POLAND
COMPETITIVENESS REPORT 2019

INTERNATIONAL COMPETITIVENESS IN THE CONTEXT OF DEVELOPMENT OF INDUSTRY 4.0

Edited by
Arkadiusz Michał Kowalski
Marzenna Anna Weresa

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Preface

The global economy is witnessing dynamic changes related to the Fourth Industrial Revolution. The latest achievements in information and communication technologies (ICT) have revolutionized manufacturing and services, as well as business practices. The Fourth Industrial Revolution means another stage of revolutionary changes in the organization and control of the entire product value chain and life cycle. The digital transformation of ICT-driven manufacturing processes manifests itself in a variety of ways, including the Internet of Things, artificial intelligence, big data analytics, cloud computing, or augmented reality [Kagermann et al., 2013; Armengaud et al., 2017]. New business models emerge, new technologies gradually change the functioning of public administration. The changes translate into the competitiveness of economies and regions [Porter, Heppelmann, 2014].

Therefore, the question arises about the traditional and new dimensions of competitiveness in the era of digital economy, and their significance for Poland. Seeking an answer to this question is the leitmotif of this monograph. The aims of the analyses conducted in this book are as follows;

- to present the theoretical background of the issue of international competitiveness, taking into account the latest developments in science,
- to identify the international competitive position of Poland compared with other European Union member states,
- to identify the state of implementation of Industry 4.0 solutions in Polish enterprises and asses the significance of the process to the competitiveness of the economy, with special focus on the concept of digital competitiveness,
- to determine the priorities of economic policy, enabling Poland to take advantage of the development opportunities related to the Fourth Industrial Revolution including Industry 4.0, and improvement of digital competitiveness.

The monograph consists of four parts divided into sub-chapters. The first part (Chapters 1–3), presents the contemporary definition of international competitiveness, and its traditional and new dimensions. This provides a theoretical background to further empirical analyses. Particularly noteworthy are the new approaches to competitiveness that have come up in the era of striving towards smart growth and the emergence of the so-called digital economy, while seeking to achieve social sustainability and optimal environmental protection. Research on competitiveness has expanded its focus to include technological, digital, socially and environmentally sustainable, and institutional competitiveness. Those considerations of a conceptual nature are complemented by an overview of the foremost manifestations of the Fourth Industrial Revolution and its consequences for the global economy.

The second part of the monograph focuses on the Polish economy and its current competitive position in the European Union. The starting point is an outline of Poland's development tendencies in 2010–2017 (Chapter 4) and an analysis of the convergence of income in Poland to the average EU level (Chapter 5). The analysis is not limited to economic growth. The following chapter discusses income disparities and poverty level in Poland, which draws reference to the social dimension of Industry 4.0 (Chapter 6). Part II ends with chapters referring to Poland's international relations, i.e., foreign trade (Chapter 7) and foreign direct investment (Chapter 8). They show the role that international links of the economy play in transmitting achievements of the digital economy.

The third part of the monograph is devoted to the main factors of the competitiveness of the Polish economy in the years 2010–2017, taking into account challenges related to the Fourth Industrial Revolution. The successive chapters analyze the Polish economic policy (Chapter 9), financial system (Chapter 10), investments and financing of the Fourth Industrial Revolution (Chapter 11), and the state and development of human resources necessary for the implementation of digital solutions (Chapter 12). The last chapter of this part sums up the analyses, depicting changes in total factor productivity in Poland from the Industry 4.0 perspective (Chapter 13).

Key aspects determining Poland's competitive position from the point of view of the Fourth Digital Revolution are presented in the last, fourth part of the monograph. This part of the monograph starts with a comparison of Poland with selected EU member states, especially from Central and Eastern Europe, in terms of Industry 4.0 development, with special focus on the identification barriers slowing down that process (Chapter 14). Such a diagnosis provides a basis for conclusions and recommendations for an innovative policy geared to supporting the creation and implementation of new technologies based on the use of digital solutions. These aspects are discussed in Chapter 15. The next chapter contains an in-depth analysis aimed to determine the degree of digitalization of the Polish economy and the participation of enterprises operating in Poland in Industrial Revolution 4.0 (Chapter 16). The last chapter of the monograph (Chapter 17) overviews the competitive position of Poland in the adoption of digital technologies in an international comparative context, and provides recommendations for policy that supports digitalization.

The monograph is wrapped up with a brief summary setting out Poland competitive position in 2018 in the context of Industry 4.0 development.

Marzenna Anna Weresa
Arkadiusz Michał Kowalski

Bibliography

Armengaud, E., Sams C., von Falck, G., List, G., Kreiner, C., Riel, A. [2017], *Industry 4.0 as Digitalization over the Entire Product Lifecycle: Opportunities in the Automotive Domain*, in: J. Stolfa, S. Stolfa, R. O'Connor, R. Messnarz (eds.) *Systems, Software and Services Process Improvement*, EuroSPI 2017, Communications in Computer and Information Science, Vol. 748. Springer, Cham, pp. 334–351

Kagermann, H., Helbig, J., Hellinger, A., Wahlster, W. [2013], *Recommendations for Implementing the strategic initiative INDUSTRIE 4.0: securing the future of German manufacturing industry; final report of the Industrie 4.0 working group*, Forschungsunion.

Porter, M.E., Heppelmann, J.E. [2014], *How Smart, Connected Products Are Transforming Competition*, "Harvard Business Review" 92, No. 11 (November 2014), pp. 64–88.

Part I

The Concept of International Competitiveness and the Fourth Industrial Revolution

Chapter 1

The Concept and Dimensions of International Competitiveness – Selected Theoretical Aspects

Arkadiusz Michał Kowalski, Marzenna Anna Weresa

Introduction

Competitiveness is the subject of economic debate that has been underway since the latter part of the 20th century among the academia, economic politicians and the business community. Competitiveness is a highly complex issue involving the use of various criteria and methods of measurement. In the era of globalization and rapid technological progress, this concept keeps evolving. New elements emerge, which affect the competitive position of economies such as digitalization, one of the key manifestations of what is called Industry 4.0. At present, international competitiveness is viewed much more broadly than just by comparing the income achieved by the population of each country.

The purpose of this chapter is to discuss the theoretical foundations of international competitiveness taking into account the multidimensionality of the concept. In particular, alongside the traditionally discussed types of competitiveness, such as income or investment competitiveness and competitiveness in international trade, new dimensions of competitiveness are presented, such as technological digital and sustainable competitiveness, encompassing social and ecological aspects.

1.1 Definitions and Nature of Competitiveness – Traditional and Contemporary Approach

The concept of competitiveness is a multidimensional phenomenon, as evidenced by the large number of definitions of this concept used in the literature. There are many sources of this diversity. They include non-uniform views on the subjective scope of competition, various views on its sources, and the different systems of values professed by the authors of the various definitions [Marciniak, 2010, p. 120]. One of the most established definitions in the economic literature was proposed in an OECD study [Hatzichronoglou, 1996], according to which competitiveness is construed as "ability of companies, industries, regions, nations or supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis".

A new definition of competitiveness has been attempted in recent years. While the traditional definitions of competitiveness were primarily related to changes in the resource efficiency of the economy, the new approach goes beyond the economic dimension. It responds to the need to integrate social aspects and certain elements of sustainable development into the concept of competitiveness, e.g., seeking to ensure social sustainability and sustainable use of the environment [Weresa, 2015, 2016]. One of the new definitions have been presented by Aiginger and Vogel [2015], where competitiveness is defined as the ability of a country (region, location) to achieve its objectives for citizens beyond GDP. This definition reflects the comprehensive nature of the concept of economic competitiveness, which refers not only to the level of income, but also to other related economic, social and environmental categories.

In the literature, the concept of competitive ability is differentiated from the competitive position [Bossak, 1984; Bieńkowski, 1995]. Competitive ability is also called input competitiveness, as it is assessed on the basis of a number of inputs describing the size, structure and utilization of production resources, the socio-economic system, the government's economic policy and the international economic environment. All these elements determine the capability of an economy to compete in foreign markets and achieve a particular competitive position. For its part, the competitive position is also known as output competitiveness, as it indicates the level of economic development achieved by the state concerned and is reflected in the level of national income, the efficiency of use of production factors or the position in foreign trade.

Economic competitiveness and its determinants can be analyzed at different levels:

1) microeconomic (from the perspective of an enterprise),
2) mesoeconomic (from the perspective of the development of an industry or the economy of a region),
3) macroeconomic (from the perspective of the national economy).

Competitiveness at the microeconomic level refers to the ability of an entity to compete with other enterprises, which is reflected in the position achieved in the market. It is crucial to increase the market share by delivering goods or services to consumers more effectively and more efficiently than other enterprises. M. Gorynia [2001, pp. 172–179], considering the competitiveness of the company as the ability to compete, and thus to operate and survive in a competitive environment, proposes a division into:

– *ex-post* competitiveness, i.e., the current competitive position, which is the result of a competitive strategy put into effect and rivals' competitive strategy,
– *ex-ante* competitiveness, i.e., a future (prospective) competitive position, which is defined by a relative (meaning relative to competitors' skills) ability of an enterprise to compete in the future, through its competitive potential.

The systems which are distinguished most often in mesoeconomic studies are the industry and the region [Budner, 2009, p. 8]. As far as the former is concerned, the competitive advantage of an industry may be of a cost-price or qualitative (differential) nature, and its most important determinants are [Jankowska, 2009]:

- intra-industry interactions, which reveal themselves in relations between businesses, in particular the phenomena of competition and cooperation,
- related industries (offering complementary products) and supporting industries (including suppliers of machinery, equipment and materials), which are perceived through the prism of characteristics of the competitiveness of their participants and the shape of intra-industry relationships,
- mesoinstitutional infrastructure, in particular business self-regulatory organizations, usually operating in the form of chambers of commerce or industry associations.

No uniform method of measuring the competitiveness of industries has yet been developed. One of the most important metrics to measure this phenomenon in international terms is the Revealed Comparative Advantage (RCA) index, which indicates the national economy's relative superiority in foreign trade in the products of a particular industry. This approach corresponds to the assumptions of neoclassical theories of foreign trade which provide that individual economies specialize in the production and export of products in which they have a comparative advantage. In her studies on the impact of innovation on the competitiveness of industries in Poland, M.A. Weresa [2007] assumed that it can be measured by changes in value added and the dynamics of marketed production.

Regional competitiveness is the ability of a region's economy to compete with other regions in various competitive arrangements, which allows the region's position to be maintained in the national and international setup. Regional competitiveness is measured by a set of objectives achieved over a time period, closely linked to the level of socio-economic development, and the quality of satisfied needs of the population of each region. A region's competitiveness is closely linked to regional efficiency, which is a multidimensional category, encompassing [Bagdziński, Kosiedowski, Marszałkowska 1995, pp. 47–48]:

- regional economic performance, related to minimizing labor inputs (both living and materialized) engaged to achieve the appropriate volume and structure of global

production, or to maximizing the ratio of global production to the consumption of production factors,
- regional social performance, linked to the outcomes achieved in pursuing the region's social development goals, which represents the region's ability to create welfare,
- regional technical performance, relating to the technical and technological aspects of the processes taking place in the region,
- regional ecological performance, including human impact on the natural environment.

Attempting to develop a definition of country competitiveness is a much more difficult task than defining the competitiveness of a company or industry [Budnikowski 2006, pp. 26–27]. Much polemic has been triggered by the views of P. Krugman [1994], who challenged the legitimacy of the concept of competitiveness at macroeconomic level. He argued that nations did not compete with each other, as companies do, because the state as such could not go bankrupt. However, such reasoning is justified with a sharp distinction of "lose-win" outcomes. In analyzing economies, we are faced with different values of benefits and rivalry is about the greatest possible share of these benefits. Competitiveness at macroeconomic level is usually related to the international market, and thus to the national open economy participating in the international division of labor.

Attention should be paid to the close link between the different levels at which competitiveness can be analyzed. A reverse relationship can be observed, where macroeconomic or mesoeconomic competitiveness, providing conditions for enterprises to invest and operate in a national or regional economy, contributes to building competitiveness in a microeconomic sense, that is to say, to the high productivity of companies, which, in turn, influences the level of macroeconomic indicators.

1.2 Traditional Dimensions of International Competitiveness

The traditional approach to the competitiveness of countries is aimed at its cost dimension, focusing on the amount and dynamics of unit labor costs and unit labor productivity. In this sense, the economy is competitive if it creates conditions for constant growth of competitiveness and improvement of living standards of the population [Porter, 2008, p. 176].

Income Competitiveness

In common terms, international competitiveness is often reduced to income competitiveness, which concerns the ability of an economy to provide a certain level of income for its inhabitants in order to ensure a specific standard of living. The basic measure of income competitiveness of an economy is the volume of GDP per capita in purchasing power parity. Despite the various shortcomings and attempts at alternative ways of measuring the competitiveness of economies, this indicator is still the one most commonly used in macroeconomic analyses as a benchmark for the competitive position of countries or regions [Kowalski, 2018]. For example, GDP per capita has remained for decades the primary determinant of the division into developed and developing countries, showing polarization in many spheres of life of the citizens of respective countries.

The weakness of the adoption of GDP per capita, which defines income competitiveness as the most important and in many studies the only measure of international competitiveness, is that this indicator does not fully reflect the actual state of the economy and many important aspects of the quality of life of the population. The measure does not show existing income inequalities between the various social groups. In addition, GDP per capita is unreliable in capturing the value of one of the most important elements of modern economies, namely innovations [Coyle 2015]. All limitations related to the determination of socio-economic success through the lens of income competitiveness have contributed to the development of research into the other dimensions of competitiveness described further on in this chapter, as well as to attempts at a broader definition of the concept. One example is the definition by Aigingear and Vogel [2015] referred to above, which focuses on the ability to achieve objectives beyond GDP.

Competitiveness in International Trade

Research on the international competitiveness of national economies often uses an economic category, referred to as comparative advantages, relating to foreign trade in a country or to international trade of a group of countries. The international dimension of the competitiveness of national economies is therefore mostly related to foreign trade (ability to sell). This approach is often complemented by an analysis of attractiveness for the influx of foreign inputs that can boost insufficient internal resources. Effective competition in the global market for goods, services and inputs is a manifestation of the competitiveness of the economy and it can further improve economic performance [Misala, 2014].

Narrowing international competitiveness down to trade in goods and services means focusing on the ability to compete in export markets [Misala, 2014; Kowalski, 2018]. The most widely used measure of competitiveness in international trade is the Revealed Comparative Advantage index based on the formula proposed by Balassa [1962]. The index shows what advantage a country gains when exporting a particular product to international markets in relation to the country's total share in global exports. Through measures such as pursuing an appropriate economic policy, national economies can create new advantages in trade and transform static comparative advantages into competitive advantages.

Investment Competitiveness

A World Bank report published in 2018 [World Bank Group 2018] defines competitiveness as the ability of countries to not only attract but also to retain and integrate private investment. Investment competitiveness is a derivative of various factors and aspects, including an important role of the investment climate and investment risk. The investment climate is the generality of conditions specific to a particular country or region relevant to the pursuit of the objective function by a foreign investor. According to L.C. Nehrta [1971], the investment climate consists of:

- political climate, determined by political stability, historical conditionality, the importance of the private sector in the economy, etc.;
- social climate, depending on the situation in the labor market, education and age structure of the labor force, the attitude of the public to private property, etc.);
- economic climate, determined on the one hand by the country's economic stability and the size and absorbency of market outlets and, on the other hand, by the technical infrastructure and the infrastructure of the business environment;
- administrative climate related to the influence of the administration on the functioning of business, including the scope of business activities, the business establishment procedure, the provisions regulating the transfer of profits, etc.;
- economic climate, i.e., the quality, stability and transparency of laws and regulations.

The other aspect of investment competitiveness mentioned above is the investment risk that can be defined as a potential risk to achieving expected economic outcomes. This means that each investment involves the possibility of benefits being smaller than expected, none or a loss being sustained. In addition, the risk of foreign investment is composed of general investment risk and special risk that results from the location of investment in a new environment [Karaszewski, 2004, pp. 57–58].

Enterprises planning investment seek to find a location that will allow for an optimal satisfaction of business needs. The appropriate selection of the target economy requires defining key locational factors and conducting an analysis of the available locations for these factors. According to Dunning and Lundan [2008], the key location-specific factors are:

- availability of significant natural resources and their spatial distribution,
- price levels and productivity of inputs,
- transport and communication costs,
- economic policy instruments addressed to investors, e.g., investment incentives, tax concessions, etc.,
- trade barriers,
- availability of infrastructural facilities in the country the fields of transport, communication, education, etc.,
- dissimilarity of local community in terms of language, culture, business and politics,
- presence and characteristics of local economies of agglomeration, e.g., those related to cluster operations,
- features of the economic system and governmental strategies for resource allocation,
- features of the legal system, e.g., proprietary rights.

Therefore, the significance of those factors cannot be ignored in considering the investment dimensions of competitiveness.

1.3 New Dimensions of Competitiveness

The traditional dimensions of competitiveness have been extended by a new approach in the 21st century, resulting from a different understanding of business objectives than before. Countries are now pursuing sustainable, smart and environmentally-friendly growth. This approach is reflected, for example, by the development goals formulated by the United Nations [UN, 2015], as well as the European Union's strategy "Europe 2020" [European Commission, 2010]. From this perspective, the traditional, cost-based approach to the competitiveness of national economies shows only a limited spectrum of this phenomenon. For example, the indicators of the potential of the knowledge-based economy, including the progressive digitalization process and the related Fourth Industrial Revolution are not taken into account in the traditional approach. It also lacks references to social issues and to the protection of natural resources.

As a result, the phenomenon of competitiveness has started to be seen in a broader context, by reinterpreting the definition itself and by extracting its new dimensions. Social and environmental issues are most often described by the term "sustainable competitiveness". In addition, the technological dimension of competitiveness, including in particular digital competitiveness, is also being highlighted today. These new dimensions of competitiveness are the subject of further considerations in this chapter.

Sustainable Competitiveness

Sustainable competitiveness is a new dimension of competitiveness, which has been introduced into the literature by the World Economic Forum [WEF, 2014]. Sustainable competitiveness is understood as factors, institutions and policy principles that determine the long-term improvement of the productivity of inputs while ensuring sustainable social development and environmental protection [Blanke et al. 2011; Corrigan et al., 2014]. Social sustainability is related to institutional factors, including the policies pursued in the country concerned. Social competitiveness is determined by ensuring security and access to healthcare, as well as integrating all members of society into the economic and social life of the nation. Social issues can be measured using metrics such as the Social Progress Index, which defines social development in terms of addressing the basic human needs, providing opportunities for personal development and the creation by the state of a basis for achieving welfare [Porter et al., 2017].

The other element of sustainable competitiveness – environmental competitiveness – is linked to the quality of institutions and the policies pursued, notably in the effective management of natural resources for sustainable improvement of the social welfare [Corrigan et al., 2014, p. 55]. The dimension of competitiveness involving the use of environmental resources takes into account the following three elements: (1) environmental policy (including in particular the responsible use of arable land and water resources, enforcement of environmental legislation and compliance with international treaties on environmental protection); (2) the utilization of renewable resources (water, forests, fauna and flora resources); (3) the quality of the environment (e.g., the level of air and water pollution).

Improving competitiveness in its sustainable dimension is a strategic objective adopted by the UN and the European Commission.

Technological and Digital Competitiveness

The technological dimension of competitiveness entails technological innovations and their impact on competitiveness. The long-term competitive position of a country is closely related to the creation of new ideas and their commercialization [Porter 2008]. Technological innovations are usually patented to provide protection to the innovator and, after commercialization, also remuneration to compensate the inventor for financial expenditure incurred for innovation. Many researchers have shown that there is a link between patents and innovation [cf., e.g.: Moser, 2003; Scotchmer, 2005; OECD, 2009]. The conclusions of these studies have resulted in a new approach to analyzing the technological competitiveness of a country using patent statistics. Indicators reflecting the global and local dimension of technological competitiveness in the different fields of technology and the evolution of these indicators over time are used to measure the competitive position. One indicator is the Revealed Technological Advantage (RTA) index which identifies the strengths and weaknesses of technological competitiveness in a comparative perspective. This measure allows the importance of local patent activity in a particular technology in a country to be assessed in comparison to the importance of patents in the same technology group on a global scale. Another way of determining technological competitiveness is the share of national patents in the global patent resource, which indicates the scientific and technological specialization of the country. This is a measure of the global impact of technologies developed in a given country.

Information and communication technologies (ICTs) are a particular type of technology that has evolved over the last twenty years. There is a growing integration of those technologies into the economy that goes beyond the application of patents, and therefore the term "digital competitiveness" has emerged in the scientific literature. Digitalization, thanks to which Industry 4.0 is developing [OECD, 2015, p. 240], has become a new feature of national economies. Digitalization means the use of ICT to create value. In the broadest sense, these are the ways in which technology connects people, machines and information. In this context, the question arises: how should the competitiveness of national economies in the digital world be understood? Recent research shows that there is a need to incorporate the digital economy as a new component of competitiveness. Digitalization fosters the emergence of new business models and also changes the way companies communicate with the market and innovate. According to the OECD [2013, p. 18], the development of digitalization can be understood as value added generated both by activities supporting the development of the Internet (e.g., manufacture of broadband equipment) and those based on the use of Internet in business (e.g., e-commerce, network services) [OECD, 2013, p. 18].

This approach means that technology development and the resulting digitalization impact changes in the productivity of production factors, which means changes in competitiveness. However, empirical research on ICT effects for changes in the efficiency of inputs is not conclusive. Brynjolfsson and Yang [1996] point to the lack of impact of ICT on productivity by calling it the paradox of productivity. The positive effects of ICT on productivity have been demonstrated, e.g., by Kretschmer [2012] and Belloc and Guerrieri [2015], but the results obtained differed depending on the industry analyzed and the methodology applied. On the other hand, OECD studies have confirmed that digitalization contributes directly to economic growth, especially when the supply of ICT-related goods and services is taken into account, but the achievement of these positive effects does not appear automatically. The effective use of information and communication technologies requires not only investment in ICT but also additional investment in the knowledge-based capital necessary for the development of ICT, i.e., development of skills, introducing organizational changes and new business models. The impact of digitalization on economic growth is therefore linked to the introduction of digital innovations understood, in a narrow sense, as the implementation of a new or substantially improved ICT product (i.e., innovation in ICT products) or more broadly, as a new or improved product, process, marketing or organizational innovations that arise as a result of the use of information and communication technologies [OECD, 2016, pp. 6–14]. The use of digital technologies in the economy creates the need to develop the skills needed to perform new tasks using ICT (including information processing, communication, e-marketing) [OECD, 2016a, p. 6].

Digital competitiveness therefore entails digital innovations and digital skills that are essential to the input side as well as the performance changes resulting from the introduction of information and communication technologies. The role of the Internet has shifted from service to basic economic infrastructure. This means that the definition and methodology for measuring competitiveness should also be adapted accordingly. In the literature, there is a discussion on this subject and proposals for new indicators of competitiveness that are relevant to the digital economy [cf., e.g.: Coyle, 2015; Ahmad, Schreyer, 2016; Weresa, 2017; DG for Communications Networks, Content and Technology, 2018].

Conclusions

A review of the literature on the competitiveness of economies shows that the last two decades have brought a new approach to defining competitiveness and its dimensions. International competitiveness has traditionally been perceived through the lens of foreign trade and attractiveness for foreign inputs [cf., e.g., Bossak, 1984; Misala, 2014]. Changes in the global economy linked to increasing internationalization, globalization, accelerating technological development, including digitalization, while aiming at a broader perception of prosperity, which is not limited to growth of per capita income, have resulted in a redefinition of competitiveness. The new elements of this concept, which are now being analyzed more broadly, are sustainable, technological and digital competitiveness.

Bibliography

Ahmad, N., Schreyer, P. [2016], *Measuring GDP in a digitalised economy*, OECD Publishing, OECD Observer No. 307 Q3 2016.

Aiginger, K., Vogel, J. [2015], *Competitiveness: from a misleading concept to a strategy supporting beyond GDP goals*, "Competitiveness Review", 25(5), pp. 497–523.

Bagdziński, S.L., Kosiedowski, W., Marszałkowska, M. [1995], *Ekonomiczne założenia rozwoju i restrukturyzacji regionu w warunkach transformacji systemowej*, in: S.L. Bagdziński (ed.), *Polityka rozwoju regionalnego i lokalnego w okresie transformacji systemowej*, Uniwersytet Mikołaja Kopernika, Toruń 1995, pp. 47–48.

Balassa, B. [1965], *Trade Liberalization and 'Revealed' Comparative Advantage*, The Manchester School, Vol. 33, pp. 99–123.

Belloc, M., Guerrieri, P. [2015], *Impact of ICT diffusion and adoption on sectoral industrial performance: evidence from a panel of European countries*, "Economia Politica", No. 32, pp. 67–84.

Bieńkowski, W. [1995], *Reaganomika i jej wpływ na konkurencyjność gospodarki amerykańskiej*, PWN, Warsaw.

Blanke, J., Crotti, R., Drzeneik-Hanouz,M., Fidanza, B., Geiger, T. [2011], *The Long-Term View: Developing a Framework for Assessing Sustainable Competitiveness*, in: WEF [2011], *The Global Competitiveness Report 2011–2012*, World Economic Forum, Geneva, pp. 51–74.

Bossak, J.W. [2001], *Międzynarodowa konkurencyjność gospodarki kraju i przedsiębiorstwa. Zagadnienia teoretyczne i metodologiczne*, in: J. Bossak, W. Bieńkowski, *Konkurencyjność gospodarki Polski w dobie integracji z Unią Europejską i globalizacji*, Vol. I, SGH, Warsaw.

Bossak, J.W. [1984], *Społeczno-ekonomiczne uwarunkowania międzynarodowej zdolności konkurencyjnej gospodarki Japonii*, "Monografie i Opracowania", No. 153, SGPiS, Warsaw.

Brynjolfsson, E., Yang, S. [1996], *Information technology and productivity: A review of the literature*, "Advances in computers" 43, No 1, pp. 179–214.

Budner, W.W. [2009], *Podmiotowość regionów a polityka i rozwój regionalny. Kontekst polski i europejski*, "Administratio Locorum", Vol. 3, No. 8.

Budnikowski, A. [2006], *Międzynarodowe stosunki gospodarcze*, Polskie Wydawnictwo Ekonomiczne, Warsaw 2006.

Corrigan, G., Crotti, R., Drzeniek Hanouz, M., Serin, C. [2014] *Assessing Progress toward Sustainable Competitiveness*, in: WEF [2014], *Global Competitiveness Report 2014–15*. World Economic Forum, Geneva, pp. 53–83.

Coyle, D. [2015], *GDP: A Brief but Affectionate History – Revised and expanded Edition*, Princeton University Press.

Coyle, D. [2015], *Modernising Economic Statistics: why it matters*, National Institute Economic Review, November http://www.niesr.ac.uk/sites/default/files/publications/NIER234 Commentary.pdf

DG for Communications Networks, Content and Technology [2018], *DESI 2018. Digital Economy and Society Index. Methodological Note*, European Commission, Brussels.

Dunning, J.H., Lundan, S.M. [2008], *Multinational enterprises and the global economy*, Edward Elgar, Northampton.

European Commission [2010], *Communication from the Commission. Europe 2020. European strategy for smart, sustainable and inclusive growth*, COM (2010) 2020, Brussels.

Gorynia, M. [2001], *Luka konkurencyjna – koncepcja i metodyka badań*, in: E. Skawińska (ed.), *Konkurencyjność podmiotów gospodarczych w procesie integracji i globalizacji*," "Zeszyty Naukowe Politechniki Poznańskiej", Wydawnictwo Politechniki Poznańskiej, Poznań 2001, pp. 172–179

Hatzichronoglou, T. [1996], *Globalisation and Competitiveness: Relevant Indicators*, "OECD Science, Technology and Industry [STI] Working Papers", No. 5, OECD, Paris.

Jankowska, B. [2009], *Konkurencyjność w ujęciu mezoekonomicznym*, in: M. Gorynia (ed.), *Kompendium wiedzy o konkurencyjności*, Wydawnictwo Naukowe PWN, Warsaw, pp. 100–125.

Karaszewski, W. [2004], *Bezpośrednie inwestycje zagraniczne. Polska na tle świata*, TNOiK – Dom Organizatora, Toruń.

Kowalski, A.M. [2018], *Benefits of Broadening the Analysis of International Competitiveness: The Case of CEE Countries*, "AIB Insights", Vol. 18, No. 1, pp. 7–11.

Kowalski, A.M. [2013], *Znaczenie klastrów dla innowacyjności gospodarki w Polsce*, SGH Publishing House, Warsaw.

Kretschmer, T. [2012], *Information and Communication Technologies and Productivity Growth: A Survey of the Literature*, "OECD Digital Economy Papers", No. 195, OECD, Paris, http://dx.doi.org/10.1787/5k9bh3jllgs7-en

Krugman, P. [1994], *Competitiveness: A Dangerous Obsession*, "Foreign Affairs", Vol. 73, No. 2, pp. 28–44.

Marciniak, S. [2010], *Innowacyjność i konkurencyjność gospodarki*, Wyd.C.H. Beck, Warsaw.

Misala, J. [2014], *Theoretical Grounds of the Development of Long-Term Competitive Advantages in International Trade*, in: M.A. Weresa (ed.), *Innovation, Human Capital and Trade Competitiveness. How Are They Connected and Why Do They Matter?,* Springer, Cham Heidelberg, New York, Dordrecht, London, pp. 3–51.

Moser, P. [2003], *How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World Fairs*, NBER Working Paper No. 9909, Cambridge MA

Nehrt, L.C. [1971], *The political climate for foreign investment*, "The International Executive", 13(1), pp. 16–18.

OECD [2009], *Patent Statistics Manual*, OECD, Paris.

OECD [2013], *Measuring the Internet Economy: A Contribution to the Research Agenda*, "OECD Digital Economy Papers", No. 226, OECD Publishing, Paris, DOI: http://dx.doi.org/10.1787/5k43gjg6r8jf-en

OECD [2015], *OECD Digital Economy Outlook 2015*, OECD Publishing, Paris, DOI: http://dx.doi.org/10.1787/9789264232440-en

OECD [2016], *Stimulation Digital Innovation for Growth and Inclusiveness*, “OECD Digital Economy Papers”, No. 256, OECD Publishing, Paris

OECD [2016a], *Skills for a Digital World*, “OECD Digital Economy Papers”, No. 250, OECD Publishing, Paris.

Porter, M.E. [2008], *On Competition*, Harvard Business School Publishing, Boston.

Porter, M.E., Stern, S., Green, M. [2017], *Social Progress Index 2017*. Social Progress Imperative, Washington, https://www.socialprogressindex.com/assets/downloads/resources/en/English-2017-Social-Progress-Index-Findings-Report_embargo-d-until-June-21–2017.pdf, accessed 20 March 2018.

WEF [2014], *Global Competitiveness Report 2014–15*, World Economic Forum, Geneva.

Scotchmer, S. [2005], *Innovation and Incentives*, MIT Press, Cambridge Mass., London.

UN [2015], *Transforming our world: the 2030 Agenda for Sustainable Development*, United nations, A/RES/70/1, https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf, accessed 5 March 2018.

Weresa, M.A. [2017], *Innovation, human capital and competitiveness in Central and Eastern Europe with regard to the challenges of a digital economy*, in: Galgóczi B., Drahokoupil J. (eds.), *Condemned to be left behind? Can Central and Eastern Europe emerge from its low-wage model?* ETUI, Brussels, pp. 81–110

Weresa, M.A. [2007], *Innowacje a konkurencyjność branż polskiego przemysłu*, in: T. Baczko (ed.), *Raport o innowacyjności gospodarki Polski w 2007 r.*, Instytut Nauk Ekonomicznych PAN, Warsaw, pp. 33–36.

Weresa, M.A. [2015], *Innovation and sustainable competitiveness: evidence from Poland*, “International Journal of Transitions and Innovation Systems”, No 4 [3–4], pp. 150–163.

Weresa, M.A. [2016], *The Competitiveness of EU Member States from Central and Eastern Europe in 2007–2014*, in: P. Trąpczyński, Ł. Puślecki, M. Jarosiński, *Competitiveness of CEE Economies and Businesses. Multidisciplinary Perspectives on Challenges and Opportunities*, Springer International Publishing, pp. 3–23.

World Bank Group [2018], *Global Investment Competitiveness Report 2017/2018: Foreign Investor Perspectives and Policy Implications*, World Bank, Washington, DC.

Chapter 2

Institutional Aspects of International Competitiveness

Krzysztof Falkowski

Introduction

The ongoing process of globalization and internationalization of the world economy, which results in an increasingly keen rivalry at all possible levels (mico-micro, micro, meso, macro, mega [Gorynia, Jankowska, 2008] and in various areas (in the sphere of manufacturing factors or in the product sphere [Weresa, 2008] is an integral part of economic activity, both nationally and internationally [Delgado et al., 2012; Fagerberg, 1996]. As indicated in Chapter 1 of this monograph, the economic literature does not offer a single, universally applicable definition of international competitiveness, which best testifies to the complexity, relativity and multifacetedness of this notion [Spence, Hazard, 1988; Flanagan et al., 2007; Falkowski, 2017; Wziątek-Kubiak, 2004; Olczyk,2008]. Perhaps this is because, as M. Gorynia pointed out [2009], the theoretical character of that term means that it does not represent any particular thing or person, or anything that we imagine as a thing or a person, that is to say, there is no referent that can be specified directly. The thing is that it all depends on who, at what level and to what extent, competes with other players on the international arena. Thus it comes as no surprise that there is no common agreement among the economists about the factors that determine that competitiveness [Delgado et al., 2012].

Nevertheless, increasingly often attention is drawn in the economic literature to the crucial importance of institutions in fostering international competitiveness [Roland, 2016]. As pointed out by the World Economic Forum, in its annual, widely recognized and valued publication *The Global Competitiveness Report*, a key role in shaping competitiveness today, is played not so much by traditional cost or resource-related factors as qualitative ones, such as the quality of the human capital held, innovativeness of the economy concerned and, above all, the efficiency of institutions – efficiency of the institutional environment within which all economic operators in the country operate [WEF, 2017].

This chapter discusses the institutional aspects of the international competitiveness of countries. In particular, it seeks an answer to two key research questions. Firstly, what is the idea of institutions and what are their basic objectives and functions in the economy. Secondly, how and to what extent institutions can influence the competitiveness of countries in the international dimension.

This chapter argues that institutions are increasingly being treated in the economic literature as an extremely important factor in determining the level of international competitiveness of countries, mainly because they form transaction costs and social capital which directly translate into the level of productivity and welfare in a country. Moreover, they have also become an area of direct international competition between countries.

The chapter consists of three main parts. The first part defines the concept of institutions, discusses their idea, characteristics and functions in the economy, and provides a classification of institutions. The second part analyses the significance of institutions to the international competitiveness of a country and their impact on its level. The third part overviews the notion of institutional competitiveness, created and increasingly used in recognition of the importance and role of institutional aspects in forming the competitiveness of countries, thus highlighting the importance of the institutional level as an area of competition between countries in the international playing field.

2.1 The Notion, Idea and Classification of Institutions

The notion of institutions is used quite widely not only in the social sciences, but also in the legal sciences, or in the colloquial language itself. All this makes it very difficult to define them clearly, in a way that would be widely accepted and used [Nelson, 2008]. Therefore, one cannot disagree with F. Fukuyama [2008] who noted that the notion of institutions is used inconsistently in economic research and, what is more, it is usually related to public authority, the rule of law and democracy. Table 2.1 presents selected definitions of institutions existing in the economic literature.

Focusing on the economic sciences, a difference can be pointed out in the definition and perception of institutions, existing between representatives of the “old” institutional economy [T. Veblen, J. Commons or W. Mitchell] and the “new” institutional economy [O.E. Williamson, K.J. Arrow, or D.C. North]. According to the former, institutions were understood as rules of behavior (social conditionality) and as social interest groups and organizations (the world of industry and business for T. Veblen and enterprises for J. Commons). The role of habits, customs and routine actions resulting from the impact of institutions that automatically limit free choices of individuals. The latter define institutions as external constraints to choices and activities of economic actors, while stressing, importantly, the independence of choices made by those actors and freedom of their activities from habits and routine behavior [Woźniak-Jęchorek, 2014].

Table 2.1 Overview of selected definitions of institutions in the economic literature

Autor	Definition
T. Veblen [1899]	Predominant habits of thought that take into account specific social conditions, specific functions of an individual and a community.
J.R. Commons [1934]	Collective action controlling individual action.
D.C. North [1990]	Rules of the game in society, and, more formally, constraints created by people that form human interactions.
D.C. North [1994]	Humanly devised constraints that structure political, economic and social interaction. They consist of both formal and informal constraints and the characteristics of their implementation. They jointly determine the structure of incentives in communities, especially in economies.
S. Pejovich [1995]	Any durable, legal, administrative and customary arrangements for repeated human behavior and interactions.
G.M. Hodgson [2001]	Systems of established and prevalent social rules and conventions that structure social interactions.
World Bank [World Bank, 2002]	Standards, rules, contract enforcement mechanisms and organizations supporting market transactions. The institutions help transmit information, enforce property rights and contracts, and manage competition in markets.
E. Ostrom [2005]	Principles and practical rules that allow or prohibit specific behavior of individuals or businesses functioning in a broadly defined environment.
World Economic Forum [WEF, 2015]	A set of formal, legally binding constraints (rules, laws, and constitutions), along with their associated enforcement mechanisms, as well as all kind of informal constraints (norms of behavior, conventions, and self-imposed codes of conduct.
K. Falkowski [2018]	A set of rules of the game, principles, procedures as well as moral and ethical norms regulating the behavior of economic actors while ensuring the maximization of certain benefits (e.g., wealth or increased competitiveness) arising from functioning within a particular community (particular system).

Source: Own study.

However, although there are significant differences in the way in which institutions are defined and perceived, certain objective characteristics can be identified, namely institutions:

a) are created by man;
b) contain an element of interaction between the entities concerned;
c) are established to shape (formally or informally) certain behavior patterns.

W. Stankiewicz [2012] has proposed his own list of basic characteristics of the institution, among which he mentioned the following:

a) institutions provide business with sustainability, continuity and stability by creating conditions that ensure the predictability of results of a specific set of actions;
b) institutions are inherited by human individuals and their groups learning through various forms of education;
c) institutions encompass a system of positive and negative incentives;
d) institutions ensure freedom and security for an individual's actions within defined limits, which is of great significance to businesses;
e) social institutions reduce uncertainty and hence transaction costs.

With regard to the idea of institutions, irrespective of how defined, they are perceived as man-made mechanisms aimed at shaping the interaction between the individuals whose behavior they influence. D.C. North [1990] pointed out very clearly that the idea of institutions is to identify/stimulate the behavior of individuals (economic actors) in a specific direction to ensure predictable and rational order leading to the reduction of uncertainty about various activities of those individuals. For his part, J.R. Commons [1934] argued, long before D.C. North, that institutions are a kind of social (collective) control framework defining the conditions of operation and functioning of individuals, at both social or political and economic level. That last-mentioned area of institutions' influence is referred to by M. Iwanek and J. Wilkin [1998], who stress that each economic system is explicitly nothing but a system of interrelated institutions, in which property rights and relationships and regulatory mechanisms deserve special attention.

