).

Dauth Wolfgang, Findeisen Sebastian, Südekum Jens, and Wößner Nicole. 2017. German robots - The Impact of Industrial Robots on Workers. *IAB Discussion Paper*: 30, 5-46.

Davenport Thomas, and Kirby Julia. 2015. Beyond Automation. *Harvard Business Review*: 58–65.

Estolatan Eric, Geuna Aldo, Guerzoni Marco, and Nuccio Massimiliano. 2018. Mapping the evolution of the robotics industry: A cross country comparison. *Innovation policy white paper series*: 2, 1-32.

European Agency for Safety and Health at Work. 2015. Przyszłość pracy: robotyka. Available online: https://osha.europa.eu/pl/publications/future-work-robotics (accessed on: 25 October 2019).

European Commission. 2017a. France: Industrie du Futur. Available online: https://ec.europa.eu/growth/tools-databases/dem/monitor/content/france-industrie-du-futur (accessed on 25 October 2019).

European Commission. 2017b. Spain: Industria Conectada 4.0. Available online: https://ec.europa.eu/growth/tools-databases/dem/monitor/content/spain-industria-conectada-40 (accessed on 25 October 2019).

Ford Martin. 2015. *Rise of the Robots: Technology and the Threat of a Jobless Future*. New York: Basic Books.

Graetz Georg, and Michaels Guy. 2017. Is modern technology responsible for jobless recoveries? *American Economic Review*: 107(5), 168-173. https://doi.org/10.1257/aer.p20171100.

GTAI. 2018. The robotics & automation industry in Germany. Available online: https://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Fact-sheets/MET/fact-sheet-robotics-automation-en.pdf?v=4 (accessed on: 25 October 2019).

International Federation of Robotics. 2017. The Impact of Robots on Productivity, Employment and Jobs. Available online: https://ifr.org/downloads/papers/IFR_The_Impact_of_Robots_on_Employment_Positioning_Paper_updated_version_2018.pdf (accessed on 27 January 2020).

Jäger Angela, Moll Cornelius, and Lerch Christian. 2015. *Analysis of the impact of robotic systems on employment in the European Union. Final report*. Luxembourg: Publications Office of the European Union.

Kagermann Henning, Helbig Johannes, and Wahlster Wolfgang. 2013. Recommendations for Implementing the strategic initiative INDUSTRIE 4.0. Available online: https://en.acatech.de/wp-content/uploads/sites/6/2018/03/Final_report__Industrie_4.0_accessible.pdf (accessed on 30 January 2020).

Lordan Grace. 2018. *Robots at work - a report on automatable and non-automatable employment shares in Europe*. Luxembourg: Publications Office of the European Union.

Oxford Economics. 2019. How robots change the world. Available online: https://www.automation.com/pdf_articles/oxford/RiseOfTheRobotsFinal240619_Digital.pdf (accessed on 27 October 2019).

Sutherland Charles. 2013. Framing a Constitution for Robotistan. *HfS Research*: 4-18.

UK-RAS Network. 2019. Robotics and Autonomous Systems. Available online: https://static1.squarespace.com/static/5981911c4c0dbff2980ad773/t/59e0e6ae9f74560 3894d3c33/1507911349074/RAS+UK+Strategy.pdf (accessed on 27 October.2019).