The formation of specific behavior of individuals in the economic sphere, aligned with the interests of a particular community, has a very important practical dimension. It reduces uncertainty and risk, which, in the context of economic activity, leads to lower transaction costs and, consequently, to an improved performance of that activity. Moreover, institutions regulating the behavior of entities (whether households, businesses or the whole national economies) also define the fundamental principles under which cooperation and competition take place simultaneously in many fields, which is intended to maximize both the benefits of individual entities and of the economic system as a whole. What poses a major challenge for institutions in this context is a clear, stable and transparent definition of the principles and rules (both formal and informal) based on which these processes are to take place. Moreover, they must exhibit relative flexibility in view of the changes occurring in the environment. According to D.C. North [1994], these changes may relate to the ability of the public to accumulate knowledge or to generate innovation, to trigger risk propensity or to eliminate bottlenecks in the economic system. However, a separate issue, also raised in the literature, is the susceptibility of institutions to any such change. It is considerably greater for formal institutions (codified rules of conduct) than those deeply embedded in human consciousness (informal institutions), arising from belonging to a given community [Roland, 2004].

Another issue of high significance is the efficiency of institutions in regulating the behavior of economic entities. J. Groenewegen, A. Spithoven and A. Van Den Berg [2010] consider institutions efficient when they meet three basic conditions. Firstly, they guarantee equal treatment of all economic entities, in accordance with the applicable laws and regulations. Secondly, they are transparent and trustworthy, and they clearly define the consequences of their existence (the effects of compliance and non-compliance). And thirdly, as already mentioned above, they are flexible, i.e. they adapt to changing business management conditions. Common knowledge, acceptance and observance of those conditions are of course absolutely prerequisite for institutions to be effective. For D.C. North [1994], the efficiency of institutions amounts to their ability to effectively resolve social and economic problems over time, and for Z. Staniek [2017] – the ability to reduce existing transaction costs. As pointed out by A. Wojtyna [2007], another important issue in this context is an appropriate, balanced relationship between complementarity and substitutivity of institutions, especially those of a formal nature (codified), without which their operation can hardly be effective (efficient).

From the point of view of human economic activity and, in broader terms, the economy as a whole, several basic functions of institutions can be identified, which are key to the efficiency of business management mentioned above. According to Z. Staniek [2017], they include the following:

a) standardization of behavior under conditions of heterogeneity of individuals and economic entities, influence on preferences;
b) fostering the conclusion of contracts that support the efficient cooperation and coordination of activities, ensuring the security of business dealings, and confidence in markets and the state;
c) reduction of transaction costs under conditions of behavioral uncertainty and cooperative and non-cooperative game playing;
d) regulation of the functioning and development of economic entities, facilitating the pursuit of interests of entities, taking into account various facets of public interest;
e) limiting the extent of market failures and government failures, developing market institutions (e.g. regulatory authorities), creating positive externalities and counteracting negative externalities;
f) taking into account risk conditions and uncertainties, fostering the rationalization of risk propensity, limiting the extent of business uncertainty;
g) extending the timeframe of the decisions taken, creating conditions conducive to economic growth and competitiveness of the economy.

There are a number of different classifications of institutions. The most popular and commonly used division is that proposed by D.C. North [1990]:

a) formal (hard) institutions – institutions created under a specific law, whose activities are strictly regulated by relevant provisions (written rules of conduct). This category of institutions includes all kind of state institutions (such as government administration of all levels, courts, the police, tax offices, the judiciary), as well as financial institutions;
b) informal (soft) institutions – institutions operating without a legal basis, beside law, so to say, often created spontaneously (broadly based culture, customs, traditions, social morality). The functions of informal institutions often amount not only to specific regulation of all social interactions, but also to social sanctioning (e.g. through social exclusion, shunning), or the sanctioning by the system of specific advocated values.

For his part, W. Bieńkowski [2005] categorizes institutions according to their nature into:

a) economic institutions – production and distribution of goods and services in the economy, as well as money circulation. They can be formal and informal;
b) political institutions – involving the acquisition, exercise and retention of political power in the state. They are generally formal institutions;
c) social institutions – ensuring the continuity of collective life through a specific integration of people by maintaining social ties between them, as a rule centered around a certain idea underlying their functioning. They can be both formal and informal. Social institutions include religious institutions (different types of churches or other types of religious organizations and associations).

Yet another division of institutions has been proposed by G.W. Kołodko [2008], who did so referring, as it were, to their functions in the economy, as he distinguishes:

a) explanatory institutions – concerning the contracting frameworks the rules for their enforcement (e.g. commercial or banking law);
b) controlling institutions – monitoring the behavior of market entities (e.g. financial supervisory commission);
c) balancing institutions – supporting the processes of economic balance maintenance and balancing economic flows (e.g. antitrust law);
d) dynamizing institutions – supporting the efficiency of direct growth factors (e.g. the stock exchange, intellectual property rights);
e) adjusting institutions – enforcing the appropriate adjustment of economic entities to the conditions arising from generally accepted rules of operation (e.g. commercial arbitration).

Finally, the last division that is worth noting, namely J. Wilkin's [2002] classification, breaks down institutions into three groups, i.e.:

a) norms – institutions defining the way people behave, adopted in a particular social group, treated as a model arising from the existing system of values; they can be of a legal, religious, ethical, customary or moral nature;
b) markets – institutions defining the manner in which human and business behavior is regulated by market mechanisms;
c) organizations – institutions established to pursue specific objectives (e.g. foundations, enterprises, state administration, local government, political parties), operating within the area of existing principles and rules of conduct. The highly important role of organizations as institutions in the economy is also noted by researchers such as G.M. Hodgson [2004], J.E. Stiglitz [2000]; or O.E. Williamson [1998].

The notion of institution is linked to the notion of institutional environment, relatively also often found in the economic literature. According to L.E. Davis and D.C. North (1971], the institutional environment is a set of fundamental political, social and legal principles that establish the basis for production, exchange and distribution. This term is explained in a similar way by A. Swaminathan and J.B. Wade [2016], according to whom it means an environment consisting of regulations, customs and recognized norms commonly prevailing in groups, associations, occupations and organizations that project and shape organizational behavior and performance. In turn, the World Economic Forum [2015] underlines the fact that this set of institutions, policies and factors regulating the coexistence of different economic entities, significantly determines the level of productivity of the entire economic system with a view to achieving the level of welfare expected by the country concerned.

2.2 Significance of Institutions to Institutional Competitiveness of a Country

With the growing importance of broadly defined institutions, both formal and informal, in the processes of economic and social growth and development in the modern world [Miozzo, Walsh, 2010], the competitiveness of economies has been studied and analyzed increasingly often through the lens of the institutions existing in a given country [Delgado et al., 2012].

In addition, the growing interest in institutions in the context of competitiveness has also resulted from the observation that institutions defining the framework for the functioning of economic operators determine their competitiveness in both the national and international dimension [Porter, 2000]. By the way, the need to pursue in-depth research into institutions and their significance to the competitiveness of different economic actors (households, enterprises, national economies) has been emphasized, among others, by: C. Crouch [2005], P. Hall i D. Soskice [2001], B. Amable [2003], or W. Kohler [2006]. Going back to the reasons for the growing interest in institutions in the research on competitiveness, another one must also be noted, namely the increase in the interest of political decision-makers in the research on institutional aspects of competitiveness, in order to make changes on this basis and to implement institutional reforms aimed at improving the competitive ability and position of the economy [Pedersen, 2008]. Lastly, according to some economists [Roland, 2016], the most important reason is that the existing differences in the international competitiveness of countries with a similar economic potential can be explained in no other rational way other than differences in the institutions existing there. Hence the legitimate need for in-depth research in this area, so as to effectively identify those institutional advantages, which are the strongest driver of high competitiveness of countries internationally.

Institutions were first linked to competition by P. Katzenstein in his book titled "*Small States in World Markets: Industrial Policy in Europe*" [1985], that is 5 years before the publication of M. Porter's pioneer work "*The Competitive Advantage of Nations*" [1990] of an unquestionably fundamental significance to research on the competitiveness of economies.

In subsequent years, institutions were viewed increasingly often as an extremely important factor that determines the competitive ability, and consequently competitive position of economies [Pedersen, 2008]. What is more, C.M. Radaelli [2003] as well as S. Borrás and K. Jacobsson [2004], even considered institutions as a key explanatory factor of the competitiveness of the economy. For their part, P. Hall and D. Soskice [2001] stated straightforwardly that institutions, directly shaping market conditions for the operation of economic entities impact their production capacity, and hence the productivity of their resources. Similar conclusions were also reached much earlier e.g. by D.C. North and R.P. Thomas [1973], D.C. North [1981] or O.E. Williamson [1985], who emphasized the important direct impact of institutions on the amount of transaction costs, and thus indirectly also on the productivity of the whole economy. Also K. Schwab and X. Sala-i-Martin [2015] linked the quality of institutions with the productivity level, pointing to their key role in creating drivers of economic activity and reducing business uncertainties. When competitiveness is identified with productivity, as proposed by most economists, mainly M.E. Porter [1998; 1990], who believes that the only significant concept of international competitiveness at national level is just productivity, defined as created value per labor or capital unit, the link between institutions and competitiveness becomes indisputable.

According to other studies, e.g. by D. Rodrik [2008], the quality of institutions (specifically, the “institutional fabric”) in a given country should be linked directly with the welfare of its citizens (income per capita), and the welfare, benchmarked against other countries, according to authors such as J. Fagerberg [1988], F. Sigurdson [1990] or T. Barker and J. Köhler [1998], is a measurable indicator of international competitiveness of a country. The higher the quality of those institutions in a given country, the higher its ability to compete with other countries, which is reflected in the level of wealth of the country’s population.

On the other hand, B.R. Routledge and J. von Amsberg [2002], P. Cooke [2004], or S. Knack and P. Keefer [1997], emphasize the link between institutions and competitiveness reflected by the quality of social capital in a given country, which determines the productivity of the whole economy. The social capital can be defined as a set of informal values and ethical norms common to the members of a particular group and allowing them to effectively cooperate, enhancing the performance of the group or institution concerned [Fukuyama, 2003]. At this point, it is also worth recalling the World Bank’s definition of social capital, according to which it means all institutions, relationships, attitudes, and values that govern interactions among people and contribute to economic and social development, and indirectly also to the improvement of the competitiveness of the economy [Grootaert, Van Bastelar, 2002]. In its definition, the World Bank explicitly identifies social capital with institutions, both formal and informal ones.

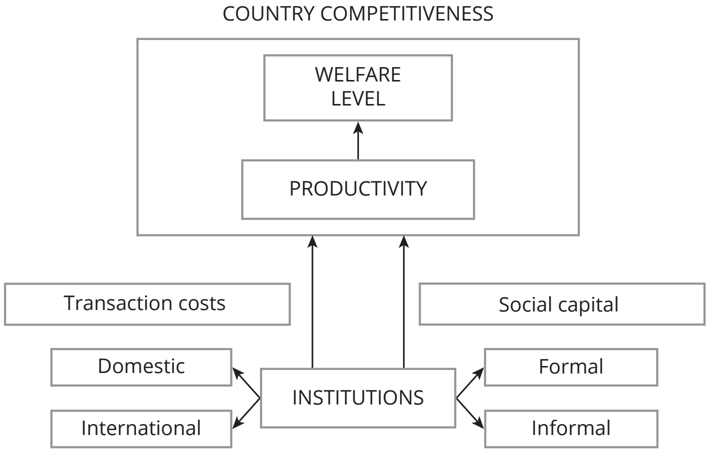
With reference to the aforesaid, two main “channels” of institutional impact (both formal and informal, national and international] on the competitiveness of a country can be identified (Figure 2.1). One involves the impact on transaction costs and the other on the quality of social capital. They, in turn, determined the productivity of the available resources (both domestic and foreign used in the country concerned), and consequently the productivity of its economy, which translates into the welfare level of its inhabitants (i.e. two basic determinants of country competitiveness).

The impact of institutions (or, more broadly, the institutional environment) on the level of a country’s competitiveness in international markets for inputs and products can be in fact tripartite (at least in theoretical terms), i.e. they may:

a) improve the international competitiveness of a country by enhancing the efficiency of the entire political, economic and social system of the country concerned, including in particular by reducing transaction costs of doing business in the country and increasing the productivity of production factors, which will necessarily increase its competitive ability, and consequently also its competitive position in the international dimension;

b) deteriorate the international competitiveness of a country by reducing the above-mentioned efficiency of the entire political, economic and social system of the country concerned, which consequently means wasting the available resources and reducing the country's competitive ability and position on the international stage;
c) remain neutral to the level of a country's international competitiveness.

Figure 2.1 Impact of institutions on a country's competitiveness level

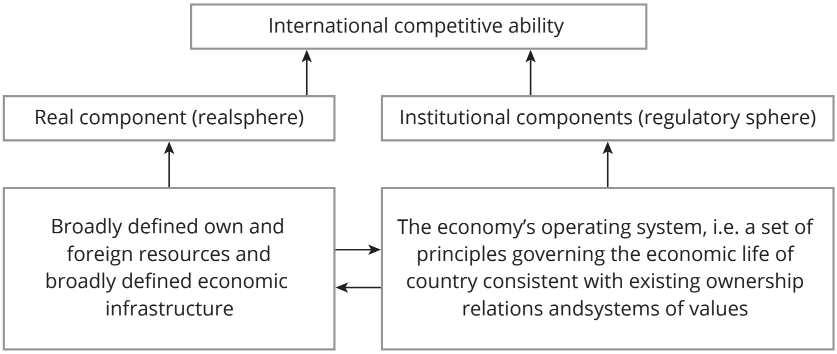


Source: Own study.

A significant importance of institutions in shaping the international competitiveness of the economy has been pointed out by J. Misala [2011], for whom the main two components of the competitive ability of countries on the international stage are the real component (real sphere) and the institutional component (regulatory sphere) (Figure 2.2). He noted that without effectively and efficiently operating institutions that determine the existing ownership relations and the principles underlying the broadly defined economic life, it will be impossible to efficiently manage the real sphere, which comprises own and foreign resources, and thus to effectively compete with other countries on the international stage.

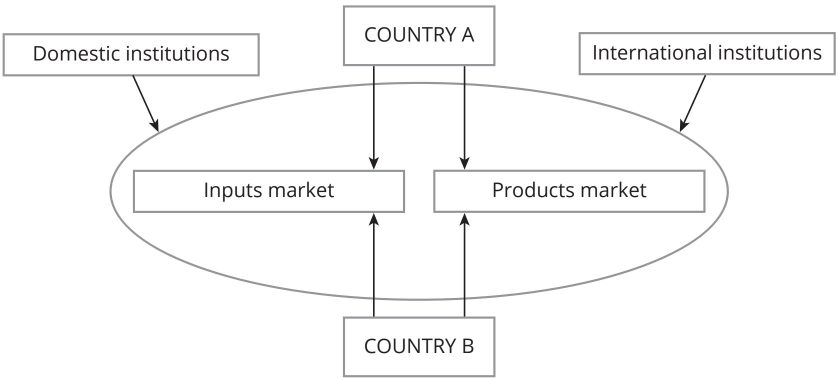
If we assume that the main arena for international competition between countries consists of the inputs market and the products market [Misala, 2011; Siebert, Klodt, 1999], the competitive position of countries in those markets is also a derivative of institutional impact (Figure 2.3). What is more, it should be stressed that the competitive ability and consequently competitive position of countries in those markets is impacted both by domestic institutions and by those of an international nature, such as those resulting from international commercial contracts and agreements, including trade agreements.

Figure 2.2 Components of a country's international competitive ability



Source: Misala [2011].

Figure 2.3 Institutions vs. areas of competition between countries on the international stage



Source: Own study.

The idea of international competitiveness was also studied by O.K. Pedersen [2008], who noted that, firstly, countries compete with one another, creating and modifying, as far as needed, the existing institutional (legal, political, economic, cultural) order, seeking to increase the attractiveness of their economies to business and to boost capital investment (both from domestic and from foreign sources), which is to consequently create comparative advantages over other countries (e.g. through changes in labor market regulations). Secondly, countries compete with one another through informed and purpose-driven creation of institutional complementarities, through gradual coordination of different areas of operation of states, economies and partly social behavior, which is particularly visible in integration groupings (e.g. within the European Union). In the context of the above, O.K. Pedersen [2008] underlines the fact that the management of institutional complementarities has become a necessity on which the competitive ability, and consequently also the competitive position of a country and its economy depends.

Reasoning along these lines, it can be concluded that today, in order to effectively compete on the international stage, countries are unable to fully autonomously, in isolation and alienation, create and develop their institutions, or, more broadly, institutional political, economic and socio-cultural frameworks, as they must "adapt" in this respect to the environment in which they operate. This adaptation may be voluntary and result from an analysis of that environment, or enforced by the fact of joining an organization or signing certain contracts or international agreements. Of course, such adaptation is not necessarily a mere absorption of institutional solutions existing in other countries or integration groups, as it can be creative, generating new solutions that do not exist elsewhere, in response to changes in the environment, with the intention to increase the country's ability to compete internationally.

In this context, it is also worth recalling the English term 'competition state', which, given the views proposed by P. Cerny and M. Evans [1999; 2003], or T. Fougner [2006], means more than 'welfare state'. The state retains the institutional arrangements characteristic of welfare states (deciding that they have proven themselves there, ensuring the achievement of a high level of social and economic development), but it makes necessary changes in response to a dynamically changing international environment under conditions of dynamic globalization processes, so as to face up to growing competition and maintain a high development level in the future. In this development strategy, based on the strengthening of the competitive ability of a country, it is institutions that are of extreme or even critical importance.

A number of various studies can be found in the economic literature, whose authors the tackled the identification of specific institutions that particularly strongly determine the level of countries' international competitiveness. And so, according to R. La Porta et al. [1998], it is the rule of law, while for D. Kaufmann et al. [2008] the quality of government is of particular importance, to L. Branstetter et al. [2014] – the costs and formalities involved in setting up a business, and to F. Brunet [2012] – the overall quality and effectiveness of the regulatory sphere in a particular country. This issue is perceived likewise by J. Misala [2011], J.W. Bossak [2013], or T. Dołęgowski [2002], who emphasize the significance of the effectiveness of the whole economic system, in particular legal order, ownership structure and mechanisms coordinating economic activities of entities, which translates into the competitive ability of the whole economy. On the other hand, an extremely important role of corruption in this respect is emphasized by S.R. Ulman [2013], M. Herciu [2006], or A. Shleifer and M. Vishny [1993]. D. Rodrik et al. [2002] note the special importance of the observance of property rights and enforceability of contracts both for economic growth and development, and for the competitiveness of a country. According to the World Economic Forum [WEF, 2016], the institutions that a significant impact on the transaction costs mentioned above, and thereby the ability of countries to compete on the international stage, are: red tape, corruption, disho0nesty in awarding public contracts, public trust level, transparency and trustworthiness, and judicial independence. In this context, it is also worth referring to T.J. Hämäläinen [2003], who notes the influence of formal and informal institutional considerations (e.g. applicable laws, as well as habits and traditional behavior patterns) on a country's competitive ability.

2.3 Institutional Competitiveness

The common recognition of the importance and role of institutions in determining the level of international competitiveness of countries, both in economic analyses and in the economic policies of many governments, has been evidenced by the emergence and increasing use of the term 'institutional competitiveness'.

Institutional competitiveness is defined as the attractiveness of a country's general institutional framework to entities pursuing (or willing to pursue) business there. The attractiveness if exemplified by the opportunity to maximize profit in microeconomic terms, which will also directly translate into the macroeconomic dimension of the economy of the country concerned [Huemer, Scheubel and Walch, 2013]. The micro and macroeconomic dimension of institutional competitiveness is also pointed out by N. Mańkowska [2013]. In contrast, O.K. Pedersen [2008] defines institutional competitiveness as the ability of a country to improve its economic and social development level faster and more clearly than other countries (comparable in terms of initial potential) owing to its efficient political and economic institutions. It is worth noting at this point that he defines institutions, after the World Bank, as standards, rules, contract enforcement mechanisms and organizations supporting market transactions which support information flows, enforcement of property rights and contracts, regulate competition in the market [World Bank, 2002].

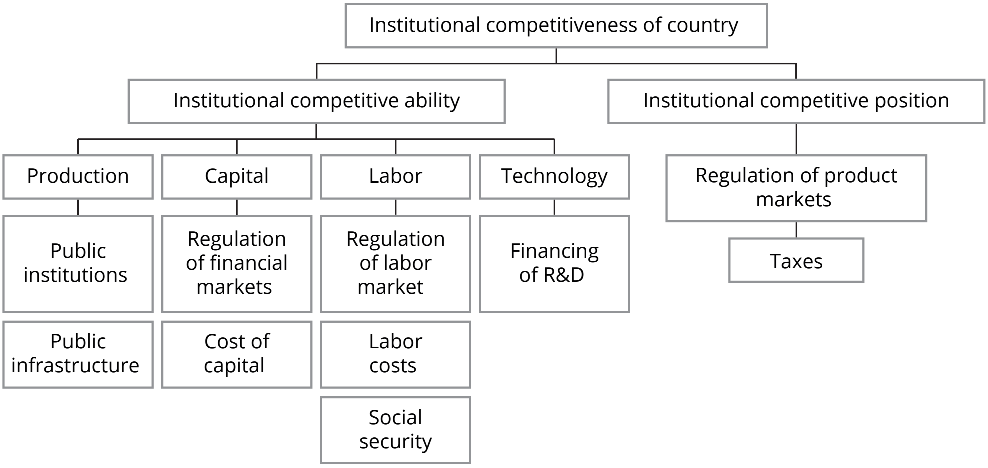
The notion of institutional competitiveness is defined in a similar way by P. Bernard and G. Boucher [2007], for whom it means the ability apply various institutional arrangements to ensure a sustainable economic growth, at a faster rate than other countries. Also the World Economic Forum draws attention to the same aspect, defining institutional competitiveness as the ability of national economic institutions (creating conditions for the operation of business entities and the national economic structure) to generate growth under conditions of structural changes in the global economy [Olczyk, 2008]. The high significance of institutional competitiveness to the economic development level is also emphasized by Ch. Ketels [2016], or T. Dołęgowski [2002], who additionally notes that nowadays countries compete with one another mainly by the quality of broadly defined institutions

S. Huemer, B. Scheubel and F. Walch [2013] have identified nine factors (within five groups) determining a country's institutional competitiveness level (Figure 2.4), namely:

- in the production area – public institutions as a "soft" production factor (in particular, soundness of public finances, extent of democracy, public policy quality, extent of law enforcement) and the public infrastructure a "hard" production factor (in particular: transport infrastructure and communication infrastructure, including the accessibility and development of the Internet, mobile communications and fixed telephone lines);
- in the capital area – regulation of financial markets (in particular, access to financial markets and soundness of financial markets, including banks) and cost of capital (in particular: short and long-term interest rates and taxes on capital);
- in the labor area – regulation of labor markets (in particular, flexibility of the labor market, including the strictness of employment protection and the ease of hiring and firing workers), labor cost (in particular the level of wages and taxes on labor) and social security (in particular, retirement age regulations);
- in the technology area – access to technology (in particular, the availability of the latest technologies, firm-level transfer and absorption of technology, influx of foreign direct investment) and the financing of research and development expenditure (in particular from public sources);
- in the area of regulation of product markets – the level of taxation; on the one hand, of consumption, and on the other hand, of the production and sale of final goods and services.

The competitive ability and position of a country can also be considered in the context of institutional competitiveness. According to the approach adopted by S. Huemer, B. Scheubel and F. Walch [2013], institutions in the areas of production, capital, labor and technology determine the institutional competitive ability, whereas regulation of product markets (specifically, the general scope of regulation of product markets determined by the level of taxation of, on the one hand, consumption, and on the other hand, the production and sale of final goods and services) determines the institutional competitive position of a country. Of course, the proposed list of components of institutional competitiveness could be freely expanded, having regard to the significance in this context of institutions such as broadly defined social capital, or the operating principles of the economic system in the country concerned, which seems by all means justified.

Figure 2.4 Components of a country's institutional competitiveness



Source: Own study based on S. Huemer, B. Scheubel, F. Walch [2013].

Conclusions

Nowadays, the high significance of institutions in shaping the international competitiveness of countries has been gaining increasing attention. It is in institutions, both formal and informal, where the causes of the existing differences in the international competitiveness of countries with similar economic potentials are believed to exist. In addition, increasingly often, economic research relating to the impact of institutions on the level of that competition seeks to identify the institutions that contribute the most to the high competitiveness of countries on the international stage, so that they can be strengthened, or implement in countries with weaker institutions and lower competitiveness.

Answering the two research questions put forward at the beginning of this paper, is should first be stated that the idea of institutions consists essentially in stimulating specific behavior of economic actors (households, enterprises, countries) which is desirable from the point of view of the group's functioning, in a specific direction, providing predictable and rational order leading to the reduction of uncertainties related to the various activities of those actors. This is also directly related to their basic objectives and functions in the economy. Secondly, institutions, in theoretical terms, may have a tripartite impact on the international competitiveness of a country, both in the international input markets and in the product markets. They may improve, deteriorate or remain neutral to the level of international competitiveness of a country. Everything depends on how strongly and in what direction (increasing or decreasing) they will impact transaction costs prevailing a particular country, and the quality of its social capital, and, indirectly, also the productivity of available production factors and social welfare, i.e. two basic determinants of a country's competitiveness. What is more, institutions themselves have today also become an area of direct competition between countries on the international stage.

Bibliography

Amable, B. [2003], *The Diversity of Modern Capitalism*, Oxford University Press, Oxford.

Barker, T., Köhler, J. [1998], *International Competitiveness and Environmental Policies*, Edward Elgar, Cheltenham.

Bernard, P., Boucher, G. [2007], *Institutional competitiveness, social investment*, and *welfare regimes*, "Regulation and Governance", 1(3), pp. 219–229.

Bieńkowski, W. [2005], *Wpływ instytucji na rozwój gospodarczy i konkurencyjność krajów postkomunistycznych. Kilka uwag w odniesieniu do Polski i Rosji*, Material copied for the conference titled: „Nowe uwarunkowania instytucjonalne a rozwój współpracy gospodarczej z krajami bałtyckimi, Białorusią, Rosją – Obwód Kaliningradzki i Ukrainą", Augustów, June 2005.

Boddy, M., Parkinson, M. (eds.) [2004], *City Matters. Competitiveness, Cohesion and Urban Governance*, Policy Press, Bristol, pp. 93–109.

Borrás, S., Jacobsson, K. [2004], *The Open Method of Co-ordination and New Governance Patterns in the EU*, "Journal of European Public Policy", No. 11, pp. 185–208.

Bossak, J. [2013], *Konkurencja i współpraca międzynarodowa*, Difin, Warsaw.

Branstetter, L., Lima, F., Lowell, J.T., Venancio, A. [2014], *Do entry regulations deter entrepreneurship and job creation? Evidence from recent reforms in Portugal*, "The Economic Journal", 124(577), pp. 805–832.

Brunet, F. [2012], *Regulatory quality and competitiveness in recent European Union member states*, "L'Europe en Formation", No. 364, pp. 59–90.

Cerny, P., Evans, M. [1999], *New Labour, Globalization, and the Competition State*, "CES Working Papers Series", No. 70.

Cerny, P., Evans, M. [2003], *Globalization and Social Policy*, in: Ellison, N., Pierson, C. (eds). [2003], *Developments in British Social Policy*, Palgrave Macmillan Press, Basingstoke.

Commons, J.R. [1934], *Institutional Economics*, Macmillian, New York.

Cooke, P. [2004], *Competitiveness as cohesion: social capital and the knowledge economy*, in:

Crouch, C. [2005], *Capitalist Diversity and Change*, Oxford University Press, Oxford.
Davis, L.E., North, D.C. [1971], *Institutional Change and American Economic Growth*, Cambridge University Press, Cambridge.
Delgado, M., Ketels, C., Porter, M.E., Stern, S. [2012], *The determinants of national competitiveness*, NBER Working Paper, No. 18249, National Bureau of Economic Research, Massachusetts.
Dołęgowski, T. [2002], *Konkurencyjność instytucjonalna i systemowa w warunkach gospodarki globalnej*, "Monografie i Opracowania" No. 505, SGH Publishing House, Warsaw.
Fagerberg, J. [1988], *International Competitiveness*, "Oxford Review of Economic Policy", Vol. 12, No. 3, pp. 1–16.
Falkowski, K. [2017], *Long-Term Comparative Advantages of the Eurasian Economic Union Member States in International Trade*, "International Journal of Management and Economics", 53(4), pp. 27–49.
Falkowski, K. [2018], *Konkurencyjność gospodarek surowcowych w handlu międzynarodowym a rola otoczenia instytucjonalnego – przypadek Azerbejdżanu*, „International Business and Global Economy", No. 37, pp. 71–83.
Flanagan, R., Lu, W., Shen, L., Jewell, C. [2007], *Competitiveness in construction: A critical review of research*, "Construction Management and Economics", No. 25, pp. 989–1000.
Fukuyama, F. [2003], *Kapitał społeczny*, in: Harrison, L.E., Huntington, S.P., (eds.), *Kultura ma znaczenie*, Zysk i S-ka, Kraków.
Fukuyama, F. [2008], *What Do We Know about the Relationship between the Political and Economic Dimension of Development?*, in: *Governance, Growth, and Development Decision-making*, The World Bank, Washington D.C., pp. 25–34.
Gorynia, M., Jankowska, B. [2008], *Klastry a międzynarodowa konkurencyjność i internacjonalizacja przedsiębiorstwa*, Difin, Warsaw.
Gorynia, M. [2009], *Teoretyczne aspekty konkurencyjności*, in: Łaźniewska, E., Gorynia, M., (eds), *Kompendium wiedzy o konkurencyjności*, Wydawnictwo Naukowe PWN, Warsaw, pp. 48–64
Groenewegen, J., Spithoven, A., Van Den Berg, A. [2010], *Institutional Economics. An Introduction*, Palgrave Macmillan, New York.
Grootaert, Ch., Van Bastelar, T. [2002], *Understanding and Measuring Social Capital: A Multidisciplinary Tool for Practitioners. Directions in Development*, World Bank, Washington DC.
Hall, P., Soskice, D., (eds.) [2001], *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*, Oxford University Press, Oxford.
Hämäläinen, T.J. [2003], *National Competitiveness and Economic Growth. The Changing Determinants of Economic Performance in the World Economy*, Edward Elgar, Cheltenham.
Herciu, M. [2006], *The Impact of Corruption on National Competitiveness*, "Studies in Business and Economics", Vol. 1(1), pp. 13–28.
Hodgson, G.M. [2001], *How economics forgot history*, Routledge, London.
Hodgson, G.M. [2004], *The Evolution of Institutional Economics: Agency, Structure and Darwinism in American Institutionalism*, Routledge, London.
Huemer, S., Scheubel, B., Walch, F. [2013], *Measuring Institutional Competitiveness in Europe*, "Working Paper Series", No. 1556, European Central Bank, Frankfurt am Main.

Iwanek, M., Wilkin, J. [1998], *Instytucje i instytucjonalizm w ekonomii*, University of Warsaw, Warsaw.

Kaufmann, D., Kraay, A., Mastruzzi, M. [2008], *Governance matters VII: Governance indicators for 1996–2007*, World Bank Policy Research Working Paper No. 4654, World Bank, Washington D.C.

Katzenstein, P. [1985], *Small States in World Markets: Industrial Policy in Europe*, Cornell University Press, New York.

Ketels, Ch. [2016], *Review of Competitiveness Frameworks*, National Competitiveness Council, Dublin.

Knack, S., Keefer, P. [1997], *Does Social Capital Have an Economic Payoff? A Cross-country Investigation*, "Quarterly Journal of Economics", 112(4), pp. 1251–1288.

Kohler, W. [2006], *The "Lisbon Goal" of the EU: Rhetoric or Substance?*, "Journal of Industry, Competition and Trade", Vol. 6, No. 2, pp. 85–113.

Kołodko, G.W. [2008], *Wędrujący świat*, Wydawnictwo Prószyński i spółka, Warsaw.

La Porta, R., Lopez-de-Silanes, F., Shlefer, A., Vishny, R. [1998], *Law and Finance*, "Journal of Political Economy", 106(6), pp. 1113–1155.

Mańkowska, N. [2013], *Konkurencyjność instytucjonalna – wybrane problemy metodologiczne*, „Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu", No. 305, pp. 445–456.

Miozzo, M., Walsh, V. [2010], *International Competitiveness and Technological Change*, Oxford University Press, New York.

Misala, J. [2011], *Międzynarodowa konkurencyjność gospodarki narodowej*, PWE, Warsaw.

Nelson, R.R. [2008], *What Enables Rapid Economic Progress: What Are the Needed Institutions?*, "Research Policy", Vol. 37, pp. 1–11.

North, D.C. [1990], *Institutions, Institutional Change and Economic Performance*, Cambridge University Press, Cambridge.

North, D.C., Thomas, R.P. [1973], *The Rise of the Western World: A New Economic History*, Cambridge University Press, Cambridge.

North, D.C. [1981], *Structure and Change in Economic History*, W.W. Norton & Co, New York.

North, D.C. [1990], *Institutions, institutional change and economic performance*, Cambridge University Press, Cambridge.

North, D.C. [1994], *Economic Performance Through Time*, "The American Economic Review", Vol. 84, No. 3, pp. 359–368.

North, D.C. [2005], *Understanding the Process of Economic Change*, Princeton University Press, Princeton.

Olczyk, M. [2008], *Konkurencyjność. Teoria i praktyka. Na przykładzie polskiego eksportu artykułów przemysłowych na unijny rynek w latach 1995–2006*, CeDeWu, Warsaw.

Ostrom, E. [1990], *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press, Cambridge.

Ostrom, E. [2005], *Understanding Institutional Diversity*, Princeton University Press, Princeton and Oxford.

Pedersen, O.K. [2008], *Institutional Competitiveness. How Nations Came to Compete,* Working Paper, No. 47, International Center for Business and Politics, Copenhagen.

Pejovich, S. [1995], *Economic Analysis of Institutions and Systems*, Kluwer A.P., Dordrecht.

Porter, M.E. [1990], *The Competitive Advantage of Nations*, The Free Press, New York.

Porter, M.E., [1998], *On competition*, Harvard Business School Press, Boston.

Porter, M.E. [2000], *Attitudes, values, beliefs, and the microeconomics of prosperity*, in: Harrison, L.E., Huntington, S.P. (eds.), *Culture Matters: How Values Shape Human Progress,* Basic Books, New York, pp. 14–28.

Radaelli, C.M. [2003], *The Open Method of Co-ordination: A New Governance Architecture for the European Union?,* Swedish Institute for European Policy Studies, Lund.

Rodrik, D., Subramanian, A., Trebbi, F. [2002], *Institutions rule: the primacy of institutions over integration and geography in economic development*, IMF Working Paper, WP/02/189, International Monetary Fund, Washington DC.

Rodrik, D. [2008], *Thinking about Governance, in: Governance, Growth and Development Decision-making*, The World Bank, Washington D.C.

Roland, G. [2004], Understanding institutional change: Fast-moving and slow-moving institutions, "Studies in Comparative International Development", 38(4), pp. 109–131.

Roland, G. [2016], *Development Economics*, Routledge, London and New York.

Routledge, B.R., von Amsberg, J. [2002], *Social Capital and Growth*, "Journal of Monetary Economics", 50(1), pp. 167–193.

Schwab, K., Sala-i-Martin, X. [2015], *The Global Competitiveness Report 2015–2016,* World Economic Forum, Geneva.

Shleifer, A., Vishny, M. [1993], *Corruption*, "Quarterly Journal of Economics", 108(3), pp. 599–617.

Siebert, H., Klodt, H. [1999], *Towards Global Competition: Catalysts and Constrains*, in: *The Future of the Global Economy: Towards a Long Boom?*, OECD, Paris.

Sigurdson, J. [1990], *The Internationalisation of R&D: An Interpretation of Forces and Responses*, in: Sigurdson, J. (ed.), *Measuring* The *Dynamics* of *Technological Change*, Pinter Publishers, London and New York.

Spence, A.M., Hazard, H.A. (eds.), [1988], *International competitiveness*, Ballinger Publishing Company, Cambridge.

Staniek, Z. [2017], *Ekonomia instytucjonalna. Dlaczego instytucje są ważne*. Wydawnictwo Difin, Warsaw.

Stankiewicz, W. [2012], *Ekonomika instytucjonalna. Zarys wykładu*, Wydawnictwo Prywatnej Wyższej Szkoły Businessu, Administracji i Technik Komputerowych, Warsaw.

Stiglitz, J.E. [2000], *Challenges in the Analysis of the Role of Institutions in Economic Development*, Villa Bording Workshop Series "The Institutional Foundations of a Market Economy".

Swaminathan, A., Wade, J.B. [2016], *Institutional Environment*, in: Augier, M., Teece, D. (eds.), *The Palgrave Encyclopedia of Strategic Management*, Palgrave Macmillan, London.

Ulman, S.R. [2013], *Corruption and National Competitiveness in Different Stages of Country Development*, "Procedia Economics and Finance", No. 6, pp. 150–160.

Veblen, T. [1899], *The Theory of the Leisure Class*, after: Veblen, T., [1971], *Teoria klasy próżniaczej*, PWN, Warsaw.

WEF [2015], *The Global Competitiveness Report 2015–2016*, World Economy Forum, Geneva.

WEF [2016], *The Global Competitiveness Report 2016–2017*, World Economy Forum, Geneva.

WEF [2017], *The Global Competitiveness Report 2017–2018*, World Economy Forum, Geneva.

Weresa, M.A. [2008], *Definicje, determinanty oraz sposoby pomiaru konkurencyjności krajów, in*: Bieńkowski, W., Czajkowski, Z., Gomułka, M., Brocka-Palacz, B., Weresa, M.A. [2008], *Czynniki i miary międzynarodowej konkurencyjności gospodarek w kontekście globalizacji – wstępne wyniki badań*, "Prace i Materiały", No. 284, SGH World Economy Research Institute, Warsaw.

Williamson, O.E. [1985], *The Economic Institutions of Capitalism*, Oxford University Press, Oxford.

Williamson, O.E. [1998], *Ekonomiczne instytucje kapitalizmu: firmy, rynki, relacje kontraktowe*, Wydawnictwo Naukowe PWN, Warsaw.

Wilkin, J. [2002], *Budowa instytucji wspierających rozwój wsi i rolnictwa w kontekście integracji Polski z Unią Europejską*, in: *Wieś i rolnictwo. Perspektywy rozwoju*, Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej, Warsaw.

Wojtyna, A. [2007], *Teoretyczny wymiar zależności między zmianami instytucjonalnymi, polityką ekonomiczną a wzrostem gospodarczym*, "Gospodarka Narodowa", No. 5–6, pp. 1–23.

World Bank [2002], *Building Institutions for Markets, World Development Report 2002*, The World Bank, Washington.

Woźniak-Jęchorek, B. [2014], *J.R. Commons vs. O.E. Williamson – dwie szkoły instytucjonalne i ich dorobek z punktu widzenia ekonomiki rynku pracy*, "Studia Prawno-Ekonomiczne", Vol. XCII, pp. 391–408.

Wziątek-Kubiak, A. [2004], *Kontrowersje wokół konkurencyjności w teorii ekonomii*, „Ekonomista", No. 6, pp. 805–807.

Chapter 3

The Fourth Industrial Revolution and Its Impact on Global Economy

Andżelika Kuźnar

Introduction

The purpose of this paper is to identify new trends in the global economy underpinned by the revolution in the application of digital techniques. The analysis includes an overview of the context of changes taking place in the global economy, arising from technological progress, and identification of the main pillars of Economy 4.0, i.e. 3D print, big data and robotization. Only the most important factors driving the fourth industrial revolution were selected due to limited volume of the text. Against this background, possible consequences will be presented in terms of production methods and changes in the international division of labor.

3.1 Industrial Revolutions in Global Economy

The global economy is undergoing continuous changes. Some of them are of an evolutionary nature, but abrupt changes also do occur, commonly called revolutionary. They result in the transformation of the ways societies manage their economies. Those revolutionary changes, which were triggered by breakthrough technological achievements, leading to significant changes in the structure and organization of production, are called industrial revolutions. Due to the fact that the history of industrial revolutions occurring until XXth century are commonly known, they are presented in a shortened form, so that more space could be devoted to the analysis of the currently ongoing changes in global economy,

The first such revolution took place toward the end of the 18th century, and it was related to the invention of the steam machine (1784) and the progressive mechanization of production, initially in the textile industry (mechanical loom) in Great Britain. The steam engine made it possible to replace human labor with machines, boosting workforce productivity, and additionally it was a source of progress in the development of means of transport (steamship, railway based on large coal resources). Combined with the 19th century achievements, such as printing and telegraph, they produced a significant reduction in transport costs.[1] From then on, the country did not have to produce everything that its inhabitants wanted to consume – production and consumption could be distributed geographically. On the one hand, this meant an increase in the capability to produce goods and, on the other hand, the capability to transport them. Baldwin [2011] believes that it was the first unbundling of the production and consumption processes in the history of globalization. Countries could start to specialize in production according to their comparative advantage. There have been surpluses that could be sold abroad (earlier the consumer possibilities were limited to the production possibilities), while low costs combined with transport capabilities supported (profitable) large-scale production. Factories started to be set up, implementing large-scale production. The best-known example is that of the manufacturing line launched by Henry Ford in 1913. Changes in production processes were also attributable to mass electrification[2], development of motoring (combustion engine invention), invention of radio and telephone. The prices of large-scale manufactured products were dropping substantially, while their quality was improving due to factors such as repeatability.

The processes in question, occurring at the turn of the 20th century, forming the second industrial revolution, led to the establishment of permanent trade links between states, contributing to the emergence of the global economy [Budnikowski, 2016, p. 17 et seq.]. It was by no accident that the best conditions for technological development prevailed in Western Europe at the time. For about a hundred years preceding the second industrial revolution, fundamental changes in the intellectual climate were taking place there, resulting in multiple inventions and new scientific theories explaining the laws of nature. It was only in the early 20th century that the US became the global leader of innovation, with its per capita income and GDP share of research and education expenditure exceeding the corresponding values in Western Europe. At that time, the rest of the world, with some exceptions in Eastern Europe, in Iberia and Latin America, experienced technological stagnation [Persson, Sharp, 2015, pp. 110–112).

1 Over the years 1800–1910, the cost of land transport dropped by 90%, and in 1870–1900 the cost of trans-Atlantic transport was reduced by 60% (see WTO, 2013, p. 46).

2 While electricity had already been used quite commonly as early as the end of the 19th century, it was not until the invention of the electric bulb, and then the putting into operation of the first public power plant by Thomas A. Edison that electricity could be supplied to a larger number of consumers.

The following decades saw a number of technical innovations emerging or a growing interest from business in earlier inventions. And so, in the 1950 s, in Japan, the just-in-time manufacturing method was used for the first time, the use of jet engines in air transport was rising; in 1961 integrated circuits were placed on the market; from the late 1960 s containerization became a standard on ocean freight; and in 1971 Intel released the first commercial microprocessor, color television and cinema became widespread, and film-makers started using the latest technologies and special effects. The Internet started to be widely used. This period of the world's economic development is referred to as the Third Industrial Revolution (or IT Revolution). Its distinguishing feature is the automation of production with the use of computers. The revolution results in progress in the gathering, processing and transmission of information. What is more, owing to the ease of communication, the quantity of information increases at a tremendous pace.

With the decrease in telecommunications costs and the growing availability of information technology, the cost and risk of production coordination was reduced. Modular production has emerged, which is easier to coordinate. As a result, the possibility emerged of spatial distribution of the production process between the corporation branches located in different countries and entities unrelated by capital or organization (outsourcing). The second unbundling in the history of globalization then took place [Baldwin, 2011]. Opportunities emerged for a profitable combination of technologies of highly developed countries with (lower-paid) workforce in developing countries. As a consequence of this, changes have taken place in world trade. While until the mid-20th century mainly final products were widely exported, produced entirely in one country (and containing the input of labor, capital and knowledge of one country), from the second half of the 20the century trade became a continuous two-way flow of intermediate goods, services, people, capital, information, originating from geographically dispersed enterprises. The proportion of parts and sub-assemblies in total global trade is estimated at 60% [UNCTAD, 2013, p. 122].

The nature of the international division of labor has changed – individual countries may participate only in part of the production stages of a particular product, which results in what is known as vertical specialization. This means a situation where countries are not categorized into those producing industrial goods and raw/agricultural goods, but the breakdown relates to the various stages of the value chain – within a single type of activity (e.g. manufacturing) [Geodecki, Grodzicki, 2015, p. 20].

Today, we are witnessing the Fourth Industrial Revolution (or: Digital Revolution). It relates to the development of digital technology and electronics and involves the integration of digital and physical systems, in all sectors of the economy. The term Industry 4.0 is widely used, or – since the changes go beyond industry – Economy 4.0.

It was used for the first time in public at the Hannover Fair in 2011 with reference to the economy of Germany [Gospodarka 4.0, 2017].

The Fourth Industrial Revolution is driven primarily by an increase in the amount of data available and its analysis (big data analysis with the use of artificial intelligence, cloud storage), the use of mobile connectivity for data transmission from devices (Internet of Things, IoT) and automation of production processes (robotization). "Smart" factories and "smart" factories emerge as a result. Other digital technologies, which cannot be listed exhaustively, as new solutions are continually emerging, also play an important role. They include e.g. 3D printing.

3.2 3D Printing

The effects of the Fourth Industrial Revolution include changes in manufacturing techniques. One example is the use of 3D printing[3] in production, which significantly reduces production costs of goods and increases the ability to manufacture more refined products, and to do so without human supervision.

This achievement can lead to enormous changes in the global economy, ranging from new uses of known or new materials (e.g. lighter, more durable, with complex shapes, for transplantation of internal organs), to the organization of supply chains (independent of costly and time-consuming deliveries from distant corners of the world).

Two main types of 3D printers are marketed – industrial (professional) and desktop (personal). 3D printers have been used in industry for about 30 years now. They are used to produce concept models, based on which target products and their components are made[4]. For example, in Portugal and the Netherlands, more than 60% of enterprises using 3D printing do so to print prototypes or models for sale[5]. In addition, 3D printing has multiple applications in medicine and dentistry (creating prototypes of implants[6]) as well as architecture and design [Ślusarczyk, 2015].

3 An additive technology which consists in the application of successive material layers to build a three-dimensional object. Models are on the basis of a digital file.

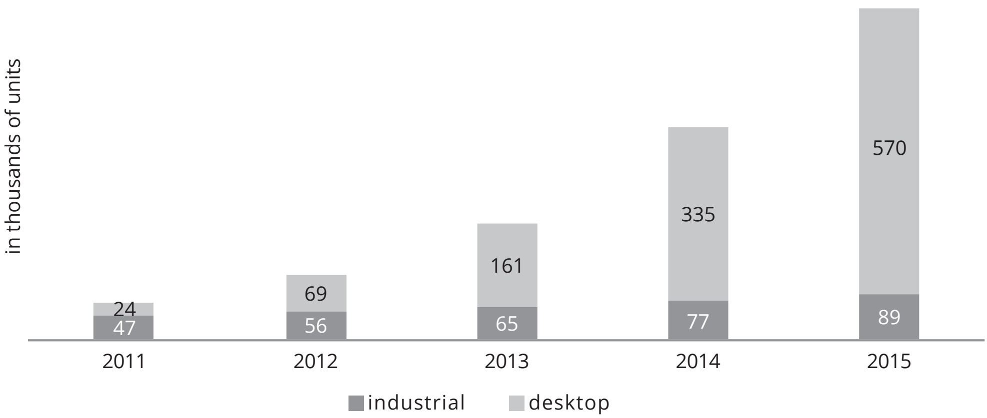
4 For example, the Polish company Emtel uses the 3D printing technology both for prototyping and for producing specially selected details for its equipment (defibrillators and cardiac monitors). The implementation of the technology in production has optimized the manufacture of components, saving time and money. As reported by the manufacturer, the production of one piece of prototype cardiac monitor housing with the use of the 3DGence One unit made it possible to save PLN 1800 and reduce the time of fabrication by almost a month – with the prototype, dimensions were represented correctly, and consequently the components produced using the injection molding method needed no further adjustments (Przychodniak, 2019).

5 According to Eurostat data: 3D printing and robotics [isoc_eb_p3d].

6 For example, in early 2019, researchers from the Foundation of Research and Science Development printed the world's first bionic pancreas, complete with blood vessels, using the 3D technique,

Desktop printers are a new phenomenon. They are gradually beginning to match industrial devices in terms of quality and parameters. They are used increasingly widely in areas such as engineering, product design, art, jewelry, dentistry and consumer products [Deloitte, 2016]. While in 2011 there were still more industrial printers sold, the proportions reversed from 2012 on (Figure 3.1). In 2015, almost 600,000 desktop printers and about 89,000 industrial printers were sold. Thus desktop printers represent about 95% of all 3D devices sold. In four years, between the end of 2011 and 2015, the number of desktop 3D printers increased fourfold, growing annually by 88% on average (by comparison, the sales of industrial printers grew by an average of 14% annually over the same period).

Figure 3.1 Sales of 3D printers in 2011–2015, in thousands



Source: Deloitte, 2016

This acceleration is attributable to four groups of factors. Firstly, for many years the development of the industry was limited to several largest manufacturers holding patents on their products. The expiry of some of those patents enabled new players to grow dynamically [Deloitte, 2016]. New manufacturers appeared, offering high-quality budget 3D printers at less than US$ 500. For example, the Chinese firm Monoprice quickly became the leading manufacturer of 3D printers. Secondly, the average prices of 3D equipment dropped dramatically. In 2017, a 3D printer with the same or better parameters than a 3D printer marketed in 2013 was available at 1/10th of the price. Thirdly, the overall quality of desktop 3D printers is improving, and they are increasingly easy to operate. This quality improvement has produced a new

https://wiadomosci.onet.pl/kraj/pierwsza-na-swiecie-bioniczna-trzustka-polacy-wydrukowali-narzad-na-drukarce-3d/1d5ls5c (access: 15.03.2019); https://fundacjabirn.pl/projekty/projekt-biodrukowanie--3d-bionicznej-trzustki/ (access: 15.03.2019).

generation of customers looking for plug-and-play 3D printers. Fourthly, designs and platforms (e.g. Thingiverse, MyMiniFactory.com) are accessible, which can be used easily for 3D printing even by less experienced users [Adams, 2018].

However, no data is available on the production volume of goods made with the use of 3D printers. However, the increase in the quantity of devices can be expected to translate in future into a growing importance of the production of goods using this method. This is not the case for the time being, because 3D printers are mainly used for prototyping.

According to the CONTEXT research firm, the value of the 3D printing market, which consists of devices, as well as consumables and maintenance service, was to reach US$5.6 bn in 2017, and in 2021 it is to rise to US$17 bn [Ślusarczyk, 2017], with volume of 3D printer sales reaching 1–1.5 million units [Adams, 2017]. Similar values are also given by Deloitte, who expects sales to exceed the value of US$20 billion in 2020 [Deloitte, 2016]. Wohlers, a consulting company specializing in 3D printing market analyses, estimates that in 2016 companies worldwide spent US$6.6 billion on 3D printers and associated services[7] [ING, 2018].

The main buyer of 3D printers is the United States (38% market share in 2012). Other major buyers are Western European countries (Germany, the United Kingdom, Italy and France – 20% in total), Japan (18%), China (9%) (Deloitte, 2016).

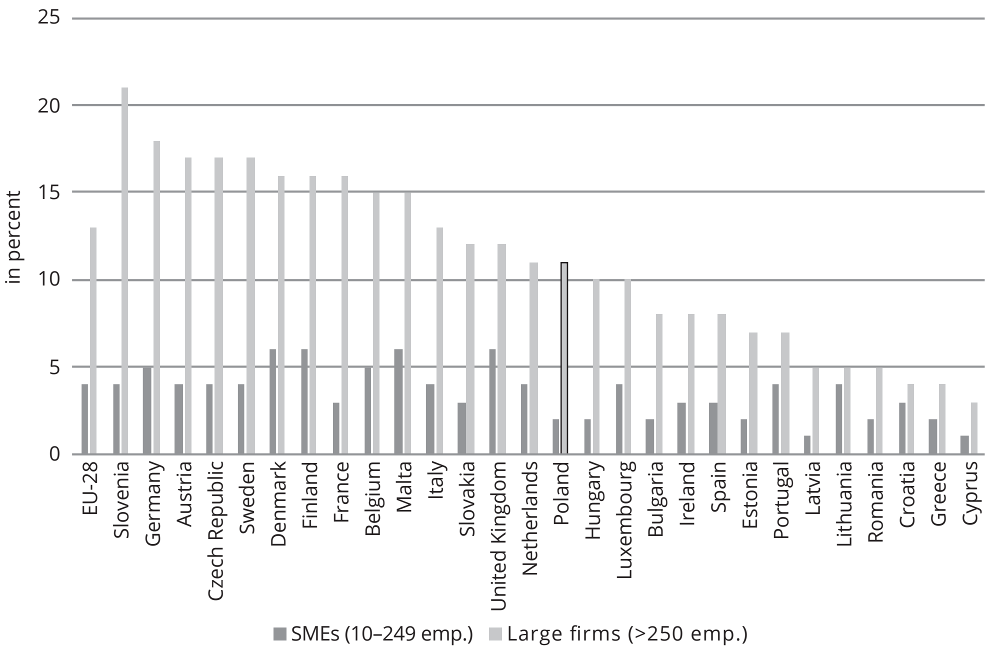
According to Eurostat data, approx. 4% of all enterprises in the EU28 use 3D printing (with the largest proportion in Finland – 7%). However, there is a definite difference between the use of 3D printing in large and small and medium-sized enterprises (SMEs). In this first group, the 3D technology is used on average by 13% of firms in the EU28 (compared with 4% in the SME group). The leaders are Slovenia (with 21% of large enterprises), Germany, Sweden, the Czech Republic and Austria (17–18%). By comparison, in Poland 11% of large enterprises used 3D printing in 2018 (Figure 3.2).

A study prepared by ING [2018] focuses on the potential impact of 3D printing on international trade flows. This relationship arises from the fact that 3D printing reduces the need to import components and parts. This will also potentially change the situation of final goods assembly plants, as many of them will no longer be needed – it will be possible to print a complete final product instead of assembling it using intermediate parts. It will also be easier to personalize goods (customization is already possible today, but with 3D printing it will be easier and cheaper). What is more, consumers can start producing (printing) goods themselves, bypassing manufacturing enterprises. This will be facilitated by an increase in the prices of 3D

[7] By comparison, in 2016 the global spending on traditional manufacturing machinery was US $6.7 trillion, i.e. 1000 times more than on 3D printers.

printers and related consumables, as well as improved skills of buyers operating such equipment. The emergence of such prosumers may significantly impact manufacturing opportunities of enterprises[8]. The trend of replacing traditional production with 3D printing can be limited by barriers to the application of the new technology in mass production[9]. Another constraint is that the share of 3D printers in the value of global production is still at a low level of less than 0.7%.

Figure 3.2 The use of 3D printing by enterprises in the EUE28 states, in 2018, in %



Source: Own study based on Eurostat data: 3D printing and robotics [isoc_eb_p3d]

However, in future, the scale of international trade is expected to be reduced. Owing to production with the use of 3D printing, the share of labor inputs in total production costs will be decreasing. Thus they will play an increasingly smaller role in production location decision-making. A process reverse to that witnessed from the end of the 20th century, i.e. the separation of production and consumption (second unbundling, Baldwin, 2011) and the related fragmentation of production, can be

8 Although not all consumers are expected to be willing to produce goods by themselves, which means that manufacturing enterprises will continue to be needed. There will also still be standard products, manufactured traditionally or with the use of industrial printers.

9 One example is Honda, currently producing vehicles which are almost entirely made up of printed components. Also aviation and medical industries also have experience in mass production (e.g. all hearing aids are manufactured today using the 3D technology).

expected, and re-organization of production processes near the consumer. This will reduce cross-border trade in components and final products, lead to transferring production to developed countries, and hence reduce global trade. This will not be compensated by demand for raw materials used for the production of printers themselves, or for printing (polymers and metals, as well as oil, gas, coke and metals such as nickel, copper, gold and silver), as 3D printing leads to smaller losses that traditional production [ING, 2018].

The changes will affect different countries to a different extent, depending on their specialisatoin in trade. The greatest shifts are to be expected in industries with the heaviest investment in 3D printing and a significant share in global trade.

They include the industrial machinery industry. In this case the highest export volumes flow from China to the USA, and there are high bilateral flows between the USA and Mexico (export and import). High volumes of mutual trade are also recorded between China and Japan, and between China and Hong Kong, but the latter is of a different nature, as in most cases it involves re-export. Thus if 3D printing reduces some of that trade, this will mainly affect manufacturers outside Hong Kong. In Hong Kong, this will affect ports and transport services. Thus, in this industry, the greatest changes can be expected in trade between China and the USA, and in intra-American and intra-Asian trade.

In the case of another industry, i.e. consumer products, the greatest export volumes go to the USA – it is the country receiving four of ten largest trade flows. The USA receives many labor-intensive goods, such as clothes, shoes and toys, and electronics (from China, Mexico, Hong Kong and Vietnam). Asian countries may suffer the most, as it will be possible to produce the above goods locally with the use of 3D printers.

The third industry with a significant share in trade and investment in 3D printing is the automotive industry. In six out of the ten largest trade flows, the largest importer from this industry is the USA (from Mexico, which is related to offshoring; from Canada – a supplier of parts; from Japan and Germany, which export cars and parts to the USA; from South Korea and China). The automotive industry exports from all those countries will suffer if the production of automotive parts is replaced by locally printed and then locally assembled printed parts. German exports will be affected the most. Germany is the source of five of the ten largest bilateral automotive flows in the world (to the USA, UK, China, France and Italy).

It is apparent from the data presented that the largest beneficiary of the substitution of traditional ways of manufacturing with 3D printing can be the USA (because it is the largest importer in industries where high investment is made in 3D printing). Production backshoring to that country will allow it to reduce the size of its trade deficit with many developing countries, including mainly China and Mexico, and with Germany.

3.3 Big Data

One of the cornerstones of the Fourth Industrial Revolution is the vast amount of data (its huge repositories being called “big data”). Big data is defined as “sets of a collection of high-volume, highly volatile or highly diverse information[10] that requires new forms of processing to support decision-making, discovering new phenomena, and optimization of processes” [Ministerstwo Cyfryzacji, 2018]. However, data becomes valuable only when analyzed. This became possible owing to an increase in the processing power (and development of artificial intelligence). These analytics are based on the automatic collection and processing of data sourced from devices (the so-called Internet of Things – see below) or directly from people. The information obtained ensures better management of corporate resources, production planning, product life cycle management, fostering relations with suppliers, and better responding to customer needs [PwC, 2017].

Big data can also be defined as a resource that can finally be used thanks to technology. Much data, such as that on weather, crops or customer orders, has always existed. But its efficient collection and informed use has not been possible until recently.

According to the Eurostat data, in 2018 big data has been used in the EU28 by 12% of enterprises, the percentage being higher in the large company group, at 33% (in Poland 8 and 26%, respectively) (Table 3.1). In Belgium and the Netherlands, more than half of large companies declare the use of big data, and almost half in Malta do so.

Table 3.1 Enterprises (without financial sector) using big data in EU28, 2018, in %

	All enterprises	SMEs (10–249 employees)	Large enterprises (>249 employees)
EU28	12	12	33
Austria	6	6	29
Belgium	20	19	55
Bulgaria	7	6	25
Croatia	10	10	27
Cyprus	5	4	32
Czech Republic	8	7	24
Denmark	14	13	46
Estonia	11	10	35

10 The data volume itself is not a sufficient determinant of big data. It is also not clear how big data sets must be to be considered as big data. The emergence of the term “big data” is related to qualitative changes resulting from the size of data sets and their accessibility.

cont. tab 3.1

	All enterprises	SMEs (10–249 employees)	Large enterprises (>249 employees)
Finland	19	18	44
France	16	16	37
Germany	15	14	34
Greece	13	12	20
Hungary	6	6	17
Ireland	20	20	47
Italy	7	7	30
Latvia	8	7	30
Lithuania	14	13	26
Luxembourg	16	16	31
Malta	24	24	48
Netherlands	22	21	53
Poland	8	7	26
Portugal	13	12	34
Romania	11	11	23
Slovakia	9	9	24
Slovenia	10	9	38
Spain	11	10	30
Sweden	10	9	34
United Kingdom*	15	15	35

Note: * 2016

Source: Own study based on Eurostat data: Big data analysis [isoc_eb_bd]

The data sources can be different. In 2013, the United Nations Economic Commission for Europe classified the sources into three groups: Social Networks, Traditional Business systems and the Internet of Things [UNECE, 2013]. Eurostat uses a modified typology as presented in Table 3.2. According to it, most data for analysis within big data systems in the case of all enterprises comes from portable devices and social media (6% of all enterprises in the EU28 use those data sources). Taking into account only those enterprises that use big data, almost half of them use the above two data sources. The situation is different in the large enterprises group. They make a greater use of data sourced from their own sensors (18% of all large firms and 54% of those using big data) (Table 3.2).

Table 3.2 Sources of data acquisition for big data analysis in enterprises (without financial sector) in EU28, 2018, in %

	All enterprises (%)	All enterprises using big data (%)	Large enterprises (>249 employees) (%)	Large enterprises using big data (%)
Analyze own data from enterprise's smart devices or sensors	4	29	18	54
Analyze data from geolocation of portable devices	6	49	13	41
Analyze data from social media	6	45	13	39
Analyze data from other sources	3	26	13	40

Source: Own study based on Eurostat data: Big data analysis [isoc_eb_bd]

To what extent the enterprises utilize the potential of advanced data analysis is a separate issue. McKinsey estimates that globally enterprises utilize only 30% of the value creation potential envisaged in 2011.[11]

The conscious use of big data may bring numerous benefits to the whole economy. They include the production of new goods (including individual orders); optimization of business processes; a more targeted marketing which uses customer feedback in product design; better organization management; faster innovations owing to a shorter research and development cycle; more efficient utilization of resources; reduction of energy consumption.

The benefits will be greater if data can freely cross state borders. The greater data sets are held in a single base, the more efficient a big data analysis can be. This freedom is important both for the understanding of rare phenomena (big data allows unobvious patterns and schemes to be detected), and for solving international problems (such as terrorism). However, the free flow of data is impeded by various regulatory barriers, partly related to the need to protect personal data, and partly non-personal data[12] [for more see e.g. Koloch et al., 2017].

The cross-border data flow is also important in the case of the Internet of Things, i.e. mutually communicated, networked devices. Its development is facilitated by a tremendous growth in the number of sensors used for measuring and recording events and situations in the physical world. These are different technologies that allow devices to be connected to the Internet, as well as remote access to them. They

11 In 2011, McKinsey estimated the opportunities of value creation in five areas, resulting from big data analysis. In 2016, they reported to what extent the potential had been achieved.

12 These are e.g. requirements that specify where data can be stored and transmitted; data destruction requirements; the need to obtain prior authorization of systems, etc.

include both household appliances and articles of everyday use, such as watches and smartphones, or machines and equipment for industrial plants [Astor, 2016]. The freedom of cross-border data flow is extremely important in international logistics. Data on vehicles and shipments located in different countries should be integrated so as to efficiently manage international supply chains. Owing to combined data, it is possible to reduce the customer service time, improve their satisfaction and offer new services, such as shipment tracking [Koloch et al., 2017].

The Internet of Things can be applied in any industry, from motoring[13] to medicine[14] to mining[15]. Enterprises using such devices can streamline processes and optimize the efficiency of their operations. With this technology, it will be possible to predict a hardware failure and prevent it. It will be possible to analyze the consumption of energy and other resources, and to optimize them. Research shows, however, that the idea of the IoT is still little known and understood by managers in enterprises, but the knowledge has been growing rapidly. The authors of the Industry 4.0 report refer to the 2015 survey results, according to which as many as 44% respondents did not understand the idea of using IoT, whereas in 2016 the proportion dropped to 19% [Astor, 2016].

3.4 Robotization

There are three categories of robots in the market: industrial, service and personal. Industrial robots are used in broadly defined industrial tasks. According to ISO ITR 8373, they are automatically controlled, reprogrammable, multipurpose manipulators programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications. Their tasks may include e.g. welding, painting, palletizing, assembly, pressing, handling, product inspection, product testing, etc.

Service robots, as defined by the International Federation of Robotics (IFR), perform useful tasks for humans or equipment excluding industrial automation applications. Tasks for humans are understood as the operation of robots to ensure human safety and provide entertainment, whereas tasks useful for equipment are understood as maintenance, repair and cleaning. Another purpose of such robots is

13 Also in trivial applications, such as recording the location of a parked car in a smartphone application or providing information on traffic jams ahead.

14 In this case, it is also important to ensure freedom of cross-border data flow. E.g., patients with implanted programmable cardiac pacemakers should be provided with remote health monitoring also when travelling abroad.

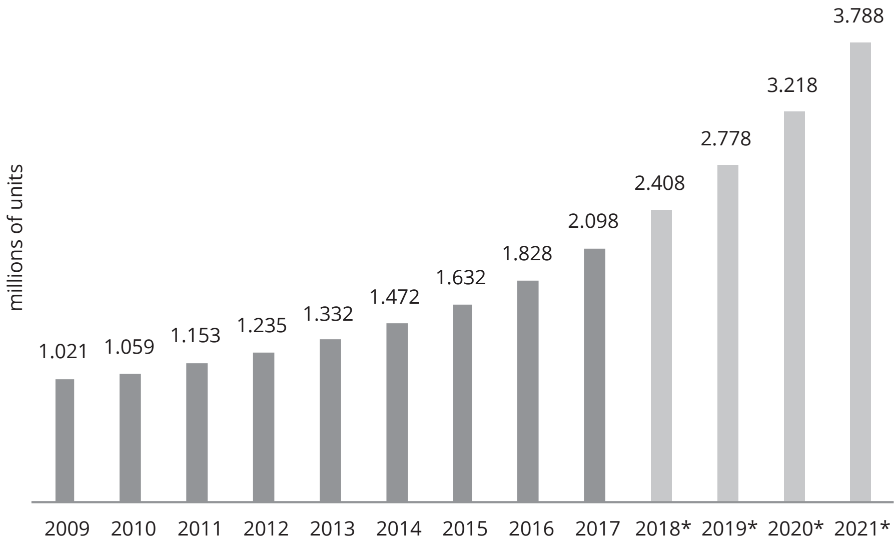
15 E.g., the multinational corporations Rio Tinto and BHP Billiton has established integrated remote operating centers in Perth, Australia, to monitor iron ore mining operations in Pilbara, 1500 km away.

to perform additional autonomous functions such as inspecting, transporting, and data acquisition [https://www.robotyka.com/teoria.php/teoria.53].

Personal robots are all kind of service robots for household applications (e.g. cleaning devices) and assisting robots (for disabled persons).

The use of robots in industrial production has been growing continuously. According to the data published by the International Federation of Robotics, in 2017 the number of industrial robots employed in the world exceeded 2 million. Estimates for 2021 expect the robot resources to nearly double, to 3.8 million units (Figure 3.3).

Figure 3.3 Industrial robots used in industrial production in the world



Note: * – forecast

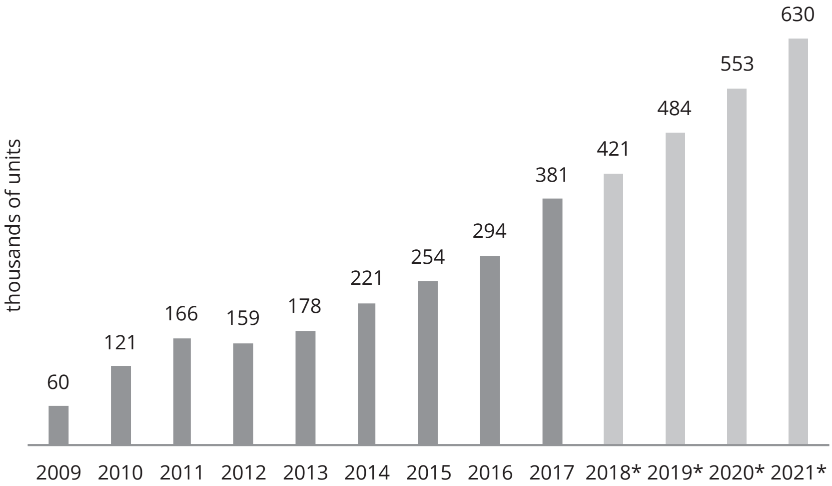
Source: IFR, 2018a

The reasons for the employment of robots in production may include: 1) robots can ensure higher precision and lower cost of manufacturing certain products; 2) work in certain locations is too dangerous for people, 3) in highly-developed countries, robots allow production to be maintained by increasing its efficiency (e.g. in the shipbuilding industry).

Industrial robot sales have been growing fast. In 2017, more than 380,000 were sold, 30% more than a year before (Figure 3.4). 2021 forecasts provide for 630,000 sold units.

The value of sales of industrial robots in 2017 reached US$16.2 bn, 21% more than in the previous year. The data does not include the costs of software, peripherals and system engineering. If included, they can increase the market value of robotic systems approximately three times, to about US$48 bn [IFR, 2018a].

Figure 3.4 Sales of industrial robots in the world

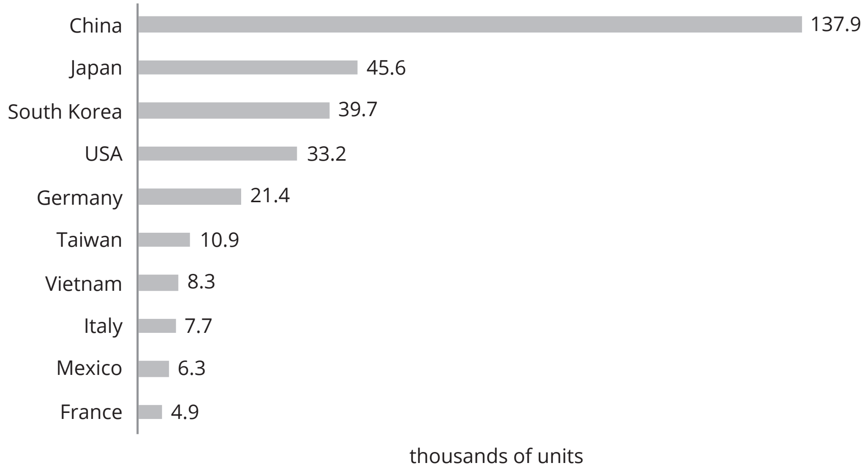


Note: * – forecast
Source: IFR, 2018a

China plays a special role in the industrial robots market. The development of robotics is one of key areas in the Chinese government's plan "Made in China 2025", and hence it is covered by a system of state incentives which encourage both domestic and international manufacturers to use industrial robots. In 2017, in China alone, about 138,000 industrial robots were sold (which represented 36% of the global robot sales) (Figure 3.5). This number significantly exceeds the total sales of robots in Europe and the Americas (about 112,000 units). Ranking next, after China, are also Asian states – Japan and South Korea – where the main drivers of the use of robots in manufacturing in the recent years have been the electrical/electronic and automotive industries.

Comparisons of absolute figures do not take into account the size of countries. Therefore, relative metrics are a better indicator to evaluate the use of robots in the economies of individual states. One of them is the number of robots per 10,000 employees. The average value in the manufacturing industry is 85. In 2017, the value was 106 in Europe and 76 in Asia. It is the highest in South Korea (710), followed by Singapore (658). Ranking next, yet far behind the list leaders, are Germany (322) and Japan (308). China has only 97 robots per 10,000 employees in the manufacturing industry. Higher ratios are achieved in the automotive industry. For example, in 2017, in South Korea, there were 2435 robots per 10,000 employees.

Figure 3.5 Ten largest sales markets for industrial robots, 2017



Source: IFR, 2018a

The industry with the highest use of industrial robots today is the automotive industry, which accounts for approx. 33% of global sales. Almost as much sales volume of robots is recorded in the electronic/electrical industry, driven by the growing demand for electronic products and new products, the need for automation of production and the increasing demand for batteries, chips and displays.

Utilization of service robots has been growing continuously. They are used increasingly widely in agriculture, medicine, logistics, rescue services, and environmental monitoring. In 2017, more than 109,000 service robots were sold (85% more than in 2016). The value of sales increase by 39% to US$6.6 bn, which results from a decline in sales of high-cost defensive robots. Overall, 395,000 service robots have been sold since 1998, but it is not clear how many of them are still in use. Service robots used in logistics (IFRb) represented the largest share, i.e. 63% of the number of installed units and 36% of the total sales value in 2017.

According to Eurostat, robots are used by a relatively small proportion of all enterprises. In the EU28, it is 7% of enterprises on average (both industrial and service robots). Higher ratios are achieved in large companies (Table 3.3). In the EU28, an average of 25% of such firms use industrial or service robots. High ratios above 30% prevail in many “new” member states, such as Slovakia (mainly due to the automotive industry), Croatia (which is largely attributable to service robots), Bulgaria,but also in Spain and Sweden which represent the “old” EU states.

Table 3.3 Utilization of industrial and service robots in large enterprises (without financial sector) in EU28, 2018, in %

	Industrial robots	Service robots	Industrial or service robots
Austria	:	:	:
Belgium	15	4	18
Bulgaria	30	6	31
Croatia	25	16	33
Cyprus	20	10	25
Czech Republic	17	6	19
Denmark	:	:	:
Estonia	7	3	9
EU28	21	9	25
Finland	22	9	26
France	22	12	27
Germany	:	:	:
Greece	18	16	26
Hungary	3	0	3
Ireland	:	:	:
Italy	14	7	18
Latvia	:	:	:
Lithuania	24	6	25
Luxembourg	8	5	13
Malta	16	5	18
Netherlands	27	10	30
Poland	20	5	22
Portugal	18	10	23
Romania	13	4	14
Slovakia	32	8	34
Slovenia	24	10	29
Spain	28	13	34
Sweden	27	12	32
United Kingdom	:	:	:

Note: : No data available

Source: Own study based on Eurostat data: 3D printing and robotics [isoc_eb_p3d]

The use of robots in production is changing conditions in the labor market, both in highly-developed and developing countries. Unskilled workers will be more easily replaced by robots, which can potentially prevent the transfer of industrial production to developing countries and even trigger the process of bringing it back to developed countries (the so-called "boomerang effect"). The occupations listed most often in various reports as the most endangered ones include call center employees, data/text inputters, employees of accounting offices, assembly line and sorting plant workers (Gajewski, Paprocki, Pieriegud, ed., 2016, p. 25]. Working in a factory that employs robots will require completely different, high skills – it will be more a job for designers, engineers, IT specialists, logisticians, marketing employees than for production floor workers. At the same time, an estimated one million operating industrial robots were directly responsible for the creation of nearly 3 million jobs (Budnikowski 2016, pp. 24–25; The Economist, 2012].

Conclusions

The digitalization of the world economy has been changing the conditions of doing business, reducing the significance of labor costs in the total production costs. With both 3D printing and robotization, as well as the ability to effectively analyze huge data sets, significant shifts can be expected in future on the global map of production and trade centers. Countries currently struggling with trade deficit, for which imports of industrial products from Asian developing countries are responsible, can improve their position without imposing trade barriers. This will foster both investment in the development of modern machines, robots, etc., and, to no lesser extent, a constant improvement of human capital. Backshoring industrial production e.g. to the United States will not mean that low-skilled factory floor workers will regain their jobs. There will be jobs, but for completely different groups of people. This poses a threat to many developing countries that have become part of global value chains, often in the role of assembly plants. Many of them will no longer be able to perform this role in the future. However, history and experience suggest that economies have a high ability to adapt to changing conditions, also to the mechanization of production.

Bibliography

Adams, S., [2018], *Half million 3D printers sold in 2017 – on track for 100M sold in 2030*, https://3dprintingindustry.com/news/half-million-3d-printers-sold-2017-track-100m-sold-2030-131642/

Astor [2016], *Przemysł 4.0. Rewolucja już tu jest. Co o niej wiesz?*, Astor Whitepaper, https://www.astor.com.pl/images/Industry_4-0_Przemysl_4-0/ASTOR_przemysl4_whitepaper.pdf

Baldwin, R. [2011], *Trade and industrialisation after globalisation's 2nd unbundling: How building and joining a supply chain are different and why it matters*, NBER Working Paper Series, No. 17716, DOI: 10.3386/w17716

Budnikowski, A. [2016], *Ekonomia międzynarodowa*, PWE, Warsaw.

Deloitte [2016], *Rynek desktopowych drukarek 3D czeka błyskawiczny wzrost,* https://www2.deloitte.com/pl/pl/pages/press-releases/articles/rynek-desktopowych-drukarek-3d.html

Gajewski, J., Paprocki, W., Pieriegud, J. [eds.] [2016], *Cyfryzacja gospodarki i społeczeństwa. Szanse i wyzwania dla sektorów infrastrukturalnych,* Instytut Badań nad Gospodarką Rynkową, Gdańsk.

Geodecki, T., Grodzicki, M.J. [2015], *Jak awansować w światowej lidze gospodarczej? Kraje Europy Środkowo-Wschodniej w globalnych łańcuchach wartości*, "Zarządzanie Publiczne", No. 3 [33].

PKN Orlen [2017], *Gospodarka 4.0. Czas zmiany dla biznesu*, PKN Orlen, Warsaw

History of The Industrial Revolution, 2019, http://www.historydiscussion.net/history/industrial-revolution/history-of-the-industrial-revolution/1784

https://fundacjabirn.pl/projekty/projekt-biodrukowanie-3d-bionicznej-trzustki/

https://wiadomosci.onet.pl/kraj/pierwsza-na-swiecie-bioniczna-trzustka-polacy-wydrukowali-narzad-na-drukarce-3d/1d5ls5c

https://www.robotyka.com/teoria.php/teoria.53

IFR [2018a], *Executive Summary World Robotics 2018 Industrial Robots*, https://www.ifr.org/downloads/press2018/Executive_Summary_WR_2018_Industrial_Robots.pdf

ING [2018], *3D printing: a threat to global trade*, https://www.ingwb.com/media/2088633/3d-printing-report-031017.pdf

IRF [2018b], *Executive Summary World Robotics 2018 Service Robots*, https://www.ifr.org/downloads/press2018/Executive_Summary_WR_Service_Robots_2018.pdf

Koloch, G.,, Grobelna, K., Zakrzewska-Szlichtyng, K., Kamiński, B., Kaszyński, D. [2017], *Intensywność wykorzystania danych w gospodarce a jej rozwój. Analiza diagnostyczna,* https://mc.bip.gov.pl/rok-2017/analiza-diagnostyczna-intesywnosc-wykorzystania-danych-w-gospodarce-a-jej-rozwoj.html

McKinsey [2016], *The age of analytics: Competing in a data-driven world*, https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/the-age-of-analytics-competing-in-a-data-driven-world

Ministerstwo Cyfryzacji [2018], *Przemysł +. Gospodarka oparta o dane*, https://www.gov.pl/web/cyfryzacja/gospodarka-oparta-o-dane-przemysl-

Persson, K.G., Sharp, P. [2015], *An Economic History of Europe. Knowledge, Institutions and Growth, 600 to the Present*, 2nd Edition, Cambridge University Press, Cambridge

Przychodniak, M. [2019], *Case study: 3DGence optymalizuje proces produkcji defibrylatorów oraz kardiomonitorów*, http://centrumdruku3d.pl/case-study-3dgence-optymalizuje-proces-produkcji-defibrylatorow-oraz-kardiomonitorow/

PwC [2017], *Przemysł 4.0 czyli wyzwania współczesnej produkcji,* https://www.pwc.pl/pl/pdf/przemysl-4–0-raport.pdf

Ślusarczyk, P. [2015], *Encyklopedia druku 3D*, http://centrumdruku3d.pl/encyklopedia--druku-3d/

Ślusarczyk, P. [2017], *CONTEXT publikuje wyniki sprzedaży najlepszych producentów drukarek 3D za pierwsze półrocze 2017 r.*, http://centrumdruku3d.pl/context-publikuje-wyniki-sprzedazy-najlepszych-producentow-drukarek-3d-pierwsze-polrocze-2017-r/

The Economist [2012], *A Third Industrial Revolution. Special Report*, http://www.economist.com/node/21552901

UNCTAD [2013], *World Investment Report. Global value chains: investment and trade for development*, Geneva.

UNECE [2013], *Classification of Types of Big Data*, https://statswiki.unece.org/display/bigdata/Classification+of+Types+of+Big+Data

WTO [2013], *World Trade Report 2013. Factors shaping the future of world trade*, Geneva, https://www.wto.org/english/res_e/publications_e/wtr13_e.htm

Part II

Competitiveness of the Polish Economy in 2010–2018 in the Face of Industry 4.0

Chapter 4

Development of the Polish Economy in 2010–2018 Compared with Other EU Countries

Ryszard Rapacki, Mariusz Próchniak

Introduction

The purpose of the chapter is to assess the economic performance of Poland in 2010–2018, with special emphasis on the real or income convergence processes in relation to more economically developed EU member states (EU15). The analysis also provides an overview of Poland's competitive position on the basis of five commonly used macroeconomic indicators of the state of the economy, that is: the economic growth rate, unemployment rate, inflation rate, general government balance, and current account balance.

4.1 International Background – Development Tendencies in World Economy

Before moving on to the principal part of our analysis aimed at the comparative assessment of Poland's economic performance in 2010–2018, we will first outline the most important development trends in the global economy during the same period.

According to preliminary, still partly estimated data provided in Table 4.1, the global gross national product increased in 2018 by 3.1%, i.e. a little faster than in 2015–2016, and faster than the medium-term trend reported in 2010–2013.

Maintaining a relatively high development dynamics of the world economy at the 2017 level resulted mainly – as was the case during the whole period under analysis – from the fast economic growth in developing countries, where GDP increased by 4.4%. Against this background, economic growth rates in Southeast Asia were particularly high (5,8%), including especially India (7.4%) and China (6,6%). The overall improvement of the economic situation in the world was also influenced by the growth rates in the developed economies, which were better than in the previous years (GDP growth of

2.2%). A significant acceleration of economic growth (but from a low base) also took place in transition economies (excluding the new EU member states from the CEE region), including Russia. On the other hand, despite the end of the economic recession in Latin America, the growth rates achieved on that continent meant – in relative terms – a negative contribution to the global development dynamics last year.

Table 4.1 Economic growth in the world in 2010–2018 (growth rate in %)

Years	2010–2014 (annual average)	2015	2016	2017	2018[a]
Worldb	2.7[d]	2.8	2.5	3.1	3.1
Developed economies	1.7	2.3	1.7	2.2	2.2
Euro area	0.8	2.1	1.9	2.4	2.0
USA	2.1	2.9	1.6	2.2	2.8
Japan	1.6	1.4	1.0	1.7	1.0
Transition economies	3.2	–2.2	0.4	2.0	2.1
Russia	3.0	–2.8	–0.1	1.5	1.5
Developing economies, of which: least developed countries	5.7 5.3	4.1 3.7	3.9 3.6	4.5 4.6	4.4 5.0
Africa[c]	4.4	3.1	1.7	3.1	3.1
Southeast Asia	7.0	5.8	6.1	6.1	5.8
China	8.6	6.9	6.7	6.9	6.6
India	7.2	8.2	7.1	6.7	7.4
Latin America	3.5	–0.1	–1.3	1.0	1.0

[a] Preliminary data. [b] At current market exchange rates. [c] Excluding Libya. [d] 2012–2014.
Growth rates for groups of countries have been calculated as the weighted average of GDP growth rates of individual countries. Weights based on 2012 prices and exchange rates.
Source: United Nations (2019), *World Economic Situation and Prospects 2019*, New York 2019.

4.2 The Size of the Polish Economy

The analysis of the economic performance achieved by Poland in 2018 and its international competitive position will begin with the presentation of a brief assessment of the economic potential of Poland against the background of the world economy, as well as Poland's position in this respect in the European Union.[1]

The basic measure of the size of an economy is the value of the gross domestic product (GDP) generated in a given country in a particular year. Despite its many

[1] The content of this and successive sub-chapters refers to the earlier editions of the Report (see e.g. Matkowski, Rapacki, Próchniak, 2016a). In this edition, the 2018 data has been updated and some content has been abridged due to volume constraints.

shortcomings and limitations, it is still the broadest measure of economic activity, widely used in macroeconomic analyses. For international comparisons, the GDP values of individual countries denominated in national currencies are converted into international currency (e.g. US dollars or euros) using current market exchange rates (CERs) or conventional conversion factors called purchasing power parities (PPPs). The GDP value calculated at PPP is believed to better reflect the real value of output produced in a given country, as it takes into account the differences in prices of goods and services in local markets. It is also less susceptible to the impact of exchange rate fluctuations. For this reason, this metric is used more often in broad international comparisons. On the other hand, the currency converters used to calculate GDP at PPP are inaccurate and often inflate the value of GDP for less developed countries compared to the GDP value of more developed countries (the same reservation applies to GDP per capita). In our assessments, the values of total GDP and GDP per capita will be provided based on both of these approaches: converted into international currency at CER and at PPP, so as to ensure more comprehensive comparisons.

According to the IMF's preliminary estimates (IMF, 2019), in 2018, Poland's GDP calculated at CER amounted to US$549.5 bn, but the GDP value calculated at PPP was more than twice as high (US$1201.9 bn). In terms of GDP value, both at CER and at PPP, Poland ranked 23 rd among the world's largest economies (between Sweden and Belgium and between Taiwan and Nigeria, respectively).[2] Compared with the previous year, Poland's position in the PPP and CER-based global rankings of economies improved by one position owing to a relatively fast growth of Poland when benchmarked against other developing economies. Yet Poland's share in the global value of output has not changed, as it still stands at 0.6% at CER and 0.9% at PPP. This indicator, reflecting Poland's position in the global economy, has remained relatively stable for many years, while the exact position of Poland in the world ranking of economies by GDP size changes every year due to cyclical fluctuations in output, changes in inflation rates and exchange rates, as well as some adjustments of GDP data and currency conversion factors.

Let us now look at the data showing Poland's position in the European Union's economy (EU-28). Table 4.2 presents data on the GDP value of the individual EU member states in 2018, expressed in EUR at current market exchange rates (CERs) and at purchasing power parity (PPP). All the GDP data for 2018 are based on preliminary estimates published by the European Commission in October 2018

2 The CER-based ranking covers 193 countries. The top three positions are taken by the USA, China and Japan, while the bottom three (in descending order) are held by Kiribati, Nauru and Tuvalu. The PPP-based ranking covers 193 countries. The top three slots are held by China, the USA and India, while the bottom three (in descending order) are the Marshall Islands, Nauru and Tuvalu.

(European Commission, 2018), which may be subject to change. The ranking of the EU member states' economies provided in the table has been drawn up in accordance with the CER-measured GDP value; the positions of individual countries in the alternative ranking based on the PPP-measured GDP value are shown in brackets.

The European Union is currently composed of 28 countries with highly diverse sizes and economic potential. The five largest countries in terms of population and production volume – Germany, the UK, France, Italy and Spain – represent 63% of the total population of the EU-28 countries and produce 70% of the total GDP at CER and 67% at PPP. The 15 countries forming the EU before its enlargement (EU15) represent 80% of the total population and produce 91% of the total GDP at CER and 86% at PPP. In contrast, the 13 new member states that joined the EU in 2004 and 2007 or later, i.e. 11 CEE countries, plus Cyprus and Malta, represent 20% of the total population, but generate only 9% or 14%, respectively, of the Community's total GDP. This huge asymmetry between the old EU and the new member states (more broadly, between Western Europe and Central and Eastern Europe) should be kept in mind when considering Poland's position in the European Union.

Table 4.2 EU28 member states according to GDP value in 2018 (in € bn)

Rank	Country	GDP at CER		GDP at PPP	
		€ bn	% (EU28=100)	€ bn	% (EU28=100)
1 (1)	Germany	3,392.0	21.3	3,148.0	19.8
2 (3)	United Kingdom	2,391.0	15.0	2,138.0	13.4
3 (2)	France	2,352.0	14.8	2,152.0	13.5
4 (4)	Italy	1,767.0	11.1	1,785.0	11.2
5 (5)	Spain	1,213.0	7.6	1,339.0	8.4
6 (7)	Netherlands	773.0	4.9	684.4	4.3
7 (6)	**Poland**	**494.7**	**3.1**	**853.1**	**5.4**
8 (10)	Sweden	467.2	2.9	379.1	2.4
9 (8)	Belgium	455.4	2.9	408.2	2.6
10 (11)	Austria	386.2	2.4	349.2	2.2
11 (13)	Ireland	322.5	2.0	286.9	1.8
12 (16)	Denmark	295.2	1.9	221.2	1.4
13 (18)	Finland	232.4	1.5	187.5	1.2
14 (12)	Czech Republic	206.0	1.3	291.8	1.8
15 (9)	Romania	203.4	1.3	385.9	2.4
16 (14)	Portugal	201.6	1.3	247.1	1.6
17 (15)	Greece	184.9	1.2	226.2	1.4
18 (17)	Hungary	130.0	0.8	212.0	1.3

Rank	Country	GDP at CER		GDP at PPP	
		€ bn	% (EU28=100)	€ bn	% (EU28=100)
19 (19)	Slovakia	90.5	0.6	131.4	0.8
20 (24)	Luxembourg	58.1	0.4	47.1	0.3
21 (20)	Bulgaria	54.9	0.3	112.3	0.7
22 (21)	Croatia	51.9	0.3	79.4	0.5
23 (23)	Slovenia	45.9	0.3	55.0	0.3
24 (22)	Lithuania	44.8	0.3	69.6	0.4
25 (25)	Latvia	29.2	0.2	41.3	0.3
26 (26)	Estonia	25.5	0.2	32.7	0.2
27 (27)	Cyprus	20.8	0.1	23.1	0.1
28 (28)	Malta	12.0	0.1	14.3	0.1
	EU28	15,901.0	100.0	15,901.0	100.0
	EU15	14,492.0	91.1	13,599.0	85.5

Note: The 2018 GDP data are the European Commission's preliminary estimates. The country's position shown in the first column corresponds to the value of GDP at CER and PPP (in brackets). Contributions to total EU28 GDP have been calculated by the author.

Source: European Commission (2018).

Poland is the largest new member state of the European Union, both in terms of its territory and population, and its GDP size. In the enlarged European Union (EU28), Poland ranks sixth in terms of territory and population (7.1% and 7.4%, respectively). Poland also ranks sixth in the EU28 in terms of GDP at PPP (5.4%), while in terms of GDP at CER it holds the seventh position (3.1%). As can be seen, Poland's contribution to the economic potential of the EU28 is much lower than might be suggested by the size of its territory and population. However, this should not come as a surprise in light of historical experience (a similar disparity is witnessed in all CEE countries).

It is worth noting that Poland's position in the European economy has improved significantly since joining the EU. Its contribution to the total GDP of all the current EU member states measured at CER increased from 1.9% in 2004 to 2.8% in 2010 and 3.1% in 2018. Similarly, Poland's contribution to the total EU28 GDP at PPP increased from 3.6% in 2004 to 4.7% in 2010 and 5.4% in 2018.

4.3 Economic Growth and Real Convergence

The previous year saw a further increase in the dynamics of economic activity in Poland. The GDP growth rate was slightly higher than a year earlier and nearly 2 percentage points higher than the average throughout the systemic transformation period. It was also the highest among the new EU member states from Central and Eastern Europe (CEE11 or, alternatively, EU11). This has not, however, fundamentally changed the existing development trends in either temporal or spatial terms. In 1990–2018, the average annual GDP growth rate in Poland was the highest in this group of countries and almost three times as high as a similar average rate in the "old" EU15 countries. Similar trends were witnessed in the development trajectories of Poland and the two reference groups in 2004–2018, i.e. after Poland's accession to the EU. The situation changed slightly in this respect in 2010–2018, i.e. the period under analysis in this Report. The variations of development dynamics decreased significantly during that period, both within the CEE group and between the CEE countries and the EU15 average. At the same time, Poland has lost its leader position to several other CEE11 countries. The respective data is provided in Table 4.3.

Table 4.3 GDP growth in 1990–2018

Country	GDP growth rate (constant prices)				Real GDP level in 2018		
	Average annual growth rate in %	Annual growth rate in %					
	1990–2018	2010	2017	2018[a]	1989 = 100	2004 = 100	2010 = 100
Poland	**3.2**	**3.6**	**4.8**	**5.1**	**246**	**172**	**131**
Bulgaria	0.9	1.3	3.8	3.5	128	153	121
Croatia	0.4	–1.5	2.9	2.8	113	116	109
Czech Republic	1.7	2.3	4.3	3.0	165	144	120
Estonia	2.0	2.3	4.9	3.5	178	144	135
Lithuania	1.0	1.6	4.1	3.4	132	152	133
Latvia	0.9	–3.9	4.6	4.1	129	143	132
Romania	1.6	–2.8	7.3	3.6	157	161	134
Slovakia	2.5	5.0	3.2	4.0	202	169	126
Slovenia	1.8	1.2	4.9	4.3	169	130	115
Hungary	1.6	0.7	4.1	4.3	157	126	122
EU15[b]	1.3	2.1	2.2	1.9	147	118	112

[a] Estimates.
[b] Weighted average.
Historical EBRD data referring to 1989 was also used to calculate the growth rates, based on 1989 = 100

Source: Eurostat (ec.europa.eu/eurostat); European Commission (European Commission, 2018); GUS (2019); own calculations.

In 1990–2018, Poland was the only country in the CEE group to have increased its real GDP level nearly two and a half times (with an index of 246). This means an average annual growth rate (taking into account the 1990–1991 transformation recession) of 3.2%. The only transition country with comparable growth dynamics was Slovakia (2.5% annually).

In the years following Poland's EU accession, its GDP increased by 72% (i.e., at an average annual rate of approx. 4.2%). Just as throughout the systemic transformation period, our country maintained its leader position among the new EU member states in this respect (a similar result was achieved by Slovakia at this time, at 69%). At the same time, Poland significantly outpaced the EU15 countries in terms of development dynamics.

Poland lost its position of economic growth leader in the CEE group during the period under analysis in this study (2010–2018); at the same time, its "growth comparative advantage" also significantly decreased relative to the EU15 (the chain GDP growth indices in the period were 131 and 112, respectively, see Table 4.3). This was mainly attributable to a significant slowdown in Poland's growth – the average annual GDP growth rate in those years was 3.2%, i.e. 1 percentage point less than in 2004–2016, that is after our accession to the EU (4.2%). It cannot be ruled out that the developments described here may be the first harbinger of the secular changes to the hitherto growth trajectories in the EU member states, mentioned in the previous edition of this monograph, and of the deceleration or even reversal of the real convergence process of the Polish economy with the EU15 countries (Matkowski, Próchniak, Rapacki, 2016b).

As a result of the combined impact of the trends presented above, Poland managed to significantly reduce its gap in economic development relative to all the existing EU member states (except for Ireland), as well as all CEE countries in 1990–2018. In this case, the changes in the relative developmental position of the Polish economy were not only a derivative of a faster rate of economic growth, but also a function of diverging demographic trends and diverse directions and pace of change in real exchange rates in individual countries.[3]

The real convergence process in Poland was unfolding at the fastest rate in relation to the United Kingdom, Italy and Greece. In relation to the last-mentioned country, Poland completely closed the gap in 2015, and in the following years overtook Greece in terms of GDP per capita. This marked a historical precedent, as Poland outpaced one of the "old" EU member states. It is not unlikely that this scenario may be repeated in relation to Portugal in the coming years.

[3] While a slight decrease in population was seen in Poland in 1989–2017 (38.446 million compared to 37.973 million, i.e. 1.2%), there was a significant demographic growth of approximately 10.6% in the EU15 (from 369 million to 408 million). Such demographic tendencies indicate greater differences between GDP growth rates per capita: in Poland, this rate was 3.2% per year, while in the EU15 – on average 1.1% annually.

Within the CEE group of new member states, Poland has been the most successful in closing the distance between its level of economic development and that of the richest countries, i.e. Slovenia and the Czech Republic; we have also managed – for the first time since pre-war period – to overtake Hungary.

Table 4.4 Development gap in new EU member states in relation to EU15 in 1989–2018 (GDP per capita at PPP, EU15 = 100)

Country	1989	2004	2010	2017	2018[a]
Poland	**38**	**43**	**57**	**65**	**67**
Bulgaria	47	30	42	47	48
Croatia	51	50	54	57	58
Czech Republic	75	69	76	82	83
Estonia	54	48	69	73	75
Lithuania	55	44	67	73	75
Latvia	52	41	57	63	65
Romania	34	30	49	58	60
Slovakia	59	50	69	71	73
Slovenia	74	75	74	78	80
Hungary	56	55	61	64	65

[a] Estimates.

Source: IMF for 1989 (IMF, 2005); Eurostat for 2004 and 2010; European Commission for 2017–2018 (European Commission, 2018); own calculations.

As shown in Table 1.4, in 2018 Poland's PPP-measured GDP per capita stood at 67% of the EU15 average.[4] This means that between 1989 and 2018 our country narrowed by 29 percentage points the development gap with "old" Union, of which 24 points were gained after its EU entry (i.e. in 2004–2018) This shows, among other things, that the rate of real convergence clearly accelerated in Poland after joining the EU; while it stood at an average of 0.5 percentage points in 1990–2003, it increased fourfold over the 2004–2018 period to almost 2 p.p. annually.

When compared to the other new EU member states from CEE, Poland's results are quite favorable, especially if seen from the perspective of the entire systemic transformation process to date. In 1990–2018, Poland was a definite leader in the process of real convergence with the EU15 countries among the new EU member states. However, our country lost its position after 2004. During the period following the enlargement of the Union, the real convergence process proceeded the fastest

4 It should be noted, however, that, when converted at the current market exchange rate, Poland's GDP represented only 37% of the EU15 average in 2017 (own calculations based on Eurostat data).

in Lithuania (31 percentage points), Romania (30 p.p.) and Estonia (27 p.p.). At the same time, Poland also saw a divergence process in relation to some CEE countries, as our development gap increased after 2004 relative to Estonia and Lithuania, and also Romania edged closer to Poland in terms of development level.

What is more, Poland's pace of catching up with more developed EU15 countries clearly slowed down in 2011–2018. While we narrowed the development gap with the EU15 by 14 percentage points during the first six years of our membership of the Union (2004–2010), during the following eight years our development gap decreased by only 10 p.p.

4.4 Socio-Economic Development and the Standard of Living

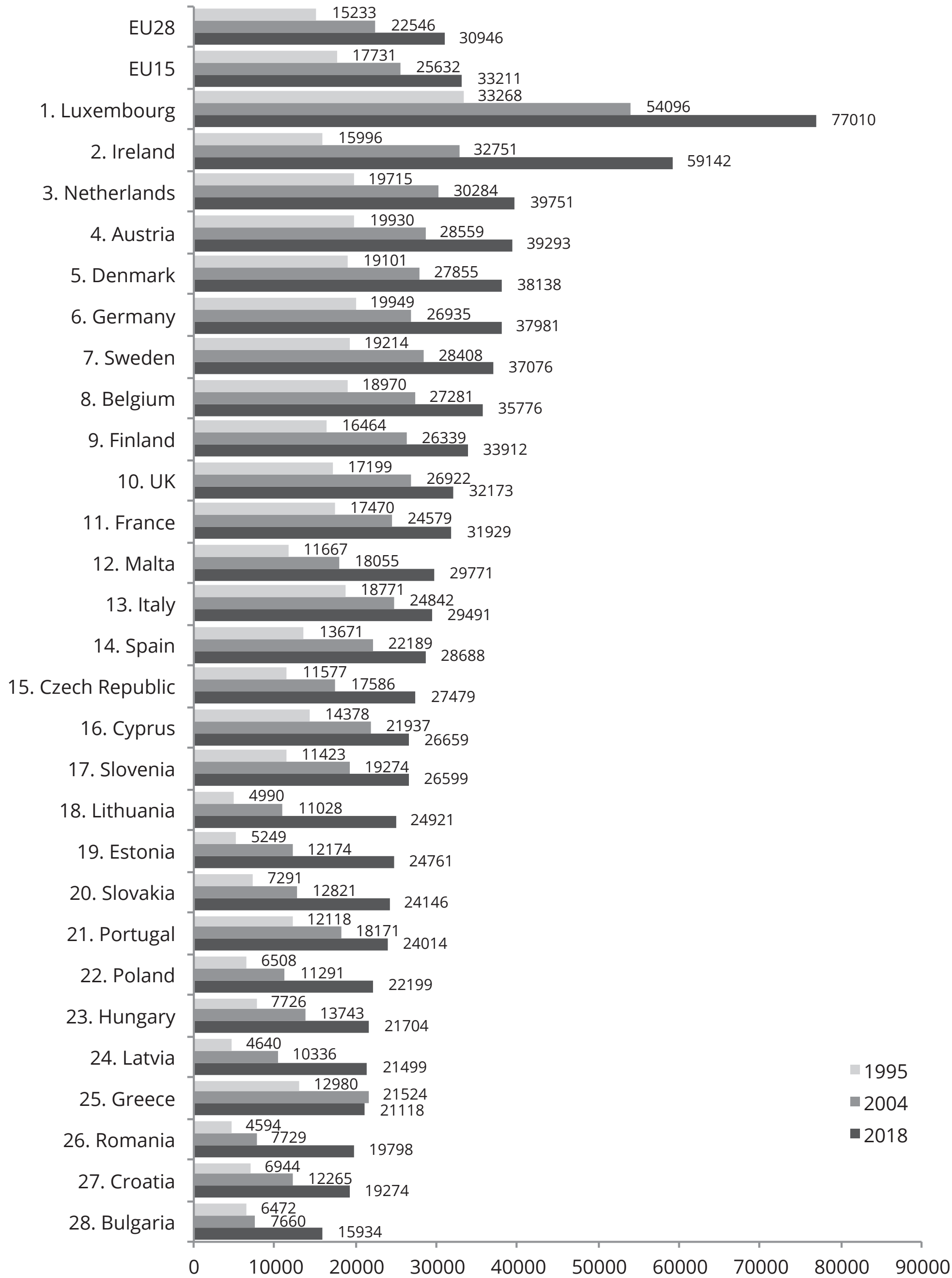
The basic indicator of the level of socio-economic development and standard of living is the gross domestic product per inhabitant. Figure 4.1 shows the ranking of the EU28 countries in terms of GDP per capita at PPP in 2004 and 2018. The chart makes it possible to compare the current level of real income in individual countries and its growth since the mid-1990s, that is, more or less, for the period from the end of the transformation recession in most CEE countries. It also makes it possible to define the dynamics of changes in GDP per capita in the period following the substantial EU enlargement. The GDP per capita data for 2018 are preliminary estimates. For CEE countries, the values of GDP per capita (as well as the values of total GDP) at PPP are much higher than corresponding values calculated at CER.

According to estimated data published by the European Commission (European Commission, 2018) in 2018 the PPP-measured average GDP per capita in the enlarged EU (EU28) amounted to €30,946. In the current euro area (EA19), it amounted to €32,842, and in the countries forming the European Union before its enlargement (EU15) it was €33,211.

The levels of income are highly divergent across the EU member states. The leader in terms of GDP per capita is Luxembourg (€77,010)[5], with Ireland ranking second (€59,142). The following countries also have high income per capita (€31,000 to 40,000): the Netherlands, Austria, Denmark, Germany, Sweden, Belgium, Finland, the United Kingdom and France. Malta, Italy and Spain have slightly lower income per

5 The exceptionally high value of GDP per capita in Luxembourg does not accurately reflect the difference in the standard of living in that country in relation to other Western European countries; this results mainly from the high income earned by international corporations, banks and financial institutions based in that country.

Figure 4.1 Ranking of EU28 countries according to GDP per capita at PPP (in €)



Note: The ranking has been drawn up in accordance with preliminary PPP-measured GDP data for 2018. The GDP per capita data was calculated by dividing the total GDP by the total population (based on European Commission data).

Source: Own calculations based on European Commission data (European Commission, 2018).

capita (between €28,000 and 30,000). Less developed countries of Western Europe, such as Cyprus, Portugal and Greece, have much lower incomes (€21,000–27,000). In Central and Eastern Europe, GDP per capita ranges between €15,934 in Bulgaria and 27,479 in the Czech Republic.

Viewed against this background, Poland's position is not impressive. With the value of GDP per capita at PPP equal to €22,199 in 2018, Poland ranks 22nd, falls within the lower income bracket among the enlarged EU countries, ahead of Hungary, Latvia, Greece, Romania, Croatia and Bulgaria.

Table 4.5 shows the level of economic development of different groups of countries in 2004–2018, measured by the value of GDP per capita at PPP. The table provides data on the European Union member states (EU28), as well as selected other groups, classified mainly according to the geographical criterion. The data contained in Table 4.5 make it possible to find out whether the other groups of countries have moved closer to the EU in terms of development level over the past 15 years, or divergence tendencies occurred instead. Such a comparison is to support the (at least approximate) assessment of the role of the Fourth Industrial Revolution and technological progress.

Table 4.5 The economic development level of the European Union compared with other groups in the world

Group	Number of countries	GDP per capita at purchasing power parity				
		2004	2010	2015	2017	2018
in international dollars (current prices)						
European Union	28	28241	33727	38505	41339	43120
Commonwealth of Independent States	12	10903	15933	18916	19813	20629
Southeast Asia	30	3843	6902	10074	11541	12460
Latin America and Caribbean	33	10243	13516	15662	15871	16287
Middle East and North Africa	21	12045	15301	17674	18542	18961
Sub-Saharan Africa	45	2393	3266	3907	3975	4086
EU28 = 100						
European Union	28	100.0	100.0	100.0	100.0	100.0
Commonwealth of Independent States	12	38.6	47.2	49.1	47.9	47.8
Southeast Asia	30	13.6	20.5	26.2	27.9	28.9
Latin America and Caribbean	33	36.3	40.1	40.7	38.4	37.8
Middle East and North Africa	21	42.7	45.4	45.9	44.9	44.0
Sub-Saharan Africa	45	8.5	9.7	10.1	9.6	9.5

Source: Own calculations based on International Monetary Fund data (IMF, 2019).

Among five groups of countries other than the EU, only two: the Commonwealth of Independent States (CIS) and Southeast Asia have markedly narrowed their development gap with the EU28. The CIS group reduced the income gap from 39% of the EU28 average in 2004 to 48% in 2018 (i.e. by 9 p.p.), and the Asian group narrowed the gap from 14% to 29% (by 15 p.p.). The other three groups (Latin America, Middle East and Africa) have narrowed the gap with the EU28 by only 1–2 p.p. in terms of relative development level, which actually means no real convergence with the EU. This may lead to the conclusion that the development of Industry 4.0 has only slightly leveraged economic growth in the countries of South America and Africa (given that, according to the convergence hypothesis, the countries should achieve a high rate of output growth due merely to the fact that they start from a lower income level than the EU). The Fourth Industrial Revolution, initiated in technologically advanced countries, such as the EU member states, has had a positive impact on the economic development of this group of countries and – among the groups identified in Table 4.5 – Asian countries.

The GDP per capita index used in the above analysis is merely an approximate and indicative measure of living standards. The level depends on many factors, not only economic ones. In the literature, there are a number of measures of the level of socio-economic development alternative to GDP per capita. One of them is the Human Development Index (HDI) published by the United Nations. It is the geometric mean of three indices expressing: Gross National Income (GNI) per capita, life expectancy, and education level, which reflect the three main tiers of social development: a long and healthy life, solid knowledge and a decent standard of living. The index ranges from 0 to 1 (higher values indicating a higher level of development).

According to the 2018 edition of the report (UNDP, 2018), based on 2017 data, the global classification leaders in terms of HDI are: Norway, Switzerland, Australia, Ireland, Germany, Iceland, Hong Kong, Sweden, Singapore, Netherlands, Denmark, Canada, USA, United Kingdom and Finland. Among the CEE countries, the highest rank in this category has Slovenia (25), followed by: Czech Republic (27), Estonia (30), Poland (33), Lithuania (35), Slovakia (38), Latvia (41), Hungary (45), Croatia (46), Bulgaria (51), and Romania (52). In terms of the value of this indicator, Poland ranks slightly above the CEE average (HDI for Poland equals 0.865 against the average of 0.852 for 11 CEE countries), but it ranks only 33 rd in the world, among 189 classified countries. Among the EU countries, Poland holds the 20th position, ahead of Lithuania, Slovakia, Latvia, Portugal, Hungary, Croatia, Bulgaria and Romania. The value of the HDI for Poland is steadily increasing, which testifies to the continuity of socio-economic development. However, Poland's position in the global HDI ranking remains rather weak.

4.5 Comparative Assessment of Macroeconomic Performance

A general assessment of the current condition of the Polish economy will be based on a comparative analysis of five commonly used macroeconomic indicators: a) economic growth rate, b) unemployment rate, c) inflation rate, d) general government balance, e) current account balance. The tool that is used in this analysis is the pentagon of macroeconomic performance.[6]

Table 4.6 Main macroeconomic indicators in Poland and the selected EU countries in 2018

Country	GDP growth	Inflation	Unemployment	General government balance	Current account balance
	%	%	%	% of GDP	% of GDP
Central and Eastern European countries					
Czech Republic	3.1	2.3	2.5	1.5	–0.4
Estonia	3.7	3.0	6.7	–0.5	2.2
Lithuania	3.5	2.5	6.5	0.6	0.3
Latvia	3.7	2.7	7.9	–1.2	–2.0
Poland	**5.1**	**2.0**	**4.1**	**–1.5**	**–0.8**
Slovakia	3.9	2.6	7.5	–0.7	–1.8
Hungary	4.0	2.8	3.9	–2.4	2.3
Western European countries					
France	1.6	1.9	8.8	–2.6	–0.9
Spain	2.7	1.8	15.6	–2.7	1.2
Germany	1.9	1.8	3.5	1.5	8.1
Sweden	2.4	1.9	6.2	1.0	2.6
Italy	1.2	1.3	10.8	–1.7	2.0

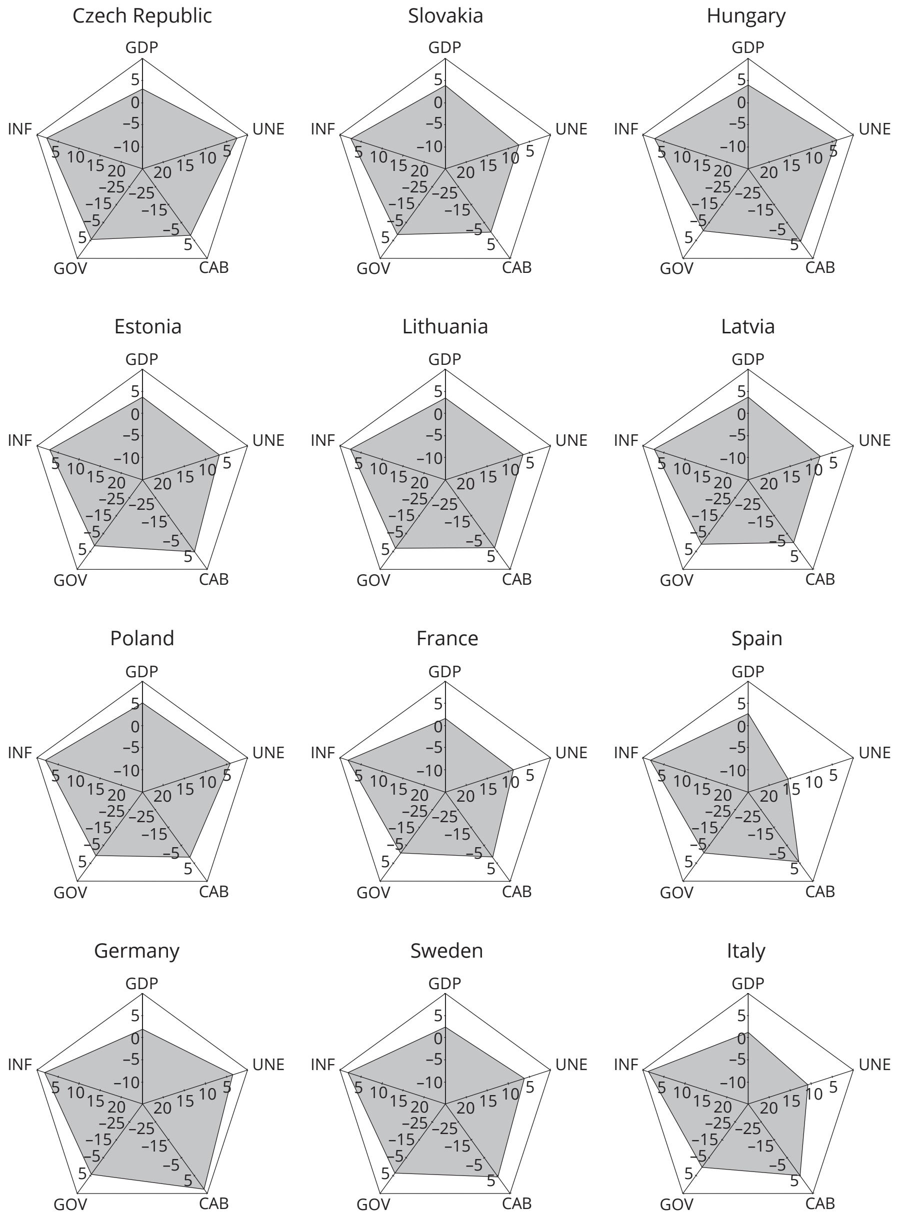
Note: All data are preliminary estimates. The inflation data represent the annual average growth rate of consumer prices. The economic growth rate for Poland is stated according to the latest Polish Central Statistical Office (GUS) data.

Source: IMF (2019), GUS (2019).

The general condition of the Polish economy will be compared with the situation of six other CEE countries: three Visegrad Group member states (the Czech Republic, Slovakia, Hungary) and three Baltic states (Estonia, Latvia, Lithuania), as well as five

[6] The author of the concept of this type of pentagons is Zbigniew Matkowski. A detailed description of the concept of pentagons and their interpretation is provided in previous editions of the report (see e.g. Matkowski, Rapacki, Próchniak, 2016a).

Figure 4.2 Macroeconomic performance of Poland and selected other EU member states in 2018



GDP – GDP growth rate (%)
INF – inflation rate (%)
UNE – unemployment rate (%)
GOV – general government balance (% of GDP)
CAB – current account balance (% of GDP)

Source: Own study based on data from Table 4.6.

Western European countries: Germany, France, Italy, Spain and Sweden. The data concerning five indicators describing the overall macroeconomic performance of Poland and the reference countries in 2018 are provided in Table 4.6. Most of the data are preliminary estimates that may still undergo some changes. Figure 4.2 shows the data in the form of pentagons to facilitate comparative analysis.

An analysis of the pentagons shows that in 2018 the overall condition of the Polish economy was better on average than that of the other six CEE countries. Poland's macroeconomic situation was close to that prevailing in the Czech Republic. Compared with the other CEE countries, Poland's economy performed much better (assuming that the rank of the individual variables is the same). In terms of economic growth, Poland performed the best in 2018 (growth rate of 5.1%), overtaking the other CEE countries analyzed on the pentagons, in which economic growth did not exceed 4.0%. In 2018, inflation in Poland was the lowest among the analyzed seven CEE countries, although in terms of changes in prices the whole group performed well (prices were growing the fastest in Estonia at 3.0% annually). Unemployment in those countries was reduced to a single-digit level. With the unemployment rate of 4.1%, Poland found itself among the group's leaders, after the Czech Republic (2.5%) and Hungary (3.9%). Poland performs relatively the worst in terms of the general government balance and the current account balance, although also in these categories Poland's results are quite decent (government budget deficit equal to 1.5% of GDP and current account deficit of 0.8% of GDP in 2018).

The pentagon representing the general condition of the Polish economy is close in shape to the pentagon drawn for Sweden, but it is slightly smaller in area. The pentagon for Germany also has a larger area than that for Poland (while it is also more irregular), which means that the situation of the German economy was better on average. This concerned all macroeconomic criteria taken into account here, except the economic growth rate.

The overall condition of the Polish economy was much better than that of France, Spain and Italy. The pentagons for these three countries have very small areas and display a high degree of asymmetry. France, Spain and Italy report very poor results in terms of the unemployment rate. In 2018, it reached a double-digit level in Spain and Italy – at 15.6% and 10.8%, respectively. It was also very high in France (8.8%). The economic growth rate of France and Italy was very low (1.6% and 1.2%, respectively); a slightly higher rate was recorded in Spain (2.7%). The government budgets of France and Spain showed a deficit of almost 3% of GDP, the highest among all the countries analyzed in the pentagons.

The pentagons for Western Europe show that the countries of that area performed well in terms of inflation rates and current account balances. In 2018, the inflation rate did not exceed 2% in those countries. Apart from France, four Western European countries achieved a current account surplus (only France recorded a small deficit). The better situation of the Western European countries in terms of current account, compared with Central and Eastern Europe, should not come as a surprise, given the structure and technological advancement of the economies, structure and directions of imports of goods and services, international expansion of their enterprises, and the related factor income flows between a given country and abroad.

Compared with the previous year, the overall condition of the Polish economy was better in 2018, taking into account the five macroeconomic indicators considered here (IMF, 2019; GUS, 2019). The GDP growth rate was by 0.3 p.p. higher than in the previous year, and the unemployment rate decrease further (from 4.9% in 2017 to 4.1% in 2018). The budget deficit decreased slightly (from 1.7% to 1.5% of GDP), the current account balance moved from surplus to a small deficit, whereas the inflation rate did not change.

To sum up, in terms of the five main macroeconomic indicators characterizing the general performance of the economy, Poland's results in 2018 were relatively good in the context of the overall economic situation in Europe, as was also the case in the previous year.

Bibliography

European Commission [2018], *Statistical Annex of European Economy*, Autumn 2018, ec.europa.eu.

Eurostat [ec.europa.eu/eurostat].

GUS [2019], *Biuletyn statystyczny*, No. 01/2019.

IMF [2005], *World Economic Outlook Database*, September.

IMF [2019], *World Economic Outlook Database*, October 2018 (updated January 2019), www.imf.org, accessed 18.02.2019.

Matkowski Z., Rapacki R., Próchniak M. [2016a], *Comparative Economic Performance: Poland and the European Union*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2016. The Role of Economic Policy and Institutions*, World Economy Research Institute, SGH Warsaw School of Economics, Warsaw, pp. 11–35.

Matkowski Z., Próchniak M., Rapacki R. [2016b], *Income Convergence in Poland vis-à-vis the EU: Major Trends and Prospects*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2016. The Role of Economic Policy and Institutions*, World Economy Research Institute, SGH Warsaw School of Economics, Warsaw, pp. 37–55.

UNDP [2018], *Human Development Indices and Indicators*: *2018 Statistical Update*, United Nations Development Programme, hdr.undp.org.

United Nations [2019], *World Economic Situation and Prospects 2019*, New York 2019.

Chapter 5

Income Convergence of Poland to the Average EU Level

Mariusz Próchniak

Introduction

The purpose of this chapter is to analyze the income convergence of 11 Central and Eastern European countries that joined the European Union in 2004, 2007 and 2013, i.e., Poland, Bulgaria, Croatia, the Czech Republic, Estonia, Lithuania, Latvia, Romania, Slovakia, Slovenia and Hungary (EU-11). The development trajectories of these countries are analyzed in relation to the former 15 EU member states (EU-15). The study is a continuation of research on this subject, presented in previous versions of the *Report* [see, e.g., Matkowski, Próchniak, Rapacki, 2016a; Próchniak, 2017, 2018]. The 2013 edition of the report also includes an analysis of regional convergence covering the regions of all the EU countries [Matkowski and Próchniak, 2013].

5.1 Theoretical Basis of the Convergence Analysis

Models of economic growth constitute the theoretical framework for the analysis of convergence in the level of income. Neoclassical models of economic growth [e.g., Solow, 1956; Mankiw, Romer, Weil, 1992] confirm the existence of conditional β-convergence. It occurs when less developed countries (with lower GDP per capita) show a faster rate of economic growth than more developed ones. The convergence is conditional because it only occurs when all countries tend to the same long-term equilibrium (steady state). The β convergence hypothesis can be explained using the Solow model [see, e.g., Rapacki, Próchniak, 2012; Próchniak, Witkowski, 2012].

In the Solow model, the basic equation describing the dynamics of the economy tending to a steady state takes the following form:

$$\dot{k} = sf(k) - (n + a + \delta)k, \tag{2.1}$$

where: k – capital per unit of effective labor in year t, $\dot{k}$ – change of k in a time unit (from a mathematical point of view, it is a derivative of k with respect to time), s – savings rate, $f(k)$ – production function (expressed per unit of effective labor), n – population growth rate, a – rate of exogenous technical progress, δ – capital depreciation rate. In the analysis of the Solow model with technical progress, the symbols k and $f(k)$ mean, respectively, capital and output per unit of effective labor, where effective labor is a product of the level of technology and labor input.

If we assume that the production function is of the Cobb-Douglas type with the form $f(k) = k^{\alpha}(0 < \alpha < 1)$, equation (2.1) is transformed to

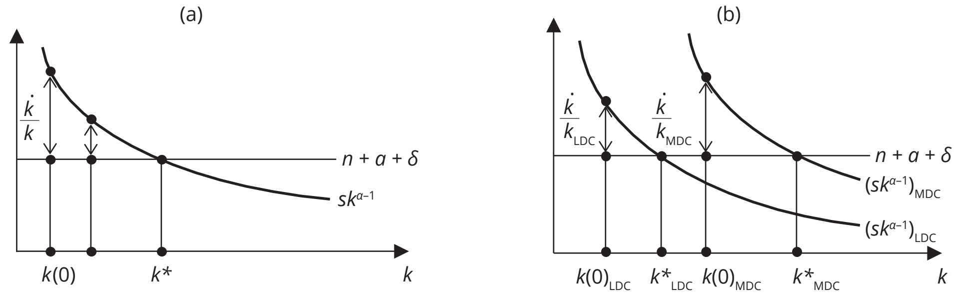
$$\dot{k} = sk^{\alpha} - (n + a + \delta)k. \tag{2.2}$$

By dividing equation (2.2) by k, we obtain a formula for the growth rate of capital per unit of effective labor during the transition period towards the steady state:

$$\frac{\dot{k}}{k} = sk^{\alpha-1} - (n + a + \delta). \tag{2.3}$$

As output is directly proportional to capital, the analogous equation characterizes the dynamics of GDP per unit of effective labor.

Figure 5.1. Economic growth in the Solow model



Source: Own study.

The best way to illustrate the convergence hypothesis is to graphically analyze equation (2.3). This is shown in Figure 5.1. The rate of growth is equal to the vertical distance between the $sk^{\alpha-1}$ curve and the $n + a + \delta$ straight line. As can be seen, the economy, which starts with the initial capital level $k(0)$ and reaches the capital level in long-term equilibrium k^*, shows a decreasing rate of economic growth. The convergence is conditional because it occurs only when both economies tend to the same steady-state.

In order to illustrate the conditional character of the convergence phenomenon, let us consider two countries: a more developed country (MDC) and a less developed country (LDC), in which the savings rates are different. Because the savings rate in a more developed country is higher, the capital level in a steady-state is also greater. This is illustrated in part (b) of Figure 5.1. Although a more developed country is starting from a higher capital level, it shows faster economic growth because it is moving toward a different long-term equilibrium. In this situation, convergence will not occur.

An important goal of empirical research is to estimate the value of parameter β, which measures the speed of the convergence process to a steady state, according to the following equation:

$$\frac{\dot{y}}{y} = \beta\left(\ln y^* - \ln y\right), \tag{2.4}$$

where: y – output per unit of effective labor in year t, $\dot{y}$ – change of y in time unit (derivative with respect to time), y^* – output per unit of effective labor in steady state.

Parameter β represents the distance which is covered by the economy tending towards the steady state during one period (year). For example, if $\beta = 0.02$, the economy covers 2% of the distance concerned each year.

Another type of catching-up is σ-convergence. It occurs when the income differential between countries decreases over time. The income differential can be measured by the standard deviation, variance or coefficient of variation of GDP per capita levels between countries or regions.

From a theoretical perspective, σ-convergence is a necessary but insufficient condition of β-convergence. Therefore, it is possible (though unlikely) that the differences in the level of income between economies will be growing over time and at the same time a less developed country will show a faster rate of economic growth. This will happen when the less developed country reaches such a fast rate of economic growth that it outstrips the more developed country in terms of income level and the differences in the development level in the final period will be higher than in the initial one.

5.2 Method

To verify the occurrence of absolute β-convergence, we estimate the following regression equation:

$$\frac{1}{T}\ln\frac{y_T}{y_0} = \alpha_0 + \alpha_1 \ln y_0 + \varepsilon_t, \tag{2.5}$$

where y_T and y_0 are income per capita in the final and initial year, while ε_t is a random factor. Thus, the average annual growth rate of real GDP per capita at purchasing power parity (PPP) between period T and 0 is the explained variable, while the natural logarithm of GDP per capita in the initial period is the explanatory variable. If the α_1 parameter is negative and statistically significant (in the empirical analysis, we assumed a significance level of 10%), β-convergence exists. In this situation, we can calculate the value of coefficient β, measuring the speed of convergence:[1]

$$\beta = -\frac{1}{T}\ln\left(1+\alpha_1 T\right). \tag{2.6}$$

In order to verify the occurrence of σ-convergence, we estimate the trend line for the disparity of income levels between countries:

$$sd\left(\ln y_t\right) = \alpha_0 + \alpha_1 t + \varepsilon_t, \tag{2.7}$$

where sd is the standard deviation, while t – time (t = 1,…, 26 for the period 1993–2018). Thus, the explained variable is the standard deviation of natural logarithms of GDP per capita levels between countries, while time is the explanatory variable. If the α_1 parameter is negative and statistically significant, σ-convergence exists.

5.3 Empirical Evidence

The study covers the period 1993–2018. All calculations were also made for three sub-periods: 1993–2000, 2000–2008 and 2008–2018, which allows the temporal stability of the phenomenon examined to be analyzed. It also makes it possible to approximately determine the strength of impact of many other, deeper factors, including digital competitiveness, on the rate of income disparity reduction. If we assume that the effects of digital competitiveness materialize in the final years of the period under

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1 Barro and Sala-i-Martin [2003, p. 467], when analyzing β-convergence based on the neoclassical model, derive an equation showing the relationship between the average rate of economic growth and the initial level of income:

$$\left(1/T\right)\ln\left(y_{iT}/y_{i0}\right) = a - \left[\left(1-e^{-\beta T}\right)/T\right]\ln\left(y_{i0}\right) + w_{i0,T},$$

where y_{iT} and y_{i0} – GDP per capita in country i in the final and initial year, T – time period, β – convergence rate, a – constant, $w_{i0,T}$ – random factor. The coefficient at the initial income level, i.e., $-[(1-e^{-\beta T})/T]$ equals parameter α_1 in formula (2.5). Thus, from the equation $\alpha_1 = -[(1-e^{-\beta T})/T]$ we obtain the formula (2.6). For a small T, estimation of the parameter in regression equation α_1 will be very close to coefficient β, because with T tending to zero the expression $(1-e^{-\beta T})/T$ tends to β.

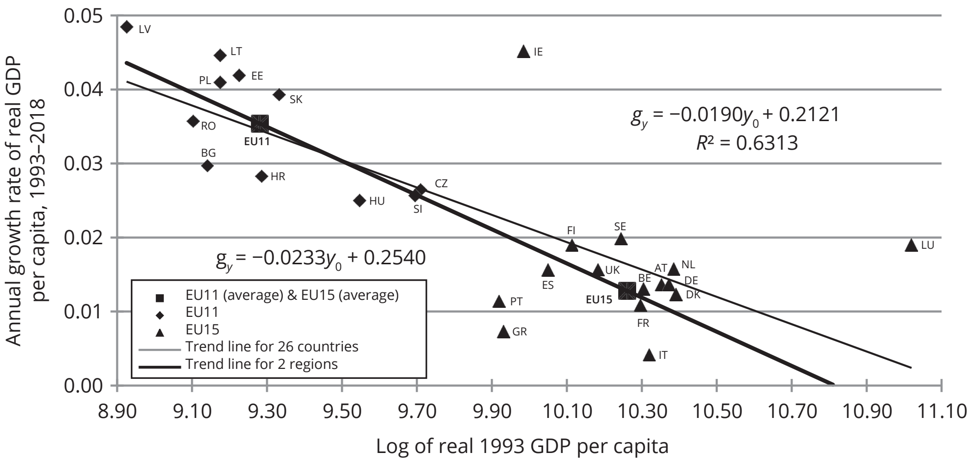
study, it will be possible to partly attribute the acceleration of the catching-up process in the later sub-periods to the impact of digital competitiveness.

Table 5.1 Results of estimation of regression equations describing β-convergence

Time period	α_0	α_1	*t*-stat. (α_0)	*t*-stat. (α_1)	*p*-value (α_0)	*p*-value (α_1)	R^2	β convergence	β
26 countries of enlarged EU									
1993–2018	0.2121	–0.0190	7.23	–6.41	0.000	0.000	0.6313	yes	0.0191
1993–2000	0.0699	–0.0036	1.20	–0.62	0.243	0.543	0.0156	no	-
2000–2008	0.4230	–0.0384	9.32	–8.60	0.000	0.000	0.7549	yes	0.0392
2008–2018	0.1738	–0.0157	2.64	–2.48	0.014	0.020	0.2043	yes	0.0158
2 regions (EU11 and EU15)									
1993–2018	0.2540	–0.0233	.	.	.	.	.	yes	0.0236
1993–2000	0.1418	–0.0113	.	.	.	.	.	yes	0.0113
2000–2008	0.4467	–0.0413	.	.	.	.	.	yes	0.0422
2008–2018	0.3489	–0.0325	.	.	.	.	.	yes	0.0330

Source: Own calculations.

Figure 5.2 Relationship between the GDP per capita growth rate in 1993–2018 and the level of GDP per capita at the beginning of the period



Source: Own calculations.

The calculations use time series of real GDP per capita at purchasing power parity (in US$) obtained from the International Monetary Fund data (IMF, 2018). When converting nominal GDP per capita at purchasing power parity (PPP), in current prices, to real GDP per capita at PPP (constant prices), we used a GDP deflator for the USA.

The results of the β-convergence analysis of the EU-11 to the EU-15 countries are presented in Table 5.1 and Figure 5.2. Convergence is analyzed both between the 26 EU countries and between two regions covering the EU-11 and EU-15 area. Aggregated data for two areas: EU-11 and EU-15 are weighted averages with variable weights reflecting the population number of a given country included in a particular group in a given year.

The results obtained confirm the existence of clear income convergence of the EU-11 to the EU-15 countries throughout the 1993–2018 period. Convergence occurred both among the 26 countries of the group examined and between the two areas, EU-11 and EU-15. Countries with lower income levels in 1993 showed, on average, a faster rate of economic growth in 1993–2018 than countries initially better developed. As the group of less developed countries in 1993 consisted of the Central and Eastern Europe countries, these results confirm the clear convergence of the EU-11 countries to the average level of income in Western Europe.

The analysis of Figure 5.2 shows that the distribution of points representing individual countries fits quite well with the negatively sloped trend line. This results in a relatively high value of the determination coefficient at a level exceeding 60%. Thus, differences in the initial income level account for almost $^2/_3$ of the economic growth rate differential in 1993–2018.

When analyzing the points representing particular countries, the situation of the individual countries can be compared and, in respect to this perspective, the changes in their competitive position over the whole period can be assessed, also with regard to digital competitiveness. The fastest rate of economic growth among the Central and Eastern European countries was recorded in the Baltic states and Poland. Latvia, Lithuania, Estonia and Poland showed economic growth in the years 1993–2018 exceeding 4% annually, with a relatively low initial income level. Slovakia also reported a rate of economic growth of around 4%, but its initial level of income was slightly higher. The performance of those countries strengthened the convergence tendency in the group as a whole. As can be seen, the situation of Poland compared to other countries is favorable. Poland ranked fourth among the 11 countries of Central and Eastern Europe in terms of the average rate of economic growth in 1993–2018, which was one of the factors behind strengthening the competitive position of the Polish economy. Such a fast rate of economic growth in Poland, but also, e.g., in Estonia, is attributable to favorable changes on the supply side, including the effects of digital competitiveness.

Aggregated data for two areas: EU-11 and EU-15 also confirm the existence of convergence in 1993–2018. In Figure 5.2, the points representing these two areas are marked with squares. The EU-11 group as a whole showed faster economic growth than the EU-15 with a much lower initial level of income.

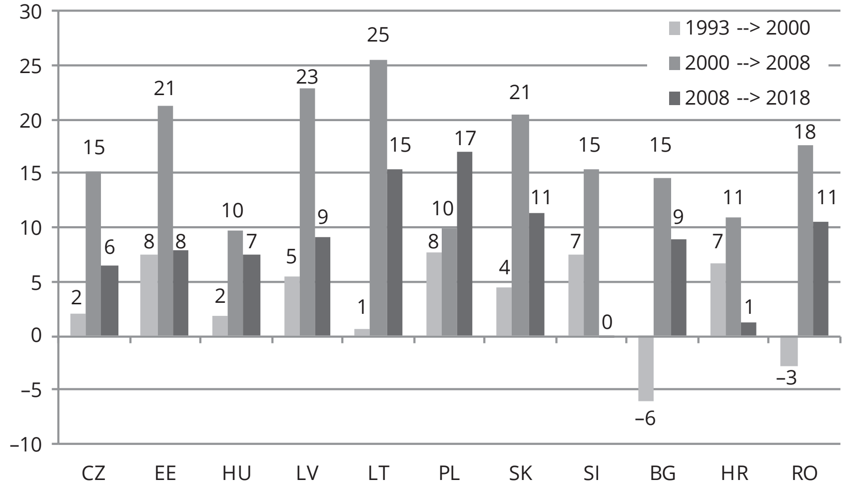
Coefficients β, which measure the speed of the convergence process, amount to 1.91% for the 26 countries and 2.36% for the two areas. They allow the time needed to reduce the development gap between the countries under study to be estimated. Namely, given that the average economic growth rate witnessed over the 1993–2018 period is maintained, the countries of the enlarged EU will need about 30–35 years to halve the distance separating them from the common hypothetical steady state (this result has been calculated as follows: $-\ln(0.5)/0.0191 = 36.3$ years and $-\ln(0.5)/0.0236 = 29.4$ years). The above results show a slow convergence of the EU-11 countries to Western Europe. Based on these estimates, it is difficult to expect a quick equalization of income levels between Poland and other Central and Eastern European countries as well as Western Europe in the medium term.

It is worth looking at the stability of the convergence processes over time. It turns out that in the separate sub-periods the speed of convergence was very diversified. The high instability of the convergence rate in the countries under study was caused, *inter alia*, by the global crisis, as well as a diverse impact of institutional factors on the economic growth, related to the European Union membership, but also, e.g., to digital competitiveness. For the 26 EU countries, in the years 1993–2000, there was no statistically significant reduction in the income gap between the EU-11 and the EU-15 countries (in average terms for the whole group). For the years 1993–2000, the slope of the trend line is negative but not statistically significant. Such estimation results of the model show the actual lack of convergence, despite the negative slope of the trend line. A very strong acceleration of the convergence rate occurred in 2000–2008, which undoubtedly had its source in the EU enlargement. A clear tendency towards convergence during the early years of the first decade of the 21st century was weakened significantly after 2008. This was largely due to the global crisis in that period.

The acceleration of the convergence rate in the 21st century compared with the 1990 s is also an effect of a combination of other factors on the supply side. Beyond any doubt, factors such as digital competitiveness were strong drivers. The technical progress resulting from the Fourth Industrial Revolution has led the transfer of technology to less developed EU countries, which had a positive effect on their economic growth. It can thus be concluded that Industry 4.0 had a positive impact on the equalization of incomes with the EU and, along with many other factors, it led to the reduction of disparities in the development level between the old and new EU member states.

The β-convergence results presented here are averaged values for the entire region. As can be seen in Figure 5.2, individual CEE countries showed different dynamics of economic growth and different degrees of convergence to Western Europe. It is worth analyzing the status of convergence of the particular EU-11 countries relative to the EU-15 in the separated sub-periods.

Figure 5.3 Extent of income gap closing between the EU-11 and the EU-15 countries in three consecutive subperiods[a]



[a] The changes are expressed in percentage points; for each year, the EU-15 GDP per capita at PPP is taken as 100.

Source: Own calculations based on IMF data (IMF, 2019).

Figure 5.3 shows a decrease in income gap (in percentage points) of a given EU-11 country in relation to the EU-15 in the years 1993–2000, 2000–2008 and 2008–2018. The data presented in the figure confirm the conclusions of the β-convergence analysis. Namely, for all the EU-11 countries, except Poland, the fastest closing of the income gap in relation to Western Europe occurred in 2000–2008. For the three Baltic states and Slovakia, the income gap in that period decreased by over 20 p.p., and for the Czech Republic, Slovenia, Bulgaria and Romania – by 15–18 p.p. Poland was the only country that improved its relative level of development the most only in recent years. While in the 1993–2000 and 2000–2008 periods Poland reduced the income gap in relation to Western Europe by 8 and 10 p.p., respectively, in the years 2008–2018 this process accelerated, and Poland managed to reduce the income gap by 17 p.p. It can be expected that in the case of Poland, an important role in accelerating the pace of convergence after the EU enlargement was played by the European funds that increased the competitiveness of Poland's economy. Poland was the largest beneficiary of the EU funds under the 2007–2013 budget. The stream of funding from the EU under various support programs positively influenced the growth of the Polish economy on the demand and supply sides, thanks to which Poland achieved relatively good results in terms of economic growth in recent years (e.g., it was the only EU country that avoided the recession during the last global crisis). The EU budget for 2014–2020, which provides for the continuation of a large inflow of structural funds to the new member states, should be one of the factors conducive to maintaining the pace of Poland's convergence to Western Europe in the coming years.

Poland's fast economic growth is also supposedly driven by the Fourth Industrial Revolution and digital competitiveness. The openness of the economy and the development of the Internet have had a positive impact on the productivity of inputs and ensured the achievement of a fast economic growth in Poland. Importantly, Polish society intensively absorbs new technologies and has a high degree of digitalization.

The positive impact of high technology development on economic growth was also confirmed in the author's another study [Próchniak, Witkowski, 2016]. This study has focused primarily on showing the strong effects of digitalization and internetization on production dynamics. The impact has proved to be the greater the lower a country's initial economic development level. Combined with the results presented here, this means that the acceleration of the rate of real convergence can be party attributed to the impact of digital competitiveness and Industry 4.0.

σ-convergence of the Central and Eastern European countries to Western Europe is measured by changes in the standard deviation of the natural logarithms of GDP per capita between the 26 EU countries, as well as between the two areas, the EU-11 and the EU-15. The results of the trend line estimation for standard deviations are presented in Table 5.2, and Figure 5.4 contains a graphical presentation of the results.

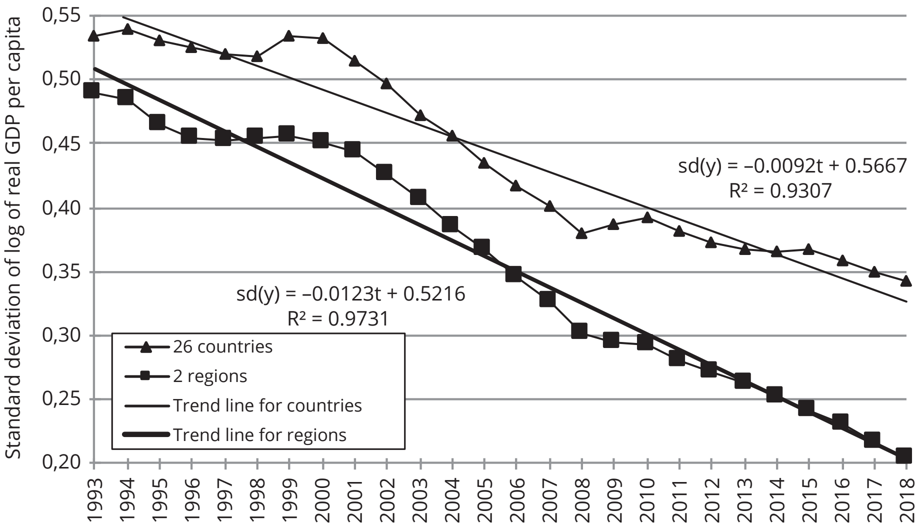
Table 5.2 Results of estimation of regression equations describing σ-convergence

Time period	α_0	α_1	*t*-stat. (α_0)	*t*-stat. (α_1)	*p*-value (α_0)	*p*-value (α_1)	R^2	σ-convergence
26 countries of enlarged EU								
1993–2018	0.5667	–0.0092	71.33	–17.95	0.000	0.000	0.9307	yes
1993–2000	0.5342	–0.0010	92.92	–0.89	0.000	0.407	0.1171	no
2000–2008	0.5519	–0.0192	381.50	–74.53	0.000	0.000	0.9987	yes
2008–2018	0.3954	–0,0043	104.22	–7.74	0.000	0.000	0.8694	yes
2 regions (EU11 and EU15)								
1993–2018	0.5216	–0.0123	81.09	–29.47	0.000	0.000	0.9731	yes
1993–2000	0.4875	–0.0053	71.45	–3.94	0.000	0.008	0.7213	yes
2000–2008	0.4794	–0.0191	142.73	–32.02	0.000	0.000	0.9932	yes
2008–2018	0.3178	–0.0099	125.05	–26.35	0.000	0.000	0.9872	yes

Source: Own calculations.

The data contained in Table 5.2 show that for the whole period there was a σ-convergence both among the 26 EU countries and between the EU-11 and the EU-15. The slopes of both estimated trend lines are negative and statistically significant at very high significance levels (as demonstrated by *p*-values equal to 0.000). High values of determination coefficients (over 90%) show a very good fit of empirical points to the trend line.

Figure 5.4 Standard deviation of GDP per capita in 1993–2018



Source: Own calculations.

Figure 5.4 shows the tendency of standard deviation of log GDP per capita levels. As can be seen, the income differential between the new and the old EU countries showed, in general, a downward trend. The most visible and systematic decrease in income disparities occurred in the second part of the analyzed period, i.e., from 2000 onwards. In 2009 and 2010 – as a result of the economic crisis and declining GDP growth rate in many previously fast developing countries – income disparities among the 26 countries of the group under study increased, although this is not confirmed by the data averaged for the two areas.

5.4 Discussion

There is much empirical research on the phenomenon of convergence, and it is impossible to list all of it here. A detailed review of the latest empirical research includes the article by Matkowski, Próchniak and Rapacki [2016b], while the books by Malaga [2004], Michałek, Siwiński and Socha [2007], Liberda [2009], Batóg [2010] and Jóźwik [2017] are entirely or largely devoted to the phenomenon of convergence in the countries of the European Union or the OECD.

Comparing the results obtained here with the literature, it should be emphasized that in recent years studies suggesting the possibility of divergence in Europe (both at the national and regional level) have been increasingly frequent. For example, Mucha [2012] suggests that for some euro area countries, having a single currency may be a source of many problems and the emergence of economic divergence in relation to other members of the Economic and Monetary Union. Monfort, Cuestas and Ordóñez [2013] analyze the real convergence of GDP per worker in 23 EU countries in 1980–2009 (Western European countries) and 1990–2009 (Central and Eastern European countries), showing that – using the club convergence research techniques – there is a strong case for the existence of per capita income divergence in the EU as a whole; however, for example, the countries of Central and Eastern Europe (excluding the Czech Republic but including Greece) form a group showing convergence. Borsi and Metiu [2013] analyze the real convergence of the 27 EU countries in the years 1970–2010, reaching the conclusion that there is no convergence of per capita income levels in the whole group and that there is convergence in the subgroups of countries that tend to different steady states. Staňisić [2012] analyzes β-convergence in the EU-25 and within two groups of countries: EU-15 and EU-10, confirming the existence of β-convergence in the EU-25 (which means the convergence of the new EU member states to Western Europe) and denying the convergence within the EU-15 and the EU-10. The author of the quoted study also claims that during the recent crisis income disparities between the EU-25 countries increased, but the scale and time range of that increase were limited and did not affect the long-term convergence path, which is a conclusion very similar to the results of our study.

It is clear therefore that the convergence process is not an automatic phenomenon. Despite the strong tendency of decreasing income disparities between Central and Eastern Europe and Western Europe in recent years, there is no guarantee that this situation will persist in the future (as evidenced by the temporal instability of our results and increasingly frequent references in the literature to the possibility of divergence tendencies emerging in Europe). Thus, it is an extremely important task for economic policy-makers to pursue measures to maintain the current long-term trends of economic growth in Europe, characterized by reducing the income differences between the eastern and western areas of our continent.

Summary and Conclusions

In the group of 26 countries of the enlarged European Union, income convergence occurs both in terms of β and σ convergence concepts. The rate of economic growth in 1993–2018 was negatively dependent on the initial level of GDP per capita. The new EU member states from Central and Eastern Europe achieved a faster rate of economic growth than the Western European countries, although the initial level of GDP per capita in the Central and Eastern European countries was much lower. Disparities in the level of income decreased, especially in the years 2000–2008, although they are still very large.

Therefore, a reduction in the differences in competitiveness measured by the standard of living of the societies of the old and the new EU countries cannot be expected unconditionally in the short-term perspective. Acceleration of the convergence process will depend, among other things, on a properly conducted economic policy aimed at reducing differences in the level of development between Central and Eastern Europe and Western Europe.

Bibliography

Barro, R., Sala-i-Martin,X. [2003], *Economic Growth*, The MIT Press, Cambridge – London.

Batóg, J. [2010], *Konwergencja dochodowa w krajach Unii Europejskiej*, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin.

Borsi, M.T., Metiu, N. [2013], *The Evolution of Economic Convergence in the European Union*, "Deutsche Bundesbank Discussion Paper", No. 28/2013.

IMF [2019], *World Economic Outlook Database*, October 2018 (updated January 2019), www.imf.org, access 6.02.2019.

Jóźwik, B. [2017], *Realna konwergencja gospodarcza państw członkowskich Unii Europejskiej z Europy Środkowej i Wschodniej. Transformacja, integracja i polityka spójności*, Wydawnictwo Naukowe PWN, Warsaw.

Liberda, Z.B. [2009], *Konwergencja gospodarcza Polski*, VIII Kongres Ekonomistów Polskich, Polskie Towarzystwo Ekonomiczne, Warsaw.

Malaga, K. [2004], *Konwergencja gospodarcza w krajach OECD w świetle zagregowanych modeli wzrostu*, Wydawnictwo Akademii Ekonomicznej, Poznań.

Mankiw, N.G., Romer, D., Weil D.N. [1992], *A Contribution to the Empirics of Economic Growth*, "Quarterly Journal of Economics", Vol. 107, pp. 407–437.

Matkowski, Z., Próchniak, M. [2013], *Real Income Convergence*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2013. National and Regional Dimensions*, World Economy Research Institute, SGH Warsaw School of Economics, Warsaw, pp. 44–64.

Matkowski, Z., Próchniak, M., Rapacki, R. [2016a], *Income Convergence in Poland vis-à-vis the EU: Major Trends and Prospects*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2016. The Role of Economic Policy and Institutions*, World Economy Research Institute, SGH Warsaw School of Economics, Warsaw, pp. 37–55.

Matkowski, Z., Próchniak, M., Rapacki, R. [2016b], *Real Income Convergence between Central Eastern and Western Europe: Past, Present, and Prospects*, "Ekonomista", No. 6, pp. 853–892.

Michałek, J.J., Siwiński, W., Socha, M. [2007], *Polska w Unii Europejskiej – dynamika konwergencji ekonomicznej*, Wydawnictwo Naukowe PWN, Warsaw.

Monfort, M., Cuestas, J.C., Ordóñez, J. [2013], *Real Convergence in Europe: A Cluster Analysis*, "Economic Modelling", Vol. 33, pp. 689–694.

Mucha, M. [2012], *Mechanizm dywergencji gospodarczej w strefie euro*, "Ekonomista", No. 4, pp. 487–498.

Próchniak, M. [2017], *Income Convergence Between the CEE Region and Western Europe*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2017. Internationalization and Poland's Competitive Position*, World Economy Research Institute, SGH Warsaw School of Economics, Warsaw, pp. 29–40.

Próchniak, M. [2018], *Convergence of Income Levels Between East-Central and Western Europe*, in: M.A. Weresa, A.M. Kowalski (eds.), *Poland. Competitiveness Report 2018. The Role of Cities in Creating Competitive Advantages*, World Economy Research Institute, SGH Warsaw School of Economics, Warsaw, pp. 29–41.

Próchniak, M., Witkowski, B. [2012], *Real Economic Convergence and the Impact of Monetary Policy on Economic Growth of the EU Countries: The Analysis of Time Stability and the Identification of Major Turning Points Based on the Bayesian Methods*, "National Bank of Poland Working Paper", No. 137, Warsaw.

Próchniak, M., Witkowski, B. [2016], *Digitalizacja i internetyzacja a wzrost gospodarczy*, "DELab UW Working Paper", No. 4, Warsaw.

Rapacki, R., Próchniak, M. [2012], *Wzrost gospodarczy w krajach Europy Środkowo-Wschodniej na tle wybranych krajów wschodzących*, "Gospodarka Narodowa", No. 1–2, pp. 65–96.

Solow, R.M. [1956], *A Contribution to the Theory of Economic Growth*, "Quarterly Journal of Economics", Vol. 70, pp. 65–94.

Staňisić, N. [2012], *The Effects of the Economic Crisis on Income Convergence in the European Union*, "Acta Oeconomica", Vol. 62, pp. 161–182.

Chapter 6

Income Inequality and Poverty in Poland in 2010–2017[1] in the Context of the Social Dimension of Industry 4.0.

Patrycja Graca-Gelert

Introduction

Low income inequality and poverty levels are two factors falling within the definition of competitiveness referring to the "improvement in sustainable economic growth" and "the ability to improve the quality of life for society" [Weresa, 2015, p. 7]. Many studies show that income disparities and the risk of poverty (or actual poverty) are negatively corelated with economic growth, while low levels of income inequality and poverty are usually associated with a high standard of living.

The main objective of this chapter was to show the main trends in income inequality and the risk of poverty in Poland compared with other EU countries in 2010–2017. A Gini coefficient decomposition analysis was carried out according to various groups selected from the entire population in 2017, along with a continuation of the study provided in the previous edition of this monograph on the impact of the benefits under the "Family 500+" program on income inequality in Poland. In addition, this chapter contains a concise overview of the literature on the impact of Industrial Revolution 4.0 on income inequality.

6.1 Income inequality and poverty in Poland in 2010–2017

As has been discussed repeatedly in previous editions of this monograph, the complexity of measurement and interpretation of income inequality and poverty or the risk of poverty is comprised of many elements such as the assumptions regarding the definition of income, poverty line, equivalence scale, reference unit, or the selection of

[1] 2018 could not be included due to unavailability of data for that year.

data sources. Having regard to these issues, we will limit ourselves in this subchapter only to signaling the characteristics of the data used in the study.

The sources of data on income inequality are many, but they are differentiated in terms of quality (i.e. comparability over time, representativeness, reliability of data) and the methodologies and assumptions adopted. For the purpose of this chapter, mainly two data sources are used – GUS household budget surveys (HBS) and EU-SILC (for Poland and other EU member states). Every data set (as regards Poland) is collected each year by the Central Statistical Office (GUS). Each source has its own characteristics, methodology[2] from which the disadvantages and advantages of each of them arise, yet a detailed discussion of the differences in methodology goes beyond the subject-matter of this study. It is worth emphasizing that the data referred to in this chapter, measures of income inequality and poverty or the risk of poverty derived from both sources differ significantly from one another, which should be borne in mind when drawing conclusions on the basis of data analysis.

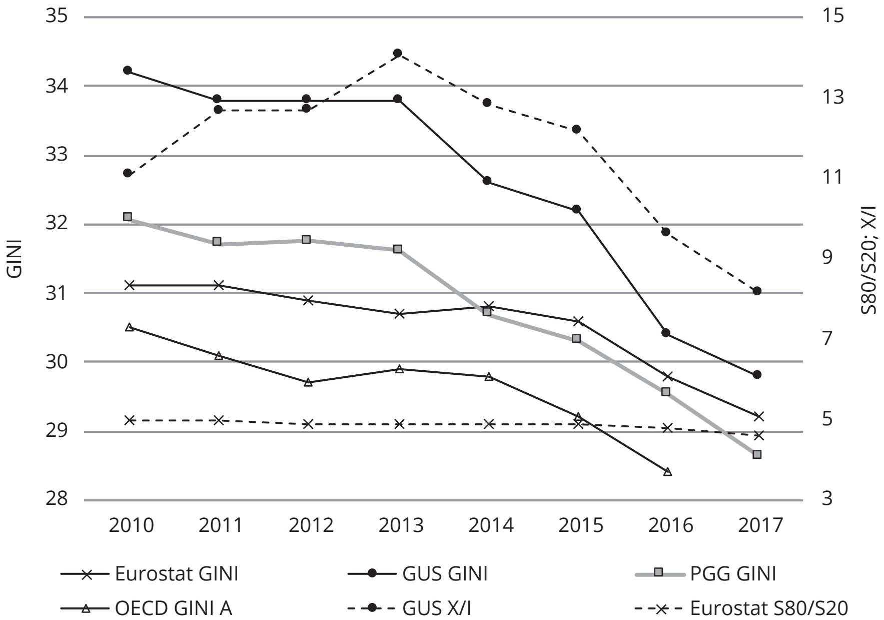
Based on the EU-SILC data, income inequality indicators are calculated and published in line with the guidelines adopted at the Laeken summit in 2001, i.e. the Gini coefficient and the 80/S20 quantile ratio. In a similar manner, on the basis of HBS, GUS calculates the Gini coefficient, but the equivalence scale and definition of income adopted differ from those used in EU-SILC – for HBS, it is available per capita household income, whereas for EU-SILC it is equivalized disposable household income (modified OECD equivalence scale). For HBS, the distribution reference unit is the household, and for EU-SILC it is the person (the equivalent household income weighing as much as there are persons in the household concerned). While in the case of poverty risk measures calculated from EU-SILC data the equivalence scale is used as for the income inequality measures, a different scale is used for the measures of poverty (extreme and relative) calculated from HBS – the original OECD equivalence scale. As far as poverty and poverty risk measures calculated on the basis of EU-SILC and HBS are concerned, the measures, definitions of the equivalence scale and poverty lines adopted also differ (see description under Figure 6.3).

Analyzing the time series from Figure 6.1, it should be stated that data from all the sources presented show that income inequality has followed a declining trend in the current decade. Additionally, the GUS X/I measure shows that until 2013 changes (i.e. reduction of inequalities) in the distribution must have taken place in the medium income groups, as the relation of the tenth to the first decile was increasing at the time. It is only after 2013 that a stronger decline in income disparities in Poland can

[2] The methodology applied in EU-SILC for Polish data is the same as for the other EU member states. This is not the case with HBS.

be seen (as also demonstrated by the measures calculated from EU-SILC data). More detailed data relating to particular income deciles in Poland over the past decade are indicative of a growing share in total (disposable household income, per capita) income of all the lower deciles up to and including the fifth one, and a decreasing share in the 7th-10th deciles from 2013 onwards [GUS, 2018a, Table 6, 2. 348]. To complement the picture of changes taking place within the income distribution, Figure 6.2 presents the Lorentz curves for per capita disposable household income in 2010 and 2017.

Figure 6.1 Income inequality in Poland, 2010–2017

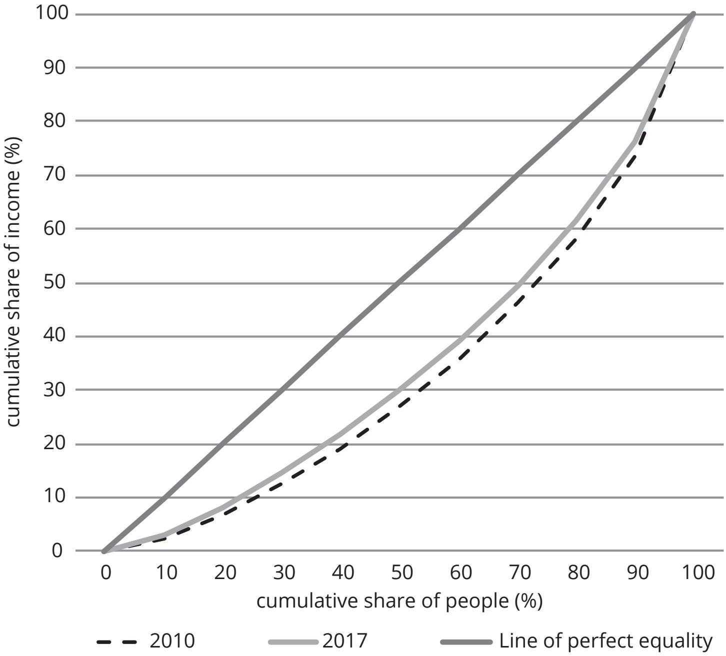


[a] Eurostat – equivalized disposable household income (modified OECD equivalence scale, with the person as the unit of reference); GUS – available per capita household income (with the household as the unit of reference), PGG GINI – equivalized disposable household income (modified OECD equivalence scale; with the household as the unit of reference), OECD GINI – equivalized disposable household income (square root equivalence scale; with the household as the unit of reference).

Source: Eurostat; GUS, 2018a, Tables 5 and 6, p. 348; OECD; own calculations based on GUS household budget surveys.

A more detailed analysis of income inequality (intra-group) shows that inequalities have been declining in the current decade in general in all the socio-economic groups except farmers. If viewed from a broader perspective, i.e. from 2003, this would show that that farmers are the only socio-economic group in which an increase of income disparities has occurred. For quite obvious reasons (high variability of income and substantial differences in this variability), this group has also displayed a significant variability of income disparities and the highest income inequality. The most similar level of income inequality compared to overall inequalities was observed for "employees", which should also not come as a surprise, as this group represents the most numerous (one carrying the heaviest "weight" in total income inequality) community among all socio-economic groups. The lowest income disparities were observed among old-age pensioners' households. In terms of income inequality in rural and urban areas, income differentials were always slightly higher in rural areas during the period under consideration.

Figure 6.2 Income inequalities in Poland, Lorenz curves for 2010 and 2017



[a] Per capital available household income.

Source: Own calculations based on data from [GUS, 2018a, Table 6, p. 348].

Looking only at intra-group inequalities does not explain all the components of income inequality in a group breakdown. It is therefore worthwhile to analyze the decomposition of the income differential. In this chapter, we have conducted such a study for three different categories – socio-economic groups, regions and place of residence classes. We have repeatedly presented the theory of decomposition by group in previous editions of the *Report*, and the most detailed discussion of the theoretical aspects can be found in last year's edition [Weresa, Kowalski, 2018]. For this reason, we have limited ourselves in this chapter to recalling the most important components of decomposition and their general interpretation.

Table 6.1 Household income differential by socio-economic group and by place of residence in Poland – 2010–2017

Households	2010	2011	2012	2013	2014	2015	2016	2017
Total	34.2	33.8	33.8	33.8	32.6	32.2	30.4	29.8
Employees	34.7	34.6	34.3	34.1	33.4	32.7	30.7	29.3
Farmers	53.3	53.9	55.9	59.9	54.4	55.3	54.1	54.7
Self-employed	37.5	37.3	38.2	37.4	37.8	37.3	34.6	34.0
Old-age pensioners	24.9	24.4	24.2	23.9	23.6	23.3	22.4	22.3
Disability pensioners	29.1	29.2	27.9	28	27.6	27.7	26.3	25.9
In cities	32.3	31.7	31.7	31.2	30.6	30.3	28.8	28.1
In rural areas	33.9	33.7	34.3	35.2	32.9	32.3	30.5	30.2

[a] Per capita disposable household income (with the household as the unit of reference).

Source: GUS, 2018a, Table 5, p. 348.

The left-hand side of the equation below presents the general form of decomposition by group, commonly used in the literature [e.g., Deutsch, Silber, 1999; Bellú, Liberati, 2006; Lambert, Aronson, 1993], whereas the middle and right side of the equation provide a more detailed representation of the individual decomposition components used in this study:

$$I_O = I_W + I_B + I_R = G_O = \left(\sum_{k=1}^{K} P_k S_k G_k \right) + \left(\frac{2cov\left[y_0, F(y_0) \right]}{\mu_0} \right) + \left(G_O - \left[I_W + I_B \right] \right) \quad [1]$$

where I_0 is overall income inequality, I_W means the contribution of intra-group inequalities to overall income inequality, I_B determines the contribution of inter-group inequalities to overall income inequality, I_R is the residual term, G_O is the total Gini coefficient, K is the number of analyzed groups ($k = 1, \ldots, K$), P_k means the population share of group k, S_k is the income share of group k, G_k represents income inequality in group k measured with the use of the Gini coefficient, y_0 is income, μ_0 denotes average income, and $F(y_0)$ is the cumulative distribution of total income.

As indicated by the last component on the right-hand side of the equation, the residual term simply represents the difference between (here:) the Gini coefficient and the sum of intra-group and inter-group income inequality contributions. The interpretation of the residual term of income inequality is as follows – I_R shows the extent to which overall income inequality results from the overlap of the distributions of income. If the distributions for individual groups overlap, then the ranking of income in the group distribution differs from the ranking of groups in the overall income distribution. I_R shows the difference in ranking, moving from intra-group inequalities to overall income inequality. This means that I_R will equal *0* if the income distributions of individual groups do not overlap. I_R will take a positive value if income distributions overlap, i.e. “the rank by subgroup incomes overlap with the rank of the total income distribution” [Bellú, Liberati, 2006, p. 16].

Tables 6.2, 6.3 and 6.4 show the results of the Gini coefficient decomposition by socio-economic group, region and class of place of residence in Poland in 2017. The calculations were made using individual non-identifiable data from household budget surveys (HBS) for two different income definitions (the upper part of the table refers to disposable income according to the definition of income used by GUS to calculate the Gini coefficient on the basis of HBS) and equivalence scales (the upper part of the table refers to household incomes per capita – such income definition is used by GUS to calculate the Gini coefficient on the basis of HBS). The DAD 4.6. software was used for calculations [Jean-Yves Duclos, Abdelkrim Araar and Carl Fortin, “DAD: A Software for Distributive Analysis/Analyse Distributive,” MIMAP programme, International Development Research Centre, Government of Canada, and CIRPÉE, Université Laval].

The decomposition calculations provided in Table 6.2 show that the results largely depend on the breakdown of the category concerned (here: socio-economic groups) into groups and on the applied definition of income and equivalence scale. However, some common features can be identified regardless of the calculation results. The highest contribution to intra-group income inequalities was attributable to income differentials among employees, followed by old-age pensioners and disability pensioners, due to both their high share in total population and the share in total income. The group of persons living on unearned sources had a negligible impact on income disparities.

With the employees group divided into two subgroups – manual and non-manual workers, it turns out that the relative contribution of the non-manual workers subgroup was greater than the relative contribution of the manual workers group to income inequality owing to a greater share of the former subgroup in total income and greater income disparities in that subgroup. At the same time, such disaggregation significantly reduces the impact of the intra-group income inequality component to the advantage of the inter-group component due to the fact that subgroups selected this way differ more in terms of average income, which should not come as a surprise here. Irrespective of the applied definition of income, equivalence scale and breakdown into subgroups, the residual term of the decomposition was relatively large, which suggests that income distributions for all groups significantly overlapped.

Table 6.2 Decomposition of the Gini coefficient by socio-economic group and sub-group (in accordance with GUS definition) in Poland in 2017

Group	Income definition	Gini coefficient[a]	Population share	Income share	Absolute contribution	Relative contribution
Employees	per capita disposable household income	0.296	0.502	0.517	0.077	0.259
Farmers		0.526	0.039	0.038	0.001	0.003
Self-employed		0.345	0.071	0.089	0.002	0.007
Pensioners		0.229	0.342	0.326	0.026	0.086
Living on unearned sources		0.344	0.045	0.029	0.000	0.002
Intra-group inequalities		---	---	---	0.106	0.356
Inter-group inequalities		---	---	---	0.047	0.157
Residual term		---	---	---	0.144	0.486
Manual workers		0.241	0.243	0.198	0.012	0.039
Non-manual workers		0.298	0.259	0.320	0.025	0.083
Old-age pensioners		0.221	0.285	0.279	0.018	0.059
Disability pensioners		0.254	0.057	0.047	0.001	0.002
Living on social benefits		0.232	0.031	0.016	0.000	0.000
Living on other unearned sources		0.379	0.014	0.014	0.000	0.000
Farmers		0.526	0.039	0.038	0.001	0.003
Self-employed		0.345	0.071	0.089	0.002	0.007
Intra-group inequalities		---	---	---	0.058	0.194
Inter-group inequalities		---	---	---	0.103	0.348
Residual term		---	---	---	0.136	0.457
Employees	equivalized disposable household income	0.256	0.502	0.552	0.071	0.248
Farmers		0.526	0.039	0.045	0.001	0.003
Self-employed		0.305	0.071	0.097	0.002	0.007
Pensioners		0.230	0.342	0.277	0.022	0.076
Living on unearned sources		0.316	0.045	0.029	0.000	0.001
Intra-group inequalities		---	---	---	0.096	0.336
Inter-group inequalities		---	---	---	0.095	0.331
Residual term		---	---	---	0.095	0.333
Manual workers		0.209	0.243	0.220	0.011	0.039
Non-manual workers		0.260	0.259	0.332	0.022	0.078
Old-age pensioners		0.224	0.285	0.239	0.015	0.053
Disability pensioners		0.229	0.057	0.038	0.000	0.002
Living on social benefits		0.271	0.031	0.018	0.000	0.001
Living on other unearned sources		0.366	0.014	0.011	0.000	0.000
Farmers		0.526	0.039	0.045	0.001	0.003
Self-employed		0.305	0.071	0.097	0.002	0.007
Intra-group inequalities		---	---	---	0.053	0.184
Inter-group inequalities		---	---	---	0.124	0.435
Residual term		---	---	---	0.109	0.382

[a] In the case of per capita disposable income, the Gini coefficient values for individual socio-economic groups may differ slightly from the values provided in Table 6.1 owing to a somewhat different method of data adjustment for the study.

Source: Own study based on GUS household budget surveys.

The decomposition of the Gini coefficient by class of the place of residence also shows a relatively high weight of the residual term in 2017, whereas intra-group inequalities had the least impact on total income disparities, with income inequality in rural areas playing the greatest role, mainly due to the high share in total population and in total income. The greatest income inequalities were reported in the largest cities, with a population of more than 500,000 and in rural areas.

Table 6.3 Decomposition of the Gini coefficient by size of place of residence of households in Poland in 2017

Group	Income definition	Gini coefficient	Population share	Income share	Absolute contribution	Relative contribution
Population of 500k and more	Per capita disposable household income	0.313	0.146	0.200	0.009	0.031
Population of 200–499k		0.268	0.099	0.112	0.003	0.010
Population of 100–199k		0.253	0.094	0.099	0.002	0.008
Population of 20–99k		0.257	0.205	0.201	0.011	0.036
Population of less than 20k		0.254	0.130	0.119	0.004	0.013
Rural areas		0.301	0.326	0.269	0.026	0.089
Intra-group inequalities		---	---	---	0.055	0.187
Inter-group inequalities		---	---	---	0.097	0.327
Residual term		---	---	---	0.144	0.487
Population of 500k and more	equivalized disposable household income	0.307	0.146	0.189	0.008	0.030
Population of 200–499k		0.267	0.099	0.108	0.003	0.010
Population of 100–199k		0.245	0.094	0.096	0.002	0.008
Population of 20–99k		0.251	0.205	0.197	0.010	0.035
Population of less than 20k		0.244	0.130	0.120	0.004	0.013
Rural areas		0.303	0.326	0.289	0.029	0.100
Intra-group inequalities		---	---	---	0.056	0.196
Inter-group inequalities		---	---	---	0.069	0.242
Residual term		---	---	---	0.161	0.562

Source: Own study based on GUS household budget surveys.

The decomposition of the Gini coefficient by region in 2017 shows that the contribution of the residual term was even greater than in the case of the previous two decompositions, while the intra-group and inter-group components were comparable at approx. 14–17.5%. The region with the greatest inequalities of income was the central region, while the lowest income differentials prevailed in the southern region. The contribution of the central region to the total income inequality was the greatest among all the regions owing to the greatest share in total population and total income, and it was the lowest in the south-western region.

Table 6.4 Decomposition of the Gini coefficient by region[a] of residence of households in Poland in 2017

Group	Income definition	Gini coefficient	Population share	Income share	Absolute contribution	Relative contribution
Central region	per capita disposable household income	0.335	0.217	0.248	0.018	0.061
Southern region		0.266	0.208	0.206	0.011	0.039
Eastern region		0.285	0.164	0.143	0.007	0.023
North-Western region		0.274	0.156	0.156	0.007	0.022
South-Western region		0.277	0.106	0.105	0.003	0.010
Northern region		0.302	0.148	0.142	0.006	0.022
Intra-group inequalities		---	---	---	0.052	0.176
Inter-group inequalities		---	---	---	0.045	0.151
Residual term		---	---	---	0.199	0.672
Central region	equivalized disposable household income	0.328	0.217	0.243	0.017	0.060
Southern region		0.249	0.208	0.207	0.011	0.037
Eastern region		0.278	0.164	0.144	0.007	0.023
North-Western region		0.264	0.156	0.158	0.007	0.023
South-Western region		0.268	0.106	0.104	0.003	0.010
Northern region		0.294	0.148	0.145	0.006	0.022
Intra-group inequalities		---	---	---	0.050	0.176
Inter-group inequalities		---	---	---	0.040	0.141
Residual term		---	---	---	0.196	0.683

[a] The division into regions (NUTS 1) adopted in the table was applicable until the end of 2017, i.e. the year of HBS data collection. Central region – Mazowieckie and Łódzkie voivodships; Southern region – Śląskie and Małopolskie voivodships; Eastern region– Podlaskie, Lubelskie, Świętokrzyskie and Podkarpackie voivodships; North-Western region – Zachodniopomorskie, Lubuskie and Wielkopolskie voivodships; South-Western region – Dolnośląskie and Opolskie voivodships; Southern region – Pomorskie, Kujawsko-Pomorskie and Warmińsko-Mazurskie voivodships.

Source: Own study based on GUS household budget surveys.

The previous edition of the *Report* tried to estimate the impact of the Family 500+ program on income inequality in Poland in 2016. This year's *Report* seeks to continue the analysis, extending the study by the year 2017. As was the case previously, a different type of the Gini coefficient has been used to examine the impact of the child support benefit on income inequality in Poland, namely the decomposition by income source. As for the decomposition by group, the detailed theory was presented in the previous editions of the *Report* [in particular in: Weresa, Kowalski, 2018]. For this reason, we will limit ourselves here to presenting a general form of decomposition and its interpretation. We have used the decomposition method by Lerman and Yitzhaki [1985] in the following form:

$$\begin{cases} G_0 = \dfrac{2\sum_{k=1}^{K} cov\left[y_k, F(y_0)\right]}{\mu_0} = \\ = \sum_{k=1}^{K} \left(\dfrac{cov\left[y_k, F(y_0)\right]}{cov\left[y_k, F(y_k)\right]} \right) \left(\dfrac{2cov\left[y_k, F(y_k)\right]}{\mu_k} \right) \left(\dfrac{\mu_k}{\mu_0} \right) = \\ = \sum_{k=1}^{K} R_k G_k S_k \end{cases} \qquad [2]$$

where G_0 is the Gini coefficient for household income, and y_0, μ_0 and $F\ (y_0)$ mean household income, average household income and the cumulative distribution of overall household income, respectively. There are K components of household income $y_0 = \sum_{k=1}^{K} y_k$, where y_1, ..., y_k are components of income, S_k is the share of the k-th component of total household income, Gk is the Gini coefficient for the k-th component of household income, and Rk is the Gini correlation of the k-th component with overall income. The product of G_k and R_k can be interpreted as the concentration coefficient for the k-th component of income. The component is also referred to as pseudo-Gini.

Table 6.5 also shows the effects of marginal changes in individual income components on total income inequality, and the relevant formula based on which the effects were calculated is as follows (Stark, Taylor, Yitzhaki (1986)):

$$\frac{\partial G_0 / \partial e_k}{G_0} = \frac{S_k R_k G_k}{G_0} - S_k \qquad [3].$$

where an exogenous change is assumed in each household income coming from the k-th component of income equal $e_k y_k$, with e_k close to 1.

Decomposition estimates were made for a scenario where the impact is demonstrated by showing the difference between the actual income and income without the child support benefit. No attempt was made to estimate the impact of 500+ on income inequality by analyzing a counterfactual distribution, i.e. income distribution that would exist if, besides the deduction of the child support benefit, a change in economic incentives were taken into account (that is, what income, i.e. from what sources and in what amount, households would receive had they not received the child support benefit; we are not examining e.g. the impact of changes in women's occupational activity resulting from the introduction of the 500+ program).

The decomposition of the Gini coefficient for the benefit under the Family 500+ program was performed using individual non-identifiable data from HBS for two income definitions used by GUS. The DAD 4.6 program was used for the calculations

[Jean-Yves Duclos, Abdelkrim Araar and Carl Fortin, "DAD: A Software for Distributive Analysis/Analyze Distributive", MIMAP programme, International Development Research Centre, Government of Canada, and CIRPÉE, Université Laval].

In 2017, the Family 500+ benefit was paid for the whole year, unlike 2016, when the benefit was put into effect from 1 April. For this reason, the share of the benefit in total income in Poland was greater in 2017 than in the previous year. The decomposition results are varied depending on the definition of income and equivalence scale applied. Regardless of these, the disparity of the child support benefit distribution was smaller by approx. 8 percentage points in 2017 compared with 2016. Besides, as is evident from the results in the last column of Table 6.5, in each year under analysis and irrespective of the definition of income and the equivalence scale, the 500+ child support benefit had the effect of reducing income inequality in absolute terms. The effect was stronger in 2017 than in 2016.

Table 6.5 Decomposition of the Gini coefficient by child support benefit (500 +) and other income in Poland in 2016–2017

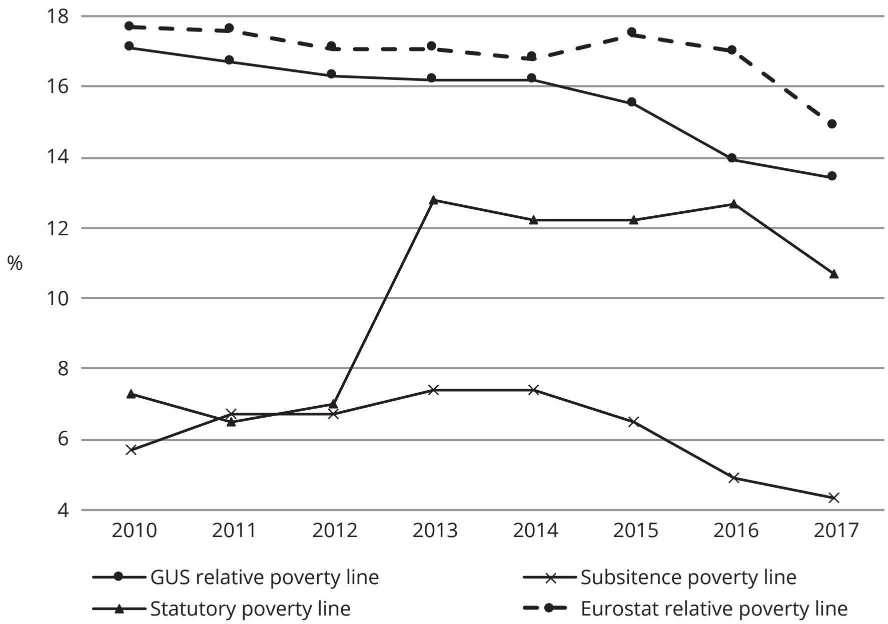
Source of income		Share in total income (Sk)	Gini coefficient for a given source of income (Gk)	Gini correlation of a given source of income with cumulative distribution of total income (Rk)	Concentration coefficient for a given source of income (Gk*Rk)	Contribution of a given source of income to Gini coefficient for total income in absolute terms (SkGkRk)	Contribution of a given source of income to Gini coefficient for total income in relative terms (SkGkRk/G0)	Effect of marginal percentage change in income from the k-th source on overall income inequality
Disposable income per capita	2016	1	0.304	1	0.304	1	1	0
	2017	1	0.297	1	0.297	1	1	0
Disposable income – child support benefit (per capita)	2016	0.985	0.315	0.996	0.314	0.309	1.019	0.033
	2017	0.976	0.315	0.996	0.313	0.306	1.032	0.056
Child support benefit, per capita	2016	0.015	0.903	–0.420	–0.379	–0.006	–0.019	–0.034
	2017	0.024	0.823	–0.491	–0.404	–0.010	–0.032	–0.056
Available income per equivalent unit[a]	2016	1	0.295	1	0.295	1	1	0
	2017	1	0.286	1	0.286	1	1	0
Available income – child support benefit (per equivalent unit)	2016	0.982	0.307	0.993	0.304	0.299	1.013	0.03
	2017	0.967	0.299	0.995	0.298	0.288	1.006	0.039
Child support benefit per equivalent unit	2016	0.018	0.906	–0.233	–0.211	–0.004	–0.013	–0.031
	2017	0.033	0.828	–0.059	–0.049	–0.002	–0.006	–0.039

[a] The modified OECD equivalence scale was used.

Source: Own study based on GUS household budget survey.

Differences emerge in the case of Gini's correlation and the associated concentration coefficient. For per capita disposable income, the values are greater (in absolute terms), i.e. they are indicative of a negative correlation of the 500+ benefit with overall income, than for equivalized disposable income. It should be borne in mind that income distributions according to either definition have a different interpretation. In particular, the ranking of households in descending order of income may change (and usually changes), which results from the inclusion of the effects of scale increasing with the number of household members (especially children). The results, i.e. the differences, fall in line with intuition, i.e. after the benefits of scale in the household are taken into account by applying the equivalence scale, certain households (those with a lower per capita income, which is related, among other things, to the number of children in the household, that is, eligibility for the child support benefit) move upwards in the income distribution ranking, due to which the child support benefit and the cumulative distribution of overall income become less negatively correlated (change from –0.491 to –0.059).

Figure 6.3 Poverty and the risk of poverty for different poverty lines[a] in Poland – 2010–2017



[a] In the case of the extreme poverty rate, the poverty line is calculated on the basis of the subsistence minimum (estimated by the Institute of Labor and Social Affairs), which only takes into account those needs that cannot be deferred, and consumption below this level leads to biological deprivation. As far as the statutory poverty line is concerned, it is defined as the amount which, in accordance with applicable Act on Social Assistance, entitles one to apply for a social assistance cash benefit. The GUS relative poverty line is set at 50% of the mean monthly household expenditure calculated on the basis of the household budget surveys (GUS, 2017b, p. 9). The Eurostat relative poverty line shown in the chart calculated on the basis of the poverty line set at 60% of median equivalized disposable income, using EU-SILC data.

Source: Eurostat; GUS, 2018b, chart 1, p. 1.

Figure 6.3 shows trends in poverty and the risk of poverty according to different measures. All of them indicate that poverty or poverty risk decreased in Poland in 2017 compared to 2016. It should be noted at this point that in the case of statutory poverty, trends – whether declining or rising – are often dictated (at least in part) by changes (or lack thereof) in the statutory poverty line. A relatively strong decline in statutory poverty in 2017 compared with 2016 resulted e.g. from the fact that the statutory poverty line had not been changed since the Q4 2015 [GUS, 2018b, p. 2]. The decline in poverty or poverty risk is considered to be attributable mainly to the growth of wages, decline in unemployment and the 500+ child support benefit [GUS, 2018b, p. 2]. Improvement regarding poverty and poverty risk was observed particularly in households living on unearned sources, with lower education (household heads), single parents supporting children, households with disabled children and large families [GUS, 2018b, p. 2].

6.2 Income Inequality and Poverty Risk in Poland Compared with Other EU Countries in 2010–2017

In 2017, income inequality in the whole European Union[3], measured with the Gini coefficient, decreased by 0.1 p.p. compared to the previous year and stood at 30.7, ranging between 23.2 and 40.2. The countries with the lowest income inequalities were three CEE countries – Slovakia (23.2), Slovenia (23.7) and the Czech Republic (24.5). In contrast, the highest level of the Gini coefficient was recorded in Bulgaria (40.2), Lithuania (37.6) and Latvia (34.5). In most countries, income disparities decreased in 2017 compared with the previous year, with the steepest decrease recorded in Romania, Cyprus, Estonia and Slovakia (by 1.6 p.p., 1.3 p.p., 1.1 p.p. and 1.1 p.p., respectively). Over the same period, income inequality increased the most in Bulgaria (by 2.5 p.p.), the United Kingdom (1.6 p.p.) and Ireland (1.1 p.p.). Analyzing data for a longer time series, i.e. 2010–2017, the greatest changes in income inequality are seen to have taken place in Slovakia (Gini coefficient decrease by 2.7 p.p.) and in Bulgaria (Gini coefficient increase by 7 p.p.). Compared with the European Union, Poland also experienced a considerable decrease in income inequality (by 1.9 p.p.) in 2010–2017, although it was significantly smaller than in 2005–2010 (by 4.5 p.p.). With the Gini coefficient of 29.2, Poland saw slightly smaller income inequalities compared with the EU average.

The social protection system can play a significant role in reducing income disparities. Eurostat data allow the impact of social transfers on income inequalities

3 As the average for all EU member states, weighted by population of each country.

to be demonstrated. The transfers can be considered including or excluding retirement pensions. And so, social transfers (excluding pensions) contributed the most to reducing income inequalities in 2017 in the European Anglo-Saxon countries (Ireland – by 11 p.p., United Kingdom – by 7.8 p.p.) and in the Nordic countries (Denmark – by 9.1 p.p., Finland – by 9.0 p.p. and Sweden – by 8.7 p.p.). Social transfers (excluding pensions) had the smallest effect on income inequality in the Mediterranean countries (Italy, where the Gini coefficient decreased by 2.2 p.p. and Greece – by 2.6 p.p.) and in the Central and Eastern European countries (Latvia – by 2.5 p.p. and Slovakia – by 3 p.p.). It could be concluded that the impact of social transfers on income disparities results largely from the design of the social protection system characteristic of the particular model of capitalism [cf. Próchniak et al., 2016; Próchniak et al., 2017; Maszczyk, s.a.]. Pensions contributed the most to reducing income inequalities in 2017 in Greece (by 22.2 p.p.), Portugal (by 21.3 p.p.) and Sweden (by 20.9 p.p.), and the least in Ireland (by 8 p.p.) and the three Baltic states (Latvia, Estonia and Lithuania by 10.2 p.p., 10.5 p.p. and 10.7 p.p., respectively). Poland was one of the countries characterized by a rather small impact of social transfers (both including and excluding pensions) on income inequality in 2017.

Table 6.6 Income inequality[a] in Poland compared with other EU countries in 2010–2017.[b]

Country/Region	2010	2011	2012	2013	2014	2015	2016	2017	2017		
	Gini coefficient (%) after social transfers								Gini coefficient (%) before social transfers (excluding pensions)	Gini coefficient (%) before social transfers (including pensions)	S80/S20
Slovakia	25.9	25.7	25.3	24.2	26.1	23.7	24.3	23.2	26.2	39.3	3.5
Slovenia	23.8	23.8	23.7	24.4	25.0	24.5	24.4	23.7	29.3	43.1	3.4
Czech Republic	24.9	25.2	24.9	24.6	25.1	25.0	25.1	24.5	28.2	43.7	3.4
Finland	25.4	25.8	25.9	25.4	25.6	25.2	25.4	25.3	34.3	48.4	3.5
Belgium	26.6	26.3	26.5	25.9	25.9	26.2	26.3	26.0	33.6	48.5	3.8
Netherlands	25.5	25.8	25.4	25.1	26.2	26.7	26.9	27.1	32.6	46.4	4.0
Denmark	26.9	26.6	26.5	26.8	27.7	27.4	27.7	27.6	36.7	49.9	4.1
Austria	28.3	27.4	27.6	27.0	27.6	27.2	27.2	27.9	33.8	47.5	4.3
Sweden	25.5	26.0	26.0	26.0	26.9	26.7	27.6	28.0	36.7	57.6	4.3
Hungary	24.1	26.9	27.2	28.3	28.6	28.2	28.2	28.1	33.9	50.7	4.3
Malta	28.6	27.2	27.1	27.9	27.7	28.1	28.5	28.3	32.0	43.9	4.2
Germany	29.3	29.0	28.3	29.7	30.7	30.1	29.5	29.1	35.0	54.4	4.5

Country/Region	2010	2011	2012	2013	2014	2015	2016	2017	2017		
	Gini coefficient (%) after social transfers								Gini coefficient (%) before social transfers (excluding pensions)	Gini coefficient (%) before social transfers (including pensions)	S80/S20
Poland	**31.1**	**31.1**	**30.9**	**30.7**	**30.8**	**30.6**	**29.8**	**29.2**	**33.6**	**47.3**	**4.6**
France	29.8	30.8	30.5	30.1	29.2	29.2	29.3	29.3	35.7	50.8	4.4
Croatia	31.6	31.2	30.9	30.9	30.2	30.4	29.8	29.9	34.1	47.8	5.0
Ireland	30.7	29.8	30.5	30.7	31.1	29.8	29.5	30.6	41.6	49.6	4.6
EU	30.5	30.8	30.5	30.5	31.0	31.0	30.8	30.7	35.9	51.0	5.1
Cyprus	30.1	29.2	31.0	32.4	34.8	33.6	32.1	30.8	34.7	48.6	4.6
Luxembourg	27.9	27.2	28.0	30.4	28.7	28.5	31.0	30.9	36.4	50.2	5.0
Estonia	31.3	31.9	32.5	32.9	35.6	34.8	32.7	31.6	35.2	45.7	5.4
Italy	31.7	32.5	32.4	32.8	32.4	32.4	33.1	32.7	34.9	48.3	5.9
Romania	33.5	33.5	34.0	34.6	35.0	37.4	34.7	33.1	36.5	51.6	6.5
UK	32.9	33.0	31.3	30.2	31.6	32.4	31.5	33.1	40.9	54.0	5.4
Greece	32.9	33.5	34.3	34.4	34.5	34.2	34.3	33.4	36.0	58.2	6.1
Portugal	33.7	34.2	34.5	34.2	34.5	34.0	33.9	33.5	36.9	58.2	5.7
Spain	33.5	34.0	34.2	33.7	34.7	34.6	34.5	34.1	38.1	49.7	6.6
Latvia	35.9	35.1	35.7	35.2	35.5	35.4	34.5	34.5	37.0	47.2	6.3
Lithuania	37.0	33.0	32.0	34.6	35.0	37.9	37.0	37.6	41.3	52.0	7.3
Bulgaria	33.2	35.0	33.6	35.4	35.4	37.0	37.7	40.2	43.4	55.2	8.2

[a] Disposable income per equivalent unit. [b] Countries in the table are ranked according to ascending income inequality measured by the Gini coefficient after social transfers in 2017.

Source: Eurostat.

In 2017, 16.7% of the EU population were at risk of poverty, which meant a substantial drop from the previous year (compared to the previous years' dynamics) – 0.4 p.p. The risk of poverty among minors under 18 years of age was higher at 20.3%. The spread of the at-risk-of-poverty rate was 14.5 p.p. (Czech Republic – 9.1%; Romania – 23.6%). In Poland, the scale of poverty risk decreased significantly – from 17.0% in 2016 to 14.9% in 2017. The phenomenon decreased especially among persons under 18 years of age – from 21.1% in 2016 to 14% in 2017. Over the years 2010–2017, Poland witnessed by far the greatest reduction in the scale of poverty risk, both overall and for minors[4] among

[4] In the case of people under 18 years of age, a significant decrease in the risk of poverty in 2010–2017 – while smaller than in Poland – was also recorded in Latvia.

all the EU member states. A decrease in the risk of poverty – while much smaller – was also recorded in the same period in two Nordic countries – Finland and Denmark (by 1.6 p.p. and 0.9 p.p., respectively). In contrast, the greatest increase in the risk of poverty was experienced in that period by Estonia (by 5.1 p.p.) and Luxembourg (4.9 p.p.). As regards the greatest changes in the risk of poverty in 2017 compared with the previous year, Poland recorded the greatest decrease. The risk of poverty was also experienced to the relatively greatest extent also by Romania (by 1.6 p.p.), Hungary (by 1.1 p.p.), Ireland (by 1.0 p.p.) and Greece (0.9 p.p.). The greatest increases in this respect were experienced by Luxembourg (by 2,2 p.p.) and the United Kingdom (by 1.2 p.p.). It is also worth noting the negative correlation between the at-risk-of-poverty rate and the poverty line (correlation coefficient of –0.43).

As with income inequality, countries differ in terms of the efficiency of reducing the risk of poverty. If treated including pensions, social transfers had the greatest impact on the reduction of the risk of poverty in countries which are characterized by a relatively low at-risk-of-poverty rate, such as Hungary (by 33.4 p.p.), France (by 32.3 p.p.), Finland (by 32.2 p.p.), but also Greece (by 30.6 p.p.), where the scale of poverty risk is relatively high compared with other UE member states. The role of reducing the risk of poverty through social transfers excluding pensions was the greatest in Ireland, Finland and Sweden. The impact of social transfers (including pensions) on the scale of poverty was the smallest in the Baltic states, i.e. in the countries with the relatively highest risk of poverty, i.e. in Latvia, Estonia and Lithuania (with the difference between the relevant at-risk-of-poverty rates being 17.7 p.p., 18.2 p.p. and 19.4 p.p., respectively). Greece and Romania were the countries where social transfers excluding pensions impacted the risk of poverty in 2017 to the smallest extent compared with all the EU countries.

In terms of assessment of "how poor" people at risk of poverty are, the depth of poverty is an important measure, which indicates by how much (in %) the median income of people considered at risk of poverty is lower (the threshold being 60% of the equivalent income). For four countries – Romania, Spain, Bulgaria and Greece – the coefficient is above 30%, while Finland saw markedly the lowest depth of poverty at 13.7% in 2017. Having regard to a significant improvement in reduction of the scale of poverty, the depth of poverty still remains quite significant in Poland (23.6%).

Table 6.7 The risk of poverty[a] in Poland compared with other EU countries in 2010–2017.[b]

Country/Region	2010	2011	2012	2013	2014	2015	2016	2017	2017				
	At-risk-of-poverty rate after social transfers								At-risk-of-poverty rate before social transfers (excluding pensions)	At-risk-of-poverty rate before social transfers (including pensions)	Poverty line[c] PPP, €	Depth of poverty[d]	At-risk-of-poverty rate after social transfers for persons under 18 years of age
Czech Republic	9.0	9.8	9.6	8.6	9.7	9.7	9.7	9.1	15.8	35.2	15 887	16.6	11.6
Finland	13.1	13.7	13.2	11.8	12.8	12.4	11.6	11.5	26.7	43.7	24 956	13.7	10.2
Denmark	13.3	12.1	12.0	11.9	12.1	12.2	11.9	12.4	25.3	40.5	26 699	21.7	10.0
Slovakia	12.0	13.0	13.2	12.8	12.6	12.3	12.7	12.4	17.5	37.4	13 305	26.0	19.9
France	13.2	13.8	14.1	13.7	13.2	13.5	13.6	13.1	23.9	45.4	25 770	16.9	19.1
Netherlands	10.3	11.0	10.1	10.4	11.6	11.6	12.7	13.2	21.9	37.9	26 737	17.8	14.4
Hungary	12.3	14.1	14.3	15.0	15.0	14.8	14.4	13.3	24.9	46.7	10 539	16.7	14.8
Slovenia	12.7	13.6	13.5	14.5	14.5	14.3	13.9	13.3	24.0	41.5	19 106	19.6	12.8
Austria	14.7	14.5	14.4	14.4	14.1	13.9	14.1	14.4	24.9	43.4	29 401	22.4	19.1
Poland	**17.7**	**17.6**	**17.1**	**17.1**	**16.8**	**17.5**	**17.0**	**14.9**	**24.0**	**43.6**	**13 964**	**23.6**	**14.0**
Ireland	15.2	15.2	16.6	15.7	16.4	16.3	16.6	15.6	32.9	42.6	23 142	18.3	17.0
Cyprus	15.6	14.8	14.7	15.3	14.4	16.2	16.1	15.7	24.5	37.5	20 800	15.1	16.5
Sweden	14.8	15.4	15.3	15.9	15.6	16.3	16.2	15.7	29.2	44.3	25 410	21.2	18.6
Belgium	14.5	15.4	15.3	15.1	15.5	14.9	15.5	16.0	26.4	43.8	26 317	17.7	18.6
Germany	15.7	15.9	16.1	16.2	16.7	16.7	16.5	16.1	24.2	42.1	26 731	20.9	15.2
Malta	15.5	15.6	15.1	15.7	15.9	16.3	16.5	16.8	23.7	37.5	22 262	16.7	21.2
EU	16.5	16.8	16.8	16.7	17.2	17.3	17.3	16.9	25.5	43.8	.	24.1	20.3
United Kingdom	17.1	16.2	16.0	15.9	16.8	16.7	15.8	17.0	29.2	43.1	22 693	20.1	21.3
Portugal	17.9	18.0	17.9	18.7	19.5	19.5	19.0	18.3	23.6	45.2	13 603	27.0	20.7
Luxembourg	14.5	13.6	15.1	15.9	16.4	15.3	16.5	18.7	29.0	47.0	36 313	21.8	22.8
Croatia	20.6	20.9	20.4	19.5	19.4	20.0	19.5	20.0	26.6	43.2	11 851	26.0	21.4
Greece	20.1	21.3	23.1	23.1	22.1	21.3	21.1	20.2	24.0	50.8	11 388	30.3	24.5
Italy	18.7	19.8	19.5	19.3	19.4	19.9	20.6	20.3	25.2	45.4	20 737	28.1	26.4
Estonia	15.9	17.4	17.6	18.5	21.9	21.6	21.7	21.0	29.0	39.2	15 697	20.7	16.5
Spain	20.7	20.7	20.8	20.4	22.2	22.1	22.3	21.6	28.4	45.0	19 548	32.4	28.3
Latvia	20.9	19.0	19.2	19.3	21.0	22.4	21.8	22.2	28.3	39.9	11 695	25.3	18.4
Lithuania	20.5	19.2	18.6	20.5	19.2	22.3	21.9	22.9	29.7	42.3	12 293	28.0	25.7
Bulgaria	20.7	22.2	21.2	21.0	21.7	22.0	22.9	23.4	29.2	44.8	9 472	30.5	29.2
Romania	21.6	22.3	22.9	22.9	25.0	25.4	25.2	23.6	28.3	47.5	6 601	34.5	32.2

[a] Relative at-risk-of-poverty rates for the poverty line at 60% of the equivalent median income. [b] Countries in the table have been ranked according to the rising at-risk-of-poverty rate after social transfers in 2017. [c] The poverty line has been defined for a household consisting of two adults and two children under 14 years of age. [d] The depth of poverty is measured here by how much the median income of people considered poor is less than 60% of the equivalent median income i.e., the value assumed for the poverty line in the case of at-risk-of-poverty rates analyzed in the table.

Source: Eurostat.

6.3 Industrial Revolution 4.0 and Income Inequality – a Review of Selected Studies

The literature on the impact of technological progress, skill-biased technological change) and globalization – the components of Industrial Revolution 4.0 (I4) – on income inequality is very extensive and has been published for decades. However, there are relatively few studies on the general and direct impact of I4 on income differentials. Nevertheless, a greater number of more detailed analyses have been published, which link I4 to income disparities, especially in the labor market, as a key element of impact on income inequality in this context. It should be emphasized that the majority of general studies on the impact of I4 on income differentials tend to be based on general hypotheses and diverse scenarios of economic processes – as a matter of fact, we are now at the threshold of I4.

Practically all studies, in which the impact of I4 on income inequality is analyzed comprehensively or partly, provide for a negative impact of I4 on income differential both within and between individual countries. There are several main sources of the impact. The **first** channel of the I4 impact on income inequality is related to the substitution of labor by capital and technology (automation of labor or routine-biased technological change, as well as capital-biased technological change and capital-augmenting technological progress, labor-saving technological progress) and the emergence of technological unemployment. One of the aspects of this channel of impact is the reduction of the share of income from employment in total income in favor of the share of income from capital. As income from capital has a more uneven distribution among households, the contribution of income differential to overall inequality is growing and consequently overall income disparities become deeper. The share of income from labor does not necessarily change due to a decline in employment – the capital-biased technological change leads to a growth in the return on capital and an increasing disparity between the return on capital and the return on labor [Lawrence, Roberts, King, 2017].

The results of studies on the risk of automation (computerization) of occupations or activities performed by employees are highly diverse and depend on the methodology and differ – sometimes substantially – depending on the analyzed countries. Estimates range between several percent [Arntz, Gregory, Zierahn, 2016] to more than 60% [Frey, Osborne, 2013; Degryse, 2016; Manyika et al., 2017]. Concerns about automation relate to the emergence of technological unemployment, which involves the reduction of employment due to labor automation progressing at a fast pace and the inability of the economy to quickly create new jobs that would correspond to the new structure of labor demand. Research shows that the risk of labor automation and employment reduction is the greatest for occupations that require low skills and education, involving routine work, and medium-paid occupations (or activities performed by workers) which require medium skills and education. In this context, many authors emphasize the problem of disappearance of the middle class as a result of automation progress [Schwab, 2016; Lawrence, Roberts, King, 2017; Degryse, 2016; Tyson, Spence, 2018; Bogenhold, Permana, 2018]. In addition, it is anticipated that due to technological change there will be a growing number of well-paid jobs, which require high skills and education for non-routine intellectual work, and at the same time very low-paid jobs for low-skilled and uneducated workers hired to perform non-routine manual work. The latter often operate as micro-enterprises, employed under "junk contracts", for a very short term without a contract of employment, with is associated with high instability of employment and a lack of professional identity (precariat; in this context, the term "uberization" of the labor market also appears) [Palier, 2018; Crouch, 2018]. The consequence of those processes will be a (further) growth in polarization between high and low-skilled individuals in the labor market [Degryse, 2016; Schwab, 2016].

Berger and Frey [2016] point out that new technologies are/will be labor-saving and will not contribute to the creation of jobs to an extent that allows technological unemployment to be avoided. In addition, the authors predict that jobs will be created mainly in the advanced technology sectors (new technology support) or in sectors where technology does not play, at least for the time being, a significant role (healthcare, government, personal services). However, not all researchers agree with the hypothesis of the decline in total employment and the emergence of large-scale technological unemployment [Lawrence, Roberts, King, 2017; Soete, 2018]. The reason is that automation usually does not (immediately) involve entire occupations, but only some activities performed by workers. As a result of automation, the nature of work is transformed by shifting workers' duties to activities classes not (yet) subject to automation. Thus automation may lead to an increase in labor productivity. Changes in employment levels will depend on the demand for goods produced – if it grows at least at the same rate as the growth of production, employment should not change, and it may even increase. In addition, wage growth resulting from increased labor productivity may lead to a decrease in labor supply due to longer free time. Such a scenario may also prevent the emergence of technological unemployment [Lawrence, Roberts, King, 2017].

Some researchers are also doubtful about the speed at which labor automation is implemented, and hence the likelihood of the impact of automation on the emergence of technological unemployment. Soete [2018] suggests that the use of new technologies (i.e. putting them into practice and on a massive scale) requires the employment of skilled workforce that may simply be lacking. Therefore, time will be needed to educate/train new employees. This will naturally delay the implementation of I4, which also require organizational changes at the enterprise and whole economy level. Lawrence, Roberts and King [2017, p. 32] list five factors on which implementation of automation will depend. They are 1) the cost of developing and deploying new technologies, 2) the relative cost of capital and labor, 3) the economic benefits of automation beyond labor costs, 4) the balance of economic power between labor and capital, and 5) social and regulatory acceptance. For their part, Arntz, Gregory and Zierahn [2016] argue that concerns about the emergence of technological unemployment and labor substitution by capital as a result of I4 are exaggerated, as 1) the introduction of new technologies is a slower process than some believe, due to economic, legal and societal hurdles, 2) workers can adjust to some extent to changing technologies by switching tasks, and 3) new technologies also generate additional jobs. The conditions around the rate of labor automation are also dealt with in the McKinsey Global Institute's report [Manyika et al., 2017, pp. 65–86]. Among other things, the authors mention 1) technical feasibility of new technologies, 2) the cost of developing and deploying new technological solutions, 3) labor market dynamics, 4) economic benefits, and 5) social and regulatory acceptance. It turns out that due to the existence of multiple conditions determining the deployment of automation and new technologies, the rate of progress of I4 and its impact on rapid changes in the labor market is probably overestimated, while many researchers [Soete, 2018; Schwab, 2016; Tyson, Spence, 2018; Crouch, 2018] have no doubt that I4 will progress much faster than its predecessors. They emphasize that the rate of technological change compared with the previous industrial revolutions and the scale and depth of changes occurring simultaneously will be exceptional and unprecedented.

The **second** mechanism of I4 impact on income inequality occurs through changes within the workforce manifesting themselves in skill-biased technological change. The processes lead to increasing disparities between the premium for high skills or high competences, and the return on low skills. The supply of highly-competent workers may fail to catch up with demand for them, potentially leading to a high increase in wages for highly-qualified individuals, high skills being understood not only as better skills and education, but also as the ability to effectively adjust to rapidly changing conditions in the labor market and the ability to learn quickly in changing circumstances (Schwab, 2016). In addition, the shrinking of the middle class in terms of income and skills, as already described above, will lead to increased polarization in the labor market. Distribution of skills and education within workforce is also a very important aspect. The less equal the distribution of skills, the greater the disparity of income will be [Berger, Frey, 2016].

The **third** source of income inequality as a I4 effect is seen by many authors of studies to be inherent in the exposure of economies to greater monopolization of branches (the "winner-takes-all" or "superstar economy" effect); [Rosen, 1981; Tyson, Spence, 2018; Soete, 2018; Guellec, Paunov, 2017; Prisecaru 2017]. This phenomenon results mainly from the enormous benefits of scale associated with the production of digital knowledge and goods (services) – as reproduction costs of such goods are close to zero, contrary to most tangible goods – and the benefits of scale associated with consumption. Globalization strengthens both phenomena. The processes would lead to an increase in the asymmetry of distribution of economic rent (profits) associated with digital innovation and transformation [Soete, 2018, p. 41] and an increasing inequality of wages resulting from a growth of wages in the highest income groups.

Some authors also emphasize the existence of a **fourth** source of income inequality as a consequence of I4, namely the inequality of sex and gender [e.g., Schwab, 2016; Howcroft, Rubery, 2018]. However, the impact is unclear and depends on very many detailed factors, especially those related to the labor market.

It is also worth keeping in mind a fifth important determinant of income differentials in the context I4. As a result of the processes described above, it becomes highly probable that income inequality will build up due to the speed and depth of change. Consequently, they may form hard-to-reverse (solidified) wage, income and wealth structures that will cause inequalities to deepen. The problem of decreasing income mobility and consolidation of high and growing income inequality can be described as the fifth source of I4 income on income inequality [Das, 2018].

Regardless of whether or not the authors believe that I4 will cause high technological unemployment, it is emphasized in the literature that the main I4 losers will be low- and medium-skilled employees and that inequality will deepen, while the work by Kuzmenko and Rolenko [2017] is worth noting here. The authors undertake an analysis of assessment of the I4 impact on income inequality in five European countries (France, Germany, Italy, the United Kingdom and Spain) until 2032. It turns out that the impact of I4 in those countries may have highly diverse effects (increase in France, the United Kingdom and Spain; stabilization in Italy; decrease of income inequality in Germany).

Authors of studies on the impact of I4 on income inequality point out several political implications. What should be the basic tool limiting inequality – at least in the near future – is the popularization and promotion of a level playing field in education and training, protection of low-skilled workers and improving their skills, especially in new technologies (Berger, Frey, 2016; Lewandowski, 2018; Tyson, Spence, 2018 – at the same time, they note that it is hard to say whether access to education will be an effective tool in reducing inequality under conditions where "intelligent machines will start replacing even highly educated workers", p. 208). What can (should) be another way of influencing income inequality is the taxation of the highest income, rent or excessive economic rent [Guellec, Paunov, 2017; Tyson, Spence, 2018; Berger, Frey, 2016]. Expansion of the social security system and the provision of equal access to public services, as well as the introduction of a new type of transfers, such as universal income, are other proposals to reduce income inequality in the future [Soete, 2018]. In general, Tyson and Spence [2018, p. 201] believe that the reduction of income and wealth inequality will require "policies capable of predicting those changes and [...] enabling the modification of distributive consequences of the impact of powerful technological factors". It is also very important whether economies will be able to create new jobs in the future.

Conclusions

To sum up, the data on income inequality in Poland, coming from various sources, show that income disparities have decreased in Poland in the current decade, with changes in income distribution in favor of decreasing disparities being witnessed in the medium income groups. The 500+ child support benefit was a relatively new driving factor behind income inequality in Poland. Both in 2016 and in 2017, it had the effect of reducing income inequality in absolute terms to a greater extent in 2017 than in 2016.

In 2017, income inequality in the whole of the European Union, measured by the Gini coefficient, dropped by 0.1 p.p. compared with the previous year. Benchmarked against other EU member states, Poland experienced a substantial reduction of income inequality (by 1.9 p.p.) in 2010–2017, although the decrease was significantly smaller than in 2005–2010 (by 4.5 p.p.). With the Gini coefficient of 29.2 in 2017, Poland was characterized by slightly smaller income inequality compared with the EU average.

All the poverty and poverty risk measures analyzed in this chapter show that poverty or poverty risk in Poland decreased in 2017 compared with 2016. Compared with the EU and over the years 2010–2017, Poland was a country that experienced by far the greatest reduction of the risk of poverty, both overall and among minors. Having regard to the significant improvement in reducing the scale of poverty, the depth of poverty in Poland remained quite significant.

The following channels of impact emerge from a review of the literature on the impact of Industry 4.0 on income inequality: 1) substitution of labor with capital and technology and the emergence of technological unemployment; 2) changes in inequality within the workforce resulting from skill-biased technological change; 3) exposure of economies to greater monopolization of branches as a result of digitalization (the "winner-takes-all" or "superstar economy" effect; 4) changes in sex and gender inequality; and 5) decreasing income mobility and consolidation of high income disparities or the growing income inequality trend.

In Poland, it will be possible to assess the effects over a longer timespan due to the fact that the progress in the development of Industry 4.0 in Poland is still relatively small.

Bibliography

Arntz, M., Gregory, T., Zierahn, U. [2016], *The risk of automation for jobs in OECD countries: a comparative analysis*, "OECD Social, Employment and Migration Working Papers", No. 189, OECD Publishing, Paris, http://dx.doi.org/10.1787/5jlz9h56dvq7-en.

Bellú, L.G., Liberati, P. [2006], *Policy impacts on inequality. Decomposition of income inequality by subgroups*, FAO, Module 052.

Berger, T., Frey, C. [2016], *Structural transformation in the OECD: digitalisation, deindustrialisation and the future of work*, "OECD Social, Employment and Migration Working Papers", No. 193, OECD Publishing, Paris, http://dx.doi.org/10.1787/5jlr068802f7-en.

Bögenhold, D., Permana, M.Y. [2018], *End of middle-classes? Social inequalities in digital age*, MPRA Paper, No. 87202.

Crouch, C. [2018], *Redefining labour relations and capital in the digital age*, in: M. Neufeind, J. O'Reilly, F. Ranft (eds.), *Work in the digital age: challenges of the fourth industrial revolution*, Rowan & Littlefield.

Das, A. [2018], *Industrial revolution 4.0: ghosts of disruption past, present and future*, "Invesco Investment Insights".

Degryse, C. [2016], *Digitalisation of the economy and its impact on labour markets*, ETUI Research Paper-Working Paper, No. 2016.02.

Deutsch, J., Silber, J. [1999], *Inequality decomposition by population subgroups and the analysis of interdistributional inequality*, in: *Handbook on income inequality measurement*, ed. J. Silber, Kluwer Academic Publishers, pp. 363–403, http://dx.doi.org/10.1007/978–94-011-4413–1.

Frey, C.B., Osborne, M. [2013], *The future of employment*, Oxford Martin Programme on Technology and Employment, Working Paper.

Guellec, D., Paunov, C. [2017], *Digital innovation and the distribution of income*, NBER Working Paper, No. 23987, National Bureau of Economic Research.

GUS [2018a], *Budżety gospodarstw domowych w 2017 r.*, GUS, Warsaw.

GUS [2018b], *Zasięg ubóstwa ekonomicznego w Polsce w 2017 r. (informacje sygnalne)*, GUS, Warsaw.

GUS [2018c], *Aneks do opracowania sygnalnego „Zasięg ubóstwa ekonomicznego w Polsce w 2017 r."*, GUS, Warsaw.

Howcroft, D., Rubery, J. (2018), *Gender equality prospects and the fourth industrial revolution*, in: M. Neufeind, J. O'Reilly, F. Ranft, (eds.), *Work in the digital age: challenges of the fourth industrial revolution*, Rowan & Littlefield.

Kuzmenko, O.V., Roienko, V.V. [2017], *Nowcasting income inequality in the context of the Fourth Industrial Revolution*, "Socio Economic Challenges", Vol. 1, No. 1, pp. 5–12.

Lambert, P.J., Aronson, J.R. [1993], *Inequality decomposition analysis and the Gini coefficient revisited*, "The Economic Journal", Vol. 103, No. 420, pp. 1221–1227, http://dx.doi.org/10.2307/2234247.

Lawrence, M., Roberts, C., King, L., [2017], *Managing automation: Employment, inequality and ethics in the digital age*, Institute for Public Policy Research, London.

Lerman, R.I., Yitzhaki, S. [1985], *Income inequality effects by income source: A new approach and applications to the United States*, "The Review of Economics and Statistics", Vol. 67, No. 1, pp. 151–156.

Lewandowski, P. [2018], *How does technology change the nature of work? Poland vs. the EU*, IBS Policy Paper, No. 2.

Maszczyk, P. [2019], *The comparative empirical analysis of the social protection system in selected Central and Eastern European Countries: Emerging Models of Capitalism*, "International Journal of Management and Economics", (mimeo).

Manyika, J., Chui, M., Miremadi, M., Bughin, J., George, K., Willmot, P., Dewhurst, M. [2017], *A future that works: Automation, employment, and productivity*, McKinsey Global Institute, McKinsey&Company.

Palier, B. [2018], *The politics of social risk and social protection in digitalised economics*, in: M. Neufeind, J. O'Reilly, F. Ranft, (eds.) [2018], *Work in the digital age: challenges of the fourth industrial revolution*, Rowan & Littlefield.

Prisecaru, P. [2017], *The challenges of the industry 4.0*, Global Economic Observer, No. 5.1.

Próchniak, M., Rapacki, R., Gardawski, J., Czerniak, A., Horbaczewska, B., Karbowski, A., Maszczyk, P., Towalski, R. [2016], *The Emerging Varieties of Capitalism in CEE11 Countries – a Tentative Comparison with Western Europe*, "Warsaw Forum of Economic Sociology", No. 7:2(14), pp. 1–64.

Próchniak, M., Rapacki, R., Gardawski, J., Czerniak, A., Horbaczewska, B., Karbowski, A., Maszczyk, P., Towalski, R. [2017], *Wyłaniające się modele kapitalizmu w Polsce i krajach Europy Środkowo-Wschodniej na tle Europy Zachodniej*, „Ekonomia. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu", No. 489, Wrocław, pp. 313–327.

Rosen S. [1981], *The economics of superstars*, "The American Economic Review", Vol. 71, No. 5, pp. 845–858.

Schwab, K. [2017], *The fourth industrial revolution*, World Economic Forum.

Soete, L. [2018], *Destructive creation: explaining the productivity paradox in the digital age*, in: M. Neufeind, J. O'Reilly, F. Ranft, (eds.), *Work in the digital age: challenges of the fourth industrial revolution*, Rowan & Littlefield.

Stark, O., Taylor, J.E., Yitzhaki, S. [1986], *Remittances and inequality*, "The Economic Journal", Vol. 96, No. 383, pp. 722–740.

Tyson, L., Spence, M. (2018), *Wpływ technologii na nierówności dochodowe i majątkowe*, in: H. Boushey, Delong J.B., Steinbaum M. (eds.), *Piketty i co dalej? Plan dla ekonomii i nierówności*, PWN, Warsaw.

Weresa, M.A. (ed.) (2015), *Poland. Competitiveness Report 2015. Innovation and Poland's Performance in 2007–2014*, SGH Publishing House, Warsaw.

Weresa, M.A., Kowalski, A.M. (eds.) [2018], *Poland. Competitiveness Report 2018. The Role of Cities in Creating Competitive Advantages*, SGH Publishing House, Warsaw.

Chapter 7

Competitiveness of Polish Industry in Foreign Trade in the Context of Industry 4.0

Mariusz-Jan Radło

Introduction

This chapter aims to assess the competitiveness of Polish industry in foreign trade in the context of Industry 4.0 The Fourth Industrial Revolution and the related development of new forms of production organization described as Industry 4.0 have profound implications for the competitiveness of Polish industrial enterprises in foreign trade. This is particularly important in view of the fact that a very large proportion of Polish exports consists of intermediate goods sold within regional and global production chains. The adaptation of Industry 4.0 solutions impacts both the operational efficiency of industrial enterprises and international cooperation opportunities for Polish enterprises within regional and global value chains – both as sub-suppliers and as coordinators of the production chain.

Due to the specificity of the definition and the imperfection of the measures of Industry 4.0, the assessment of the competitiveness of Polish industry in foreign trade in the context of digitalization will be made indirectly. Firstly, the assessment is achieved by the competitive position defined by the size, dynamics and structure of the Polish industry's exports, the balance of commodity trade, as well as the indicators of the revealed comparative advantage in trade. This evaluation will additionally take into account the aspect of the participation of Polish industry in value chains, including the participation in the export of different types of goods of various categories of use (intermediate, final and consumer goods). Secondly, the potential of Industry 4.0 in Poland in the context of available measures and the results of other studies on the potential of this type of industry in Poland will be determined. At this point, it should be noted that quantitative measures to assess the importance of Industry 4.0 for foreign trade have not yet been developed. However, its importance is unquestionable, as evidenced, e.g., by the fact that the inclusion of enterprises into international production chains often requires the fulfilment of a number of requirements typical of Industry 4.0.

In line with the above goals, this chapter consists of three sub-chapters. The first one, following the introduction, presents the concept of Industry 4.0, the ways of measuring it, as well as its importance for foreign trade and related production chains, and a description of its significance to competitiveness in trade. The second sub-chapter assesses the potential of the Polish economy in the context of Industry 4.0 on the basis of available measures and the results of the existing research on the subject. Finally, the third sub-chapter presents an assessment of the competitiveness of the Polish industry based on data on foreign trade in commodities according to the BEC (Broad Economic Categories) nomenclature, which takes into account the economic use of goods and divides them into final goods and semi-finished products. It thus allows the links of the Polish industry to be assessed within international production chains.

7.1 Industry 4.0 and Competitive Advantages

The term Industry 4.0 was coined in economics by the German government (*Industrie 4.0*), which assumed that the aim of the Fourth Industrial Revolution is to work with a higher level of automation, achieving a higher level of operational productivity by connecting the physical world with the virtual world and digitalization of many production processes. In this approach, production processes were to be automated, and machines and devices were to communicate with each other within a digitally connected production chain (Chiarello et al., 2018; Dalenogare et al., 2018; Castelo-Branco et al., 2019; Frank et al., 2019a and b; Alcácer and Cruz-Machado, 2019].

Different authors have developed the Industry 4.0 definition by precisely defining the links within organizational structures, the processes which this concept is intended to cover or specific technologies. For example, Castelo-Branco et al. [2019] pointed out that Industry 4.0 is a concept that represents the adoption by industrial enterprises of the techniques and processes allowed by digitalization, cloud computing, the Internet of Things, and big data in order to gain a competitive advantage in domestic and global markets. Barreto et al. [2017] pointed out that, from the point of view of the organizational structure, Industry 4.0 covers horizontal integration through networks to facilitate internal cooperation, vertical integration of subsystems in the factory to create flexible and adaptable production systems, and engineering integration throughout the value chain to enable product customization. For their part, Chiarello et al. [2018] defined Industry 4.0 in the context of Porter's value chain concept and demonstrated the application of various technologies typical of Industry 4.0 in elements of the value chain such as production, internal logistics, orders, maintenance, external logistics, distribution and sales, and aftersales services. The last-mentioned approach to the

Industry 4.0 concept shows that it goes significantly beyond the purely production sphere, and involves the organization and coordination of all processes within the value chain, including also service processes. The broader approach to the Industry 4.0 concept described above was the source for the emergence and development of concepts such as Logistics 4.0 [Barreto et al., 2017; Müller and Voigt, 2018] or Supply Chain 4.0 [Dossou, 2018].

Trying to combine the notion of Industry 4.0 with the notion of competitiveness as defined by Porter [1990], who pointed out that competitiveness of enterprises is their ability to compete in global markets. However, the competitiveness of whole industries or economies is more difficult to define. For whole economies, their competitive position is best defined by labor productivity and the position of the economy concerned in foreign trade [Radło, 2008]. The competitive position of entire industries can also be assessed through the prism of foreign trade and the level of labor productivity achieved. From a competitive analysis standpoint, the role of Industry 4.0 should be seen among the factors influencing the competitive position. The development of technology and capabilities typical of this industry is determined by the ability to optimize the entire value chain at each stage and within each stage. It will therefore influence the productivity level achieved, as well as the ability of enterprises to join production chains that have already adapted solutions typical of Industry 4.0. However, the latter will be particularly important for those industries that export intermediate goods used in production processes by other enterprises.

7.2 Industry 4.0 in the Polish Economy

In the opinion of Michałowski et al. [2018] the potential of the Polish economy in the context of Industry 4.0, assessed on the basis of NRI (Networked Readiness Index), DESI (Digital Economy and Society Index) or EDPR (European Digital Progress Report) rankings remains rather low, the Polish economy being ranked among low-income countries in the area discussed, such as Romania, Greece, Bulgaria, Italy, Hungary, Croatia, Cyprus, or Slovakia. While they note the improvement reported for this item, it still falls below the average for the European Union countries. The Industry 4.0- related features ranked highest for Poland are the telecommunications infrastructure and human capital. In contrast, the greatest problems are seen to occur in areas such as the use of the Internet by enterprises, integration of digital technologies and digital public services. The Polish economy is also ranked low from the point of view of Industry 4.0 by Castelo-Branco et al. [2019]. In their study, they assessed the economies of the European Union from the point of view of the available indicators measuring the infrastructure for Industry 4.0, and maturity in terms of big data analysis, ranking Poland among “laggards” next to Bulgaria and Hungary. The Polish economy also holds a fairly distant 36 position in the IMD [2018] ranking on digital competitiveness, in which 63 economies were assessed.

While the Polish economy scored relatively poorly in the rankings and assessments described above, the WEF and ATK report [2018], which assessed broader conditions for the development of industry, the Polish economy was seen to perform better. The report indicated that the Fourth Industrial Revolution and emerging technologies, such as the Internet of Things, artificial intelligence, robotics and incremental production, stimulate the development of new production techniques and business models, which will substantially production. These new trends make the competitiveness of low-cost production export as a growth and development factor weaker and it becomes necessary to adapt to these new trends in order to meet new challenges. This study has assessed 100 economies in terms of the production structure (diversity and scale) and production factors (technologies and innovations, human capital, foreign trade and investment, institutional conditions, sustainability of resources and foreign demand for goods from the country concerned. Of the 100 rated economies, 25 were classified as leaders, among whom the Polish economy was ranked the 18th. It should also be noted that the leading countries are defined as those currently leading in production and well prepared for production in the future. They have the most complex economies in the world and are responsible for most of the global value added. The countries are the best performers in all production areas. The opportunity they face is the first mover advantage. The countries lead in designing, testing and creating new technologies, and many of them have developed strategies to leverage the Fourth Industrial Revolution (WEF and ATK, 2018). The above description sounds optimistic in the light of the previously mentioned assessments of the Polish economy, but it should be noted that the Polish economy does not hold a high position among the leaders. Nevertheless, the ranking testifies to recognition of the achievements of the Polish economy and some of its features. Those issues are worth looking at when analyzing the specific components of the ranking presented in Tables 7.1 and 7.2.

Table 7.1 shows data on the assessment of the production structure in the 25 leading countries in the overall ranking. Among those economies Poland took a relatively high 16th position. A large scale of industrial production (15th) and a high level of diversification of the Polish economy (19th) contributed particularly to reaching such a position. A slightly different picture of the Polish economy was shown by an analysis of factors of production. In this respect, Poland was at the bottom of the ranking of the leading economies – 24th, before Slovenia. However, it should be noted that in the overall ranking Poland only ranked 31st in terms of production factors. This means that it was ranked among the leaders mainly due to the assessment of the structure of its economy. The analysis of the various areas comprising broadly defined production factors indicates that Poland scored relatively high in terms of global trade and investment, the demand environment and sustainable resources. In the other areas, this item scored worse. This concerned the institutional framework, technologies and innovations, and human capital.

Table 7.1 Ranking 25 countries leading in terms of production structure

Country	Production structure		Diversity		Scale	
	(1)	(2)	(1)	(2)	(1)	(2)
Japan	8.99	1	10.00	1	7.47	5
South Korea	8.85	2	8.96	4	8.69	2
Germany	8.68	3	9.40	3	7.59	4
Switzerland	8.39	4	9.82	2	6.25	12
China	8.25	5	7.08	27	10.00	1
Czech Republic	7.94	6	8.74	5	6.76	8
United States	7.78	7	8.58	8	6.59	10
Sweden	7.46	8	8.74	5	5.55	23
Austria	7.46	9	8.69	7	5.62	21
Ireland	7.34	10	8.16	13	6.11	14
Singapore	7.28	11	8.40	11	5.59	22
United Kingdom	7.05	13	8.58	8	4.74	37
Finland	7.00	14	8.43	10	4.85	33
Italy	6.99	15	7.74	18	5.87	16
France	6.87	18	8.00	15	5.18	28
Poland	**6.83**	**19**	**7.47**	**21**	**5.88**	**15**
Malaysia	6.81	20	6.80	30	6.82	7
Slovenia	6.80	21	8.27	12	4.60	39
Belgium	6.51	24	7.61	19	4.88	32
Israel	6.43	25	7.87	16	4.27	48
Netherlands	6.32	26	7.43	22	4.65	38
Denmark	6.29	27	7.61	19	4.31	46
Spain	6.05	29	6.70	32	5.06	30
Canada	5.81	33	6.50	34	4.77	34
Estonia	5.75	34	7.36	23	3.34	70

Source: Own study based on WEF and ATK [2018].

Table 7.2 Ranking of 25 countries leading in terms of production factors

Country \ Factor	Production factors		Technologies and innovations		Human capital		Global trade and investment		Institutional framework		Sustainable resources		Demand environment	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
USA	8.16	1	8.52	1	7.91	3	7.73	5	8.55	9	6.69	37	8.54	1
Singapore	7.96	2	7.36	6	8.00	2	9.02	1	9.13	1	6.10	56	6.38	14
Switzerland	7.92	3	7.87	3	8.47	1	7.21	10	8.83	5	8.75	3	6.68	7
United Kingdom	7.84	4	8.05	2	7.48	8	8.29	4	8.24	13	7.42	22	7.08	6
Netherlands	7.75	5	7.73	4	7.12	13	8.37	3	8.69	8	7.73	15	6.56	9
Germany	7.56	6	7.16	8	7.49	7	7.32	8	8.22	14	7.78	13	7.55	4
Canada	7.54	7	7.08	10	7.90	4	7.49	6	8.47	10	7.71	16	6.42	12
Sweden	7.40	9	7.31	7	7.51	6	6.77	19	8.82	6	8.78	2	5.88	24
Denmark	7.20	10	6.90	12	7.30	12	6.79	18	8.84	4	8.38	8	5.41	34
Finland	7.16	11	7.45	5	7.34	11	6.06	29	8.89	3	8.46	6	5.29	37
France	6.89	14	6.82	14	6.48	23	6.94	14	7.31	21	8.19	10	6.50	10
Ireland	6.85	15	6.57	18	6.99	14	6.83	16	7.92	16	6.70	36	5.66	30
Japan	6.82	16	6.58	16	6.03	28	6.20	27	7.76	17	6.67	39	7.81	3
Belgium	6.80	17	6.41	19	6.91	15	6.66	21	7.57	18	7.12	24	6.22	18
Austria	6.79	18	6.20	21	6.78	18	6.54	22	8.04	15	8.74	4	5.63	31
South Korea	6.51	21	6.57	17	5.90	30	6.82	17	6.86	25	6.49	46	6.40	13
Malaysia	6.51	22	5.85	23	6.52	21	7.39	7	6.56	30	5.98	60	6.32	17
Israel	6.24	23	6.79	15	6.83	17	5.34	53	7.01	23	6.03	58	4.96	44
Spain	6.23	24	5.69	26	5.90	31	6.85	15	6.54	31	6.91	29	5.93	22
China	6.14	25	5.74	25	5.57	40	7.21	9	4.88	61	5.52	66	7.93	2
Czech Republic	6.01	26	5.07	31	6.50	22	6.22	26	6.66	29	7.57	18	4.97	43
Estonia	6.00	27	5.80	24	6.52	20	5.83	35	7.33	20	6.24	52	3.95	74
Italy	5.90	30	5.66	27	5.89	32	6.02	30	5.23	48	6.92	28	6.62	8
Poland	**5.83**	**31**	**4.75**	**37**	**5.66**	**36**	**6.41**	**23**	**6.14**	**39**	**7.09**	**25**	**5.90**	**23**
Slovenia	5.71	32	4.82	35	6.03	27	5.62	40	6.79	27	8.56	5	4.18	67

Notes: (1) score, (2) ranking position.

Source: Own study based on WEF and ATK [2018].

Comparing the ranking in question to previous assessments of the potential of the Polish economy in the context of Industry 4.0, it should be pointed out that the results are only apparently contradictory because the WEF and ATK [2018] discussed is consistent with the observations made by Michałowski et al. [2018], Castelo-Branco et al. [2019] or IMD [2018] regarding the assessment of the technological potential or ICT infrastructure. Compared with those studies, the WEF and ATK [2018] ranking is broader and includes a greater number of factors determining the industrial potential of an economy. At the same time, it is useful in that it demonstrates weaknesses that need improvement, including in the context of preparedness of Polish industry for challenges of the Fourth Industrial Revolution.

7.3 Competitiveness of Polish Industry in Foreign Trade

For the purpose of this study, the competitiveness of Polish industry in foreign trade will be assessed with the use of the BEC (Broad Economic Categories) nomenclature, which makes it possible to distinguish the direction of use of imports and exports, and consequently to distinguish the flows of capital goods, intermediate goods and consumer goods. It allows a more precise description of the nature of trade flows, including linking them to an analysis of industries and production chains [GUS, 2017].

According to the Polish exports data for 2018, as presented in Table 7.3, the Polish commodity exports comprised 42.3% of intermediate goods, 34.4% consumer goods, and 20.4% capital goods. Passenger cars have been excluded from the categories, as they may be both consumer and capital goods; their share in commodity exports was 2.8% in 2018. It should also be noted that significant changes have taken place, both in the volume and structure of exports of goods, over the past 15 years, i.e. since 2004. The nominal value of total Polish exports of goods increased from PLN 272.1 bn in 2004, to PLN 882.6 bn in 2017 and PLN 940.4 bn in 2018.

The structure of Polish exports by use of goods was also changing at the same. Exports of Polish consumer goods were increasing faster than exports of other categories of goods – from PLN 131.1 bn in 2004, to PLN 303.2 bn in 2017 and PLN 323.2 bn in 2018. This translated into an increase in the share of consumer goods in total exports of goods in 2004–2018 from 27% to 34.4%. Exports of capital goods were growing only slightly faster than total exports of goods and increased from PLN 51.3 bn to PLN 173.6 bn in 2017 and PLN 192 bn in 2018. Exports of intermediate goods were growing at the slowest rate compared with other categories of use but their share in exports of goods remained the highest throughout the period. It increased from PLN 131.1 bn in 2004 to PLN 375.3 bn in 2017 and PLN 397.7 bn in 2018. Consequently, its share in total exports of goods dropped from 48.2% to 42.3%.

When analyzing the structure of exports within the three categories of goods by use, it should be noted that, in the case of export of intermediate goods, processed industrial supplies not elsewhere specified had the highest share exports in 2018.

Table 7.3 Export of industrial commodities (2004, 2010, 2017 and 2018), PLN bn, %

Flows/years Commodity group	Export				% of total commodity exports			
	2004	2010	2017	2018	2004	2010	2017	2018
Total	272.1	481.1	882.6	940.4	100.0	100.0	100.0	100.0
01 – Capital goods (except transport equipment)	14.9	39.7	89.2	99.5	5.5	8.3	10.1	10.6
02 – Industrial transport equipment	16.8	19.9	33.4	37.9	6.2	4.1	3.8	4.0
03 – Food and beverages, unprocessed, mainly for industry	1.5	2.5	4.2	3.5	0.6	0.5	0.5	0.4
04 – Food and beverages, processed, mainly for industry	1.7	3.0	5.8	5.7	0.6	0.6	0.7	0.6
05 – Industrial supplies not elsewhere specified, unprocessed	5.1	8.2	14.7	17.4	1.9	1.7	1.7	1.9
06 – Industrial supplies not elsewhere specified, processed	75.1	122.5	223.4	235.8	27.6	25.5	25.3	25.1
07 – Fuels and lubricants, unprocessed	5.2	3.7	4.4	3.7	1.9	0.8	0.5	0.4
08 – Fuels and lubricants, processed (other than motor spirit)	9.2	15.2	17.1	20.0	3.4	3.2	1.9	2.1
09 – Parts and accessories for capital goods (ex. parts and acc. for trans. eq.)	19.6	33.9	51.0	54.6	7.2	7.0	5.8	5.8
10 – Parts and accessories for transport equipment	33.3	53.9	105.7	111.6	12.2	11.2	12.0	11.9
11 – Food and beverages, unprocessed, mainly for households	4.3	7.7	13.7	13.7	1.6	1.6	1.6	1.5
12 – Food and beverages, processed, mainly for households	14.1	32.5	73.0	77.0	5.2	6.8	8.3	8.2
13 – Transport equipment, non-industrial	1.0	1.1	2.9	3.0	0.4	0.2	0.3	0.3
14 – Consumer goods not elsewhere specified, durable	22.9	48.9	73.7	80.2	8.4	10.2	8.4	8.5
15 – Consumer goods not elsewhere specified, semi-durable	17.1	24.3	62.6	69.5	6.3	5.1	7.1	7.4
16 – Consumer goods not elsewhere specified, non-durable	14.2	36.5	77.1	79.8	5.2	7.6	8.7	8.5
18 – Passenger cars	15.6	26.5	29.4	26.2	5.7	5.5	3.3	2.8
19 – Goods not elsewhere specified, non-durable	0.5	1.0	1.4	1.4	0.2	0.2	0.2	0.1
Capital goods and industrial transport equipment (01+02+09)	51.3	93.5	173.6	192.0	18.9	19.4	19.7	20.4
Intermediate (03+04+05+06+07+08+10)	131.1	209.0	375.3	397.7	48.2	43.4	42.5	42.3
Consumer goods except passenger cars (11+12+13+14+15+16)	73.6	151.0	303.0	323.2	27.0	31.4	34.3	34.4

Notes: Group categories according to the BEC nomenclature.

Source: Own study based on GUS data.

Moreover, their share of total exports fell to 25.1% (PLN 235.8 billion) in 2018 compared to 2004, when it represented 27.6% (PLN 75.1 billion), but its value in the period in question increased from PLN 75.1 billion to PLN 235.8. Ranking next were parts and accessories for transport equipment. Their share in total goods exports fell slightly over the 2004–2018 period from 12.2% to 11.9%, but its value increased from PLN 33.3 bn to PLN 111.6 billion. The share of each of the other categories of intermediate goods in Polish exports of goods did not exceed 2.1% in 2018.

An analysis of changes in the structure of consumer goods exports shows that four commodity groups had a comparable share in the exports of such goods in 2018. The first group consisted of durable consumer goods not elsewhere specified. Their share in total goods exports increased slightly over the 2004–2018 period from 8.4% to 8.5%, but their export value increased from PLN 22.9 bn to PLN 80.2 bn. The second largest group consisted of non-durable consumer goods not elsewhere specified, whose share in goods exports increased over the period in question from 5.2% to 8.5%, and their export value increased from PLN 14.2 bn to PLN 79.8 bn. Ranking third were food and beverages, processed, mainly for households, whose share in goods esports increased from 5.2% to 8.2%, and their export value increased from PLN 14.1 bn to PLN 77 bn. The fourth group comprised semi-durable consumer goods not elsewhere specified. Their share in goods exports increased over the period in question from 6.3% to 7.4%, and their export value increased from PLN 17.1 bn to PLN 69.5 bn.

While the share of exports of capital goods in total goods exports changed only slightly during the period under study, the shares of the individual commodity groups falling within this category of goods changed significantly. The share of capital goods (except transport equipment) increased significantly over the 2004–2018 period from 5.5% to 10.6%, and their export value increased from PLN 14.9 bn to PLN 99.9 bn. In contrast, the share of exports of parts and accessories for capital goods (except parts and accessories for transport equipment) decreased from 7.2% to 5.8%, of the goods export value, but the value of the exports increased from PLN 19.6 bn to PLN 54.6 bn. The share of industrial transport equipment exports also fell during the period under study, from 6.2% to 4%, whereas their value increased from PLN 16.8 bn to PLN 37.9 billion.

The above trends in changes in the structure of Polish exports should be viewed positively. In particular, Poland's continuing strong position in intermediate goods exports should be pointed out, which is indicative of strong forward linkages along value chains. What is more, the exports involve mainly processed goods for industry as well as parts and accessories for transport equipment. It should also be noted that those categories of export goods are particularly susceptible to the impact of factors related to the development of international production chains, in which solutions typical of Industry 4.0 have an increasing role. This means that maintaining a competitive position in exporting those goods in the future will require ongoing adaptation of such solutions in business. The positive developments that come to the fore in assessing trends in the export of final goods are the key significance of processed goods and relatively high diversification of Polish exports of consumer goods, as well as their growing share in total exports. The trend is positive in that it supports the diversification of exports and renders exports resistant to economic fluctuations. This is so because exports of intermediate goods are more susceptible to economic fluctuations than exports of consumer goods.

When assessing the competitiveness of Polish exports of goods, one must not disregard imports, which additionally indicate, in the case of intermediate goods, the strength of backward linkages in value chains. Those issues will be analyzed indirectly on the basis of an analysis of the balance of commodity trade presented in Table 7.4. In the case of intermediate goods, a growing deficit in commodity trade was recorded in all categories of intermediate goods except parts and accessories for transport equipment. A trade surplus of PLN 45.1 bn was recorded in this category of goods in 2018. However, a trade deficit was reported in the other categories of intermediate goods. It was the highest for unprocessed fuels and lubricants and for processed industrial supplies not elsewhere specified. The trends described show growing backward linkages in production chains in the Polish economy – in particular with regard to goods for industry. It should also be noted that while Poland records a deficit (stable over the entire period) also in trade in capital goods, there has been a growing surplus in consumer goods trade, in particular in the processed goods category. During 2004–2018, the surplus increased from PLN 25.3 bn to PLN 122.2 bn, and it largely accounted for the overall improvement in the balance of trade in the period under study.

The above trends of changes in the structure of Polish commodity exports and in the commodity trade balance is worth complementing with an analysis of revealed comparative advantage (RCA) indices, the values of which for different commodity groups are presented in Table 7.5. An analysis of that table shows that, in terms of the use of exported goods, Poland has been recording positive RCA values in consumer goods trade and negative values in capital and intermediate goods trade. At the same time, the value of RCA showing advantages in consumer goods trade are greater in absolute terms than absolute RCA values for trade in capital and intermediate goods. It should also be noted that in 2018 Poland reported negative RCA values in all categories of intermediate goods, but most of them were close to zero (except trade in unprocessed fuels and lubricants). In the case of capital goods, a positive RCA was recorded only for industrial transport equipment. For consumer goods, a positive RCA was recorded in almost all categories of goods except unprocessed food and beverages (RCA –0.2) and semi-durable consumer goods not elsewhere specified (RCA 0).

Table 7.4 Balance of trade in industrial commodities (2004, 2010, 2017 and 2018), PLN bn

Commodity group	2004	2010	2017	2018
Total	–53.5	–55.1	2.5	–21.4
01 – Capital goods (except transport equipment)	–28.3	–29.3	–19.0	–15.9
02 – Industrial transport equipment	–2.3	4.4	7.2	8.0
03 – Food and beverages, unprocessed, mainly for industry	0.2	–0.4	–2.9	–3.3
04 – Food and beverages, processed, mainly for industry	–0.7	–1.4	–2.1	–1.8
05 – Industrial supplies not elsewhere specified, unprocessed	–3.3	–3.6	–5.7	–3.6
06 – Industrial supplies not elsewhere specified, processed	–33.1	–37.2	–44.0	–49.9
07 – Fuels and lubricants, unprocessed	–15.8	–49.8	–45.2	–67.6
08 – Fuels and lubricants, processed (other than motor spirit)	0.7	1.2	–5.9	–6.7
09 – Parts and accessories for capital goods (ex. parts and acc. for trans. eq.)	–9.8	–22.9	–32.0	–34.5
10 – Parts and accessories for transport equipment	11.1	18.3	42.8	45.1
11 – Food and beverages, unprocessed, mainly for households	0.3	–0.9	–3.6	–3.9
12 – Food and beverages, processed, mainly for households	6.8	14.0	39.0	42.1
13 – Transport equipment, non-industrial	0.6	0.5	1.9	1.9
14 – Consumer goods not elsewhere specified, durable	16.2	37.4	51.6	54.2
15 – Consumer goods not elsewhere specified, semi-durable	5.7	0.6	–0.7	1.7
16 – Consumer goods not elsewhere specified, non-durable	–4.3	3.8	26.7	26.2
18 – Passenger cars	2.5	9.9	–5.6	–13.3
19 – Goods not elsewhere specified, non-durable	0.1	0.3	0.3	0.0
Capital goods and industrial transport equipment (01+02+09)	–40.4	–47.8	–43.8	–42.4
Intermediate (03+04+05+06+07+08+10)	–40.9	–72.9	–63.0	–87.8
Consumer goods except passenger cars (11+12+13+14+15+16)	25.3	55.4	114.9	122.2

Notes: Group categories according to the BEC nomenclature. Logarithmic RCA.

Source: Own study based on GUS data.

Table 7.5 RCA indices for trade in industrial commodities (2004, 2010, 2017 and 2018)

Commodity group	2004	2010	2017	2018
01 – Capital goods (except transport equipment)	–0.9	–0.4	–0.2	–0.1
02 – Industrial transport equipment	0.1	0.4	0.2	0.3
03 – Food and beverages, unprocessed, mainly for industry	0.3	0.0	–0.5	–0.6
04 – Food and beverages, processed, mainly for industry	–0.2	–0.3	–0.3	–0.3
05 – Industrial supplies not elsewhere specified, unprocessed	–0.3	–0.3	–0.3	–0.2

cont. tab 7.5

Commodity group	2004	2010	2017	2018
06 – Industrial supplies not elsewhere specified, processed	–0.2	–0.2	–0.2	–0.2
07 – Fuels and lubricants, unprocessed	–1.2	–2.6	–2.4	–2.9
08 – Fuels and lubricants, processed (other than motor spirit)	0.3	0.2	–0.3	–0.3
09 – Parts and accessories for capital goods (ex. parts and acc. for trans. eq.)	–0.2	–0.4	–0.5	–0.5
10 – Parts and accessories for transport equipment	0.6	0.5	0.5	0.5
11 – Food and beverages, unprocessed, mainly for households	0.3	0.0	–0.2	–0.2
12 – Food and beverages, processed, mainly for households	0.8	0.7	0.8	0.8
13 – Transport equipment, non-industrial	1.1	0.7	1.1	1.0
14 – Consumer goods not elsewhere specified, durable	1.4	1.6	1.2	1.1
15 – Consumer goods not elsewhere specified, semi-durable	0.6	0.1	0.0	0.0
16 – Consumer goods not elsewhere specified, non-durable	–0.1	0.2	0.4	0.4
18 – Passenger cars	0.4	0.6	–0.2	–0.4
19 – Goods not elsewhere specified, non-durable	0.4	0.5	0.2	0.0
Capital goods and industrial transport equipment (01+02+09)	–0.4	–0.3	–0.2	–0.2
Intermediate (03+04+05+06+07+08+10)	–0.1	–0.2	–0.2	–0.2
Consumer goods except passenger cars (11+12+13+14+15+16)	0.6	0.6	0.5	0.5

Notes: Group categories according to the BEC nomenclature. Logarithmic RCA.

Source: Own study based on GUS data.

Summary and Conclusions

To sum up the above analyses of competitiveness of Polish industry in foreign trade on the basis of trade data according to the BAC nomenclature, it should be noted that Polish industry is characterized by strong backward and forward linkages within value chains. That said, the linkages are stronger backwards than forward. As regards backward linkages, purchases of less processed goods stand out, whereas in forward linkages sales of more processed goods prevail. The trend consolidated over the analyzed period, which should be viewed positively. Throughout the period, Poland was also a net importer of capital goods, and despite an increase in exports of imports of the goods the deficit remained constant at well over PLN 40 bn annually. At the same time, over the entire period under study, the Polish economy was strengthening its advantage in exports of consumer goods, including in particular processed goods. It can also be taken for granted that at least a part of imports of intermediate goods represented the import of supplies for the production of those goods.

Referring the assessment of the competitiveness of Polish industry to the presented analyses of the potential of the Polish economy with regard to Industry 4.0, it should be pointed out that Poland was clear weaknesses in digital infrastructure or utilization of digital solutions by enterprises. However the impact of those weaknesses has been mitigated so far by the export-promoting development of Polish industry related both to the inflow of foreign investors and to the growth of the export capacity of domestic enterprises. For this reason, a clear strength of the Polish economy in the context of Industry 4.0 is the dynamics of Polish exports. Strong linkages of the Polish economy in value chains and an increasing diversification of Polish exports are indicative of a high potential of the Polish economy. However, further persistence of weaknesses of the Polish economy with regard to Industry 4.0, with simultaneous depletion of labor cost advantages may pose a risk to the sustainability of the export-promoting development of the Polish economy.

Bibliography

Alcácer, V., Cruz-Machado, V. [2019], *Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems, Engineering Science and Technology*, an International Journal, In press, corrected proof.

Barreto, L., Amaral, A., Pereira, T. [2017], *Industry 4.0 implications in logistics: an overview*, "Procedia Manufacturing", Vol. 13, 2017, pp. 1245–1252.

Castelo-Branco, I., Cruz-Jesus, F., Oliveira, T. [2019], *Assessing Industry 4.0 readiness in manufacturing: Evidence for the European Union*, "Computers in Industry" Vol. 107, 2019, pp. 22–32.

Chiarello, F., Trivelli, L., Bonaccorsi, A., Fantoni, G. [2018], *Extracting and mapping industry 4.0 technologies using Wikipedia*, "Computers in Industry", Vol. 100, September 2018, pp. 244–257.

Dalenogare, L.S., Benitez, G.B., Ayala, N.F., Frank, A.G. [2018], *The expected contribution of Industry 4.0 technologies for industrial performance*, "International Journal of Production Economics", Vol. 204, October 2018, pp. 383–394.

Dossou, P-E. [2018], *Impact of Sustainability on the supply chain 4.0 performance*, "Procedia Manufacturing", Vol. 17, 2018, pp. 452–459.

Frank, A.G., Dalenogare, L.S., Ayala, N.F. [2019a], *Industry 4.0 technologies: Implementation patterns in manufacturing companies*, "International Journal of Production Economics", Vol. 210, April 2019, pp. 15–26.

Frank, A.G., Mendes, G.H.S., Ayala, N.F., Ghezzi, A. (2019b), *Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective*, "Technological Forecasting and Social Change", Vol. 141, April 2019, pp. 341–351.

GUS [2017], *Rocznik statystyczny handle zagranicznego 2017*, Główny Urząd Statystyczny, Warsaw.

IMD [2018], *IMD World Digital Competitiveness Ranking 2018*, Lausanne.

Michałowski, B., Jarzynowski, M., Pacek, P. [2018], *Szanse i wyzwania polskiego przemysłu 4.0. Integracja robotyki i automatyki przemysłowej z rynkiem teleinformatyki*, Agencja Rozwoju Przemysłu, Warsaw.

Müller, J.M., Voigt, K-I. [2018] *The Impact of Industry 4.0 on Supply Chains in Engineer-to-Order Industries – An Exploratory Case Study*, "IFAC-PapersOnLine", Vol. 51, Issue 11, 2018, pp. 122–127.

Porter, M.E. [1990], *The Competitive Advantage of Nations*, Macmillan Business, London.

Radło, M-J. [2008], *Międzynarodowa konkurencyjność gospodarki. Uwagi na temat definicji, czynników i miar*, in: W. Bieńkowski et al., *Czynniki i miary międzynarodowej konkurencyjności gospodarek w kontekście globalizacji – wstępne wyniki badań*, "Prace i Materiały" No. 284, Instytut Gospodarki Światowej, Warsaw.

WEF and ATK [2018], *Readiness for the Future of Production Report 2018*, World Economic Forum in collaboration with A.T. Kearney, Internet: http://www3.weforum.org/docs/FOP_Readiness_Report_2018.pdf.

Chapter 8

Significance of Foreign Direct Investment to the Digital Competitiveness of the Polish Economy

Tomasz M. Napiórkowski

Introduction

The role of individual production factors changes with the development of the economy. In the initial stage, the workforce resource is of key significance. Over time, physical capital begins to play a role, followed by a broadly defined technology and human capital. The last three factors translate into higher labor productivity, and thereby into higher competitiveness of an economy. Watching the economic development of countries of key significance to the global economy (USA, China, etc.), it can be noted that the main determinant of their current and (and probably above all) future competitiveness is technology. However, technology itself is not enough, as it requires elements such as the capacity of business entities to absorb technology and, in order to deploy multiple technological solutions, a high degree of digitalization of the economy as a whole.

With this in mind, the aim of this study is to link foreign direct investment (hereinafter: FDI) to Poland's digital competitiveness. In other words, this study seeks answers to the question about the importance of Foreign Direct Investment to the digital competitiveness of the Polish economy. The link between digital competitiveness and foreign direct investment has not yet been a subject of extensive research.

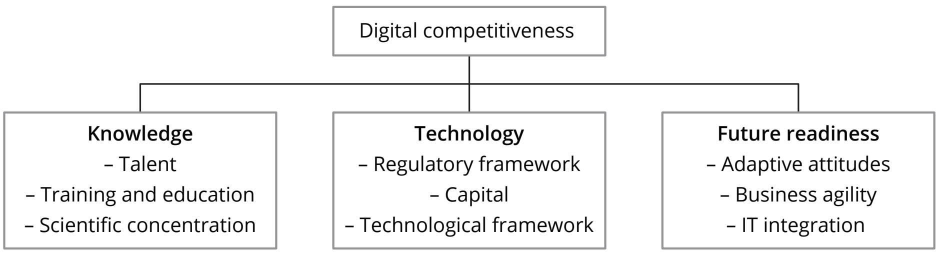
The main limitation of the study, which should be mentioned at the outset, because it significantly determines the choice of the research method, is the absence of sufficiently long time series, which could be used for econometric modelling. Based on the literature, a link will be established between the effects of FDI on the host country and the elements of the Digital Competitiveness Model, hereinafter: DCM [IMD, 2017]. In the next step, the FDI values (stock and flows) in Poland will be linked (using trend analysis) to Poland's digital competitiveness. Keeping in mind the above, and the very limited literature on the subject being considered, both the study and its results should be treated as preliminary exploratory research.

For consistency reasons, the definitions come from data sources for the given indicators. Digital competitiveness is defined as the "capacity of an economy to adopt and explore digital technologies leading to the transformation in government practices, business models and society in general" [IMD, 2017, p. 19], while foreign direct investment is defined as "an investment involving a long term relationship and reflecting a lasting interest and control by a resident entity in one economy (foreign direct investor or parent enterprise) in an enterprise resident in an economy other than that of the foreign direct investor (FDI enterprise or affiliate enterprise or foreign affiliate", where FDI gives the investor at least 10% of the voting power [UNCTAD, 2017a, p. 3].

8.1 Digital Competitiveness and Foreign Direct Investment – Theoretical Model

According to the IMD report [2017], "a digital competitiveness framework must be built on factors, which encompass organizational, institutional and structural elements" [IMD, 2017, pp. 19–20]. The model (Figure 8.1) proposed by the authors of the study is based on three factors: knowledge, technology and readiness to change.

Figure 8.1 Digital Competitiveness Model (DCM)



Source: IMD [2017, p. 20].

The knowledge factor describes the existing infrastructure needed to create digital competitiveness. While its first two elements (i.e. "Talent" and "Training and education") can be described as part of human capital, "Scientific concentration" represents the need to invest in knowledge and to expand its existing resources and to build new ones for existing knowledge areas. The second of the analyzed factors ("Technology") is focused on the existing regulatory framework that should support and promote changes (e.g. innovative business) necessary to achieve the highest possible competitiveness level. As with knowledge, also in the case of technology, continuous investment is necessary, as well as attracting new potential investments, the risk of these investments should not only be minimized but also adequately managed. The third and final element of the "Technology" factor is the existing (i.e., available) technology infrastructure, the quality of which is not without significance. The "Future readiness" factor represents the preparedness of a given economy for digital transformation. This factor includes elements such as the willingness of society to change, the flexibility of the enterprise sector in areas such as the modification of an existing business model or the introduction of relevant practices and processes [IMD, 2017].

Having regard to the literature examining the impact of FDI on a host country, at least at a theoretical level, a link can be found between the benefits of hosting the investments analyzed and the changes in the values of factors behind digital competitiveness.

Despite the heterogeneity of the results of empirical studies on the benefits of hosting Foreign Direct Investment [e.g., McGrattan, 2011; Iamsiraroj i Ulubaşoğlu, 2016][1], the theoretical background of the influence of FDI on the economy of the host country has been documented [e.g., Napiórkowski, 2017]. Authors such as Pilbeam and Oboleviciute [2012] indicate the positive impact of FDI on national investment, while Tomohara and Takii [2011] or Javorcik [2015] note an increase in wages in the host economy. While direct benefits of FDI (i.e., which do not require parallel investment or other significant activities on the host side) are important for the economic development of the host country, FDI spillovers (i.e., indirect benefits) are more important having regard to the DCM model. They are technology transfer [Liu et al., 2016] and knowledge transfer [Temiz and Gökmen, 2014]. The channels, through which those FDI spillovers are transferred are demonstration (or imitation) of foreign solutions, mobility of workers, export[2], competition, and forward or backward linkages in the value chain between foreign firms and host country firms [Crespo and Fontoura, 2007, p. 411]. Salim et al. [2017] define technology spillovers as "the beneficial impacts of new technological knowledge on the productivity and technological capability of other firms or countries " [Salim et al., 2017, p. 209]. Knowledge spillovers (at firm level) are defined by Smeets [2008] as "knowledge created by one firm (a multinational enterprise) that is used by a second firm (a host-country firm) for which the host-country firm does not (fully) compensate the multinational enterprise… [knowledge transfer itself being defined

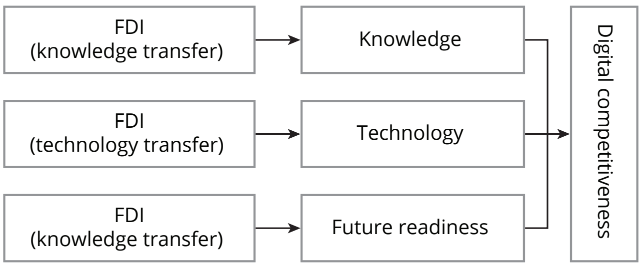
1 Examples of such discrepancies are e.g. studies by Pilbeam and Oboleviciute [2012] and Szkorupová [2015]. The pair of researchers came to the conclusion that "FDI has no negative impact on domestic investment in [Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovenia and Slovakia]" [Pilbeam and Oboleviciute, 2012, p. 89], while Szkorupová has shown that effect of crowding out of domestic investment does exist in the countries concerned (Czech Republic, Estonia, Hungary and Slovakia). These differences may arise from empirical elements [e.g. Faral et at., 2016].

2 Also Kim et al. [2015].

as] the purposeful or intended diffusion of knowledge from one firm to the other" [Smeets, 2008, p. 109]. To obtain spillovers, absorptive capacity of business entities[3] in the host country is necessary [e.g., Azam and Ahmed, 2015 – or, more extensively, Aprillyanti and Alon, 2017].

Combining the analyzed literature on FDI with the DCM model, a digital competitiveness model can be developed that takes into account the spillovers of hosting foreign direct investment (Figure 8.2).

Figure 8.2 Digital Competitiveness Model (DCM) taking into account FDI hosting spillovers



Source: Own study based on IMD [2017, p. 20].

In the report "World Investment Report 2017. Investment and the Digital Economy" [UNCTAD, 2017b], the authors stress that the relationship between the digital economy[4] and foreign direct investment is a bilateral relationship, and that digital transformation may simultaneously be a big challenge and a big opportunity for developing countries. The authors of the report also stress that the development of digital economies can be both, an accelerator and an inhibitor of development for multinational corporations. A high degree of digitalization provides, e.g., new channels through which foreign firms can reach customers, which may eliminate the need to operate their own distribution or production centers in the customer's country. On the other hand, firms that have developed their online presence (i.e., established their market presence in a potential host country, e.g., through online sales) incur a lower risk when deciding to embark on Foreign Firect Investment, which, by definition, is the riskiest form of international expansion. Furthermore, high levels of digitalization allow for more accurate, yet less

[3] Speaking of the capacity to absorb FDI spillovers, it should be noted that the definition of this phenomenon ("the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" [Apriliyantii and Alon, 2017, p. 896]) is largely analogical to the third factor of the DCM model, i.e. the ability to adopt change.

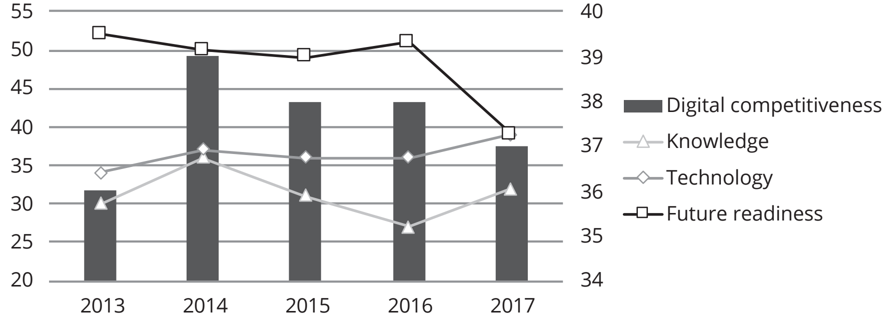
[4] "The digital economy – the application of internet-based digital technologies to the production and trade of goods and services" [UNCTAD, 2017b, p. 156].

costly management systems. All this leads the authors of the analyzed report to the conclusion that the existing regulatory framework related to the direct investments examined will have to be verified, as they are mostly based on, e.g., the physical presence of assets of a (foreign) parent firm. Based on the three trends presented in the UNCTAD report [2017b], describing how digital and technological transnational corporations are internationalized (i.e., limited physical presence of assets, large cash reserves kept overseas and concentration of productive investment in a small number of developed economies), it is concluded that digitalization will also affect the role played by the traditional determinants of foreign direct investment. Referring to the theoretical model linking Foreign Direct Investment with digital competitiveness (Figure 8.2), in which FDI spillovers are fundamental, in should be stressed, on the basis of the analyzed UNCTAD report [2017b], that the inclusion of a host-country firm into the digitalization-based value chain of a transnational corporation poses additional challenges to the host-country firm. It should be reiterated here that it is through participation in value chains that the transfer of technology and knowledge takes place – two elements linking FDI with digital competitiveness.

8.2 Digital Competitiveness the Polish Economy – Status Quo

The 2017 IMD study shows that in 2017 Poland ranked 37th among 63 analyzed economies in terms of digital competitiveness (Figure 8.3). While this means an upward movement by one place from 2016, Poland's digital competitiveness was ranked better in 2013–36th.

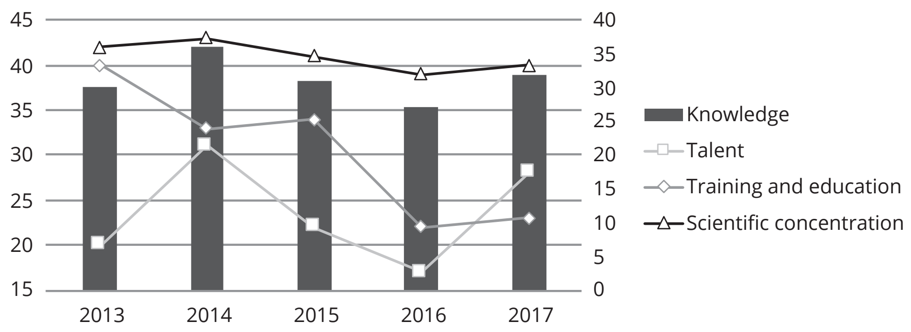
Figure 8.3 Digital competitiveness of Poland (right-hand axis, position in ranking) and its key elements (left-hand axis, position in ranking)



Source: Own study based on IMD [2017] data.

In 2017, Poland was ranked 32nd for the "Knowledge" factor, down by as many as 5 places compared with the previous year, in which Poland performed the best in the period under study (i.e., 2013–2017; Figure 8.4). The strength of the "Knowledge" factor in Poland is "Training and education", and its weakness is "Scientific concentration". However, it is worth noting the "Talent" category, as in 2016 Poland ranked 17th, but only 28th a year later.

Figure 8.4 "Knowledge" category (right-hand axis, position in ranking) and its elements (left-hand axis, position in ranking)

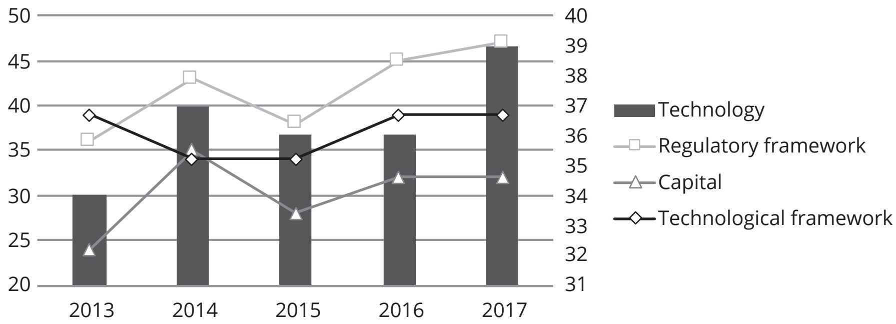


Source: Own study based on IMD [2017] data.

For the "Technology" factor (39th in 2017, down by 3 places), the "Capital" category ranks the highest (32nd), and "Regulatory framework" ranks the lowest (47th) (Figure 8.5). In the latter case, the authors of the IMD report point out the ease of starting a business and immigration law as two key weakness of this factor. To sum up, it can be stated that in the case of two of the three elements of the "Technology" factor ("Capital" and "Technological framework"), Poland's situation has stabilized, while with regard to the regulatory framework Poland ranks worse compared to the other economies.

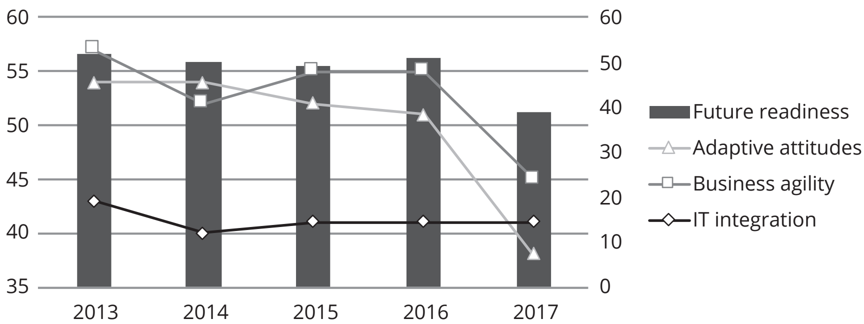
In terms of "Future readiness", Poland ranked 39th in 2017, which means a considerable improvement from the 51st place in 2016 (Figure 8.6). While the "Adaptive attitudes" component is the greatest strength of the factor in question (38th in 2017, 51st in 2016), the authors of the report indicate the "Attitude toward globalization" (forming part of adaptive attitudes) as a key weakness. "IT integration" is persistently ranked around the 40th place, and it is in that category where the key weaknesses of the Polish economy are seen to exist when it comes to building digital competitiveness, such as "Public-private partnerships" and "Cyber security". As can be noticed, in each of the elements of the "Future readiness" factor (except IT integration), Poland moved upwards in the IMD ranking.

Figure 8.5 “Technology” category (right-hand axis, position in ranking) and its components (left-hand axis, position in ranking)



Source: Own study based on IMD [2017] data.

Figure 8.6 “Future readiness” category (right-hand axis, position in ranking) and its components (left-hand axis, position in ranking)

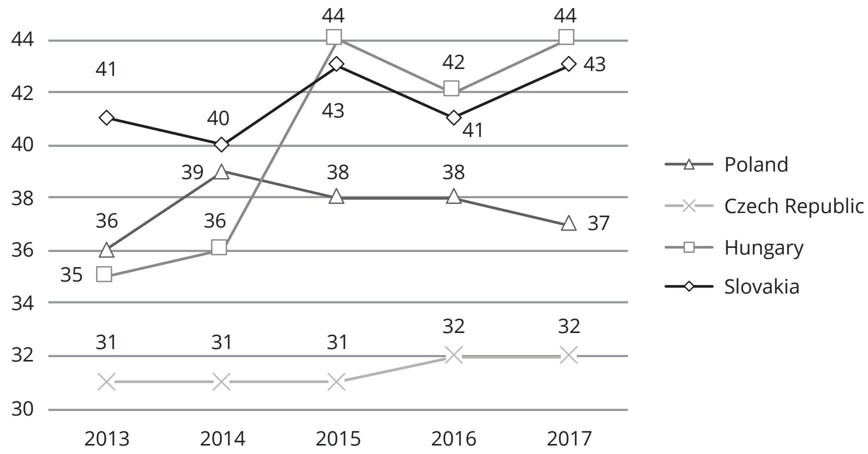


Source: Own study based on IMD [2017] data.

The data presented show that Poland’s digital competitiveness has gradually recovered after the decline in 2014. By comparison, in 2017, the Czech Republic maintained the 32nd place (as it did in 2016) in terms of competitiveness, Hungary ranked 44th (down by 2 places compared to 2016), and Slovakia was 43 rd, having slid down from the 41st place (Figure 8.7). Thus, Poland can be said to rank in the middle among the Visegrad Group countries for digital competitiveness.

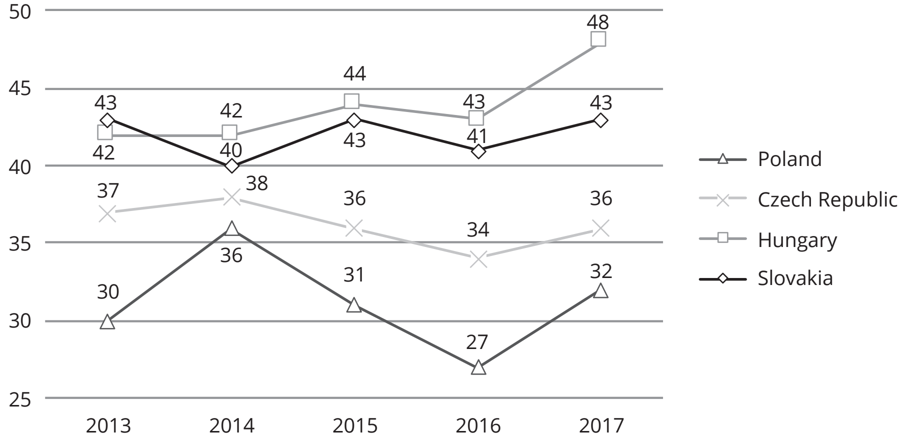
Analyzing the three factors behind digital competitiveness in each of the four Visegrad Group countries, Poland is a leader in terms of knowledge (the Czech Republic ranking second, followed by Slovakia and Hungary; Figure 8.8). Interestingly, in the last year of the study (i.e., in 2017), each of the analyzed countries dropped in the ranking in terms of the studied factor.

Figure 8.7 Digital competitiveness of the Visegrad Group countries (left-hand axis, position in ranking)



Source: Own study based on IMD [2017] data.

Figure 8.8 "Knowledge" factor in the Visegrad Group (left-hand axis, position in ranking)

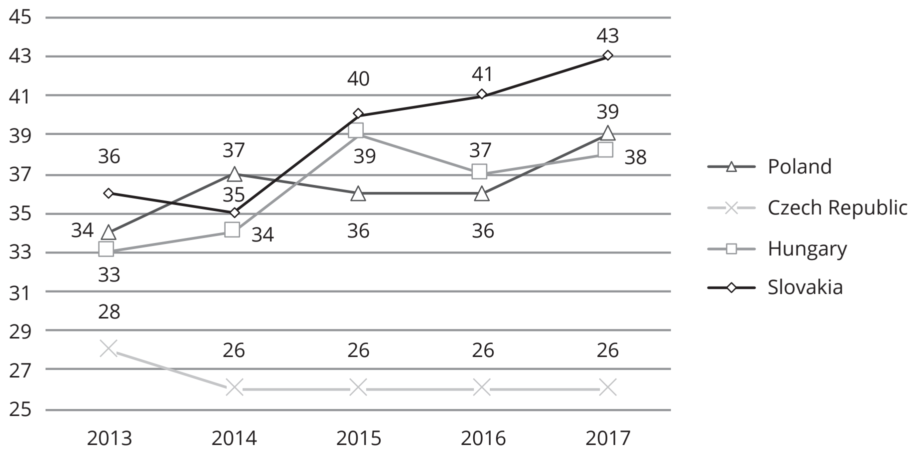


Source: Own study based on IMD [2017] data.

For the "Technology" factor, the Czech Republic is a clear leader, holding a very stable 26th place (Figure 8.9). The position of Poland (39th) is very close to Hungary's (38th), whereas Slovakia (continuing a decline seen in the previous years), hold a distant 43th place in the ranking. Interestingly, also Poland and Hungary witnessed a drop in the ranking for technology in 2017.

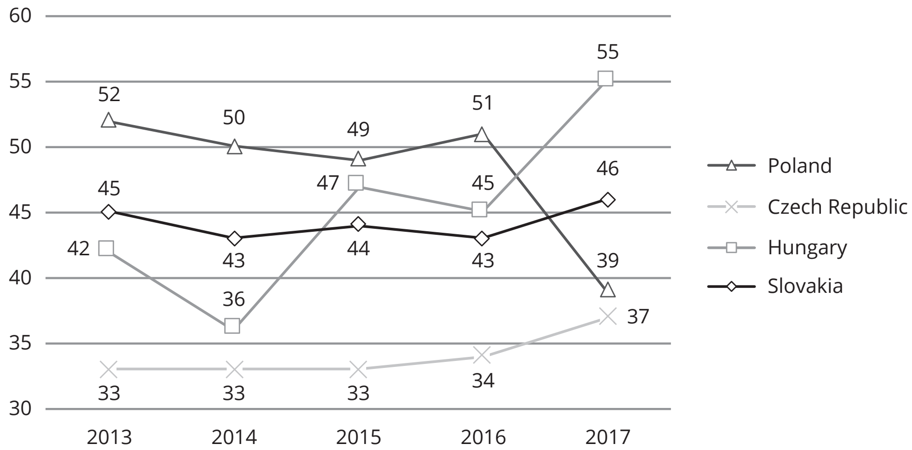
The Czech Republic and Poland rank very close to each other when it comes to future readiness (37th and 39th, respectively; Figure 8.10). The difference is that the Czech Republic is seen to have dropped in the ranking for the factor concerned for two years, while Poland experienced a significant upward movement from the 51st to the 39th place. The position of Slovakia (46th) and Hungary (55th) deteriorated significantly (down from the 43 rd and 45th place, respectively).

Figure 8.9 “Technology” factor in the Visegrad Group (left-hand axis, position in ranking)



Source: Own study based on IMD [2017] data.

Figure 8.10 “Future readiness” factor in the Visegrad Group (left-hand axis, position in ranking)

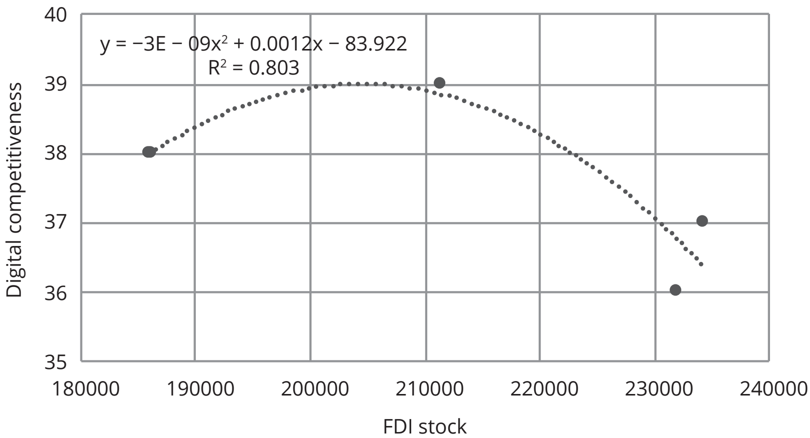


Source: Own study based on IMD [2017] data.

8.3 Digital Competitiveness and Foreign Direct Investment – Empirical Approach

The purpose of this part of the study is to analyze the relationship between Poland's digital competitiveness and FDI activity in Poland. The digital competitiveness of Poland is represented by its position in the IDM ranking [2017], and FDI activity by its stock[5] in Poland and inflows[6] to Poland [data from UNCTAD, 2018b]. As has already been mentioned in the introduction, it must be emphasized again that, due to a lack of sufficiently long time series, the analysis provided in this study is an exploratory analysis.

Figure 8.11 Digital competitiveness (vertical axis, position in ranking) and FDI stock in Poland (horizontal axis, USD millions, constant prices) – Poland



Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

The first conclusion that arises from the empirical analysis is that the relationship between digital competitiveness and FDI resources is not linear (in this case, the coefficient of determination, R-squared, is 38.72%) but rather parabolic (R-squared = 80.3%; Figure 8.11). That is, digital competitiveness grows with FDI stock, but only to a certain

5 "For associate and subsidiary enterprises, it is the value of the share of their capital and reserves (including retained profits) attributable to the parent enterprise (this is equal to total assets minus total liabilities), plus the net indebtedness of the associate or subsidiary to the parent firm. For branches, it is the value of fixed assets and the value of current assets and investments, excluding amounts due from the parent, less liabilities to third parties" [UNCTAD, 2018a].

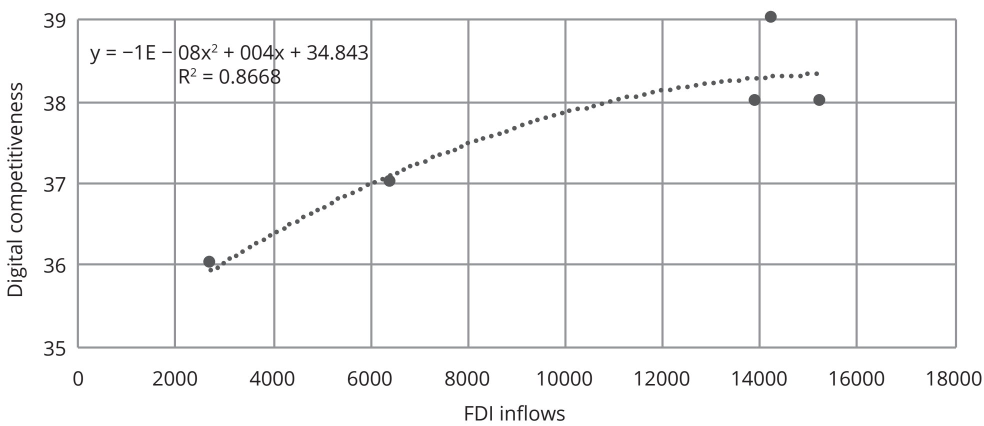
6 "For associates and subsidiaries, FDI flows consist of the net sales of shares and loans (including non-cash acquisitions made against equipment, manufacturing rights, etc.) to the parent company plus the parent firm´s share of the affiliate´s reinvested earnings plus total net intra-company loans (short- and long-term) provided by the parent company. For branches, FDI flows consist of the increase in reinvested earnings plus the net increase in funds received from the foreign direct investor" [UNCTAD, 2018a]

point. For FDI inflows, the coefficient of determination is 86.68%; Figure 8.12). In other words, with an increase in FDI, digital competitiveness grows, but the marginal effect of the relationship is characterized by a negative trend, and in the case of resources it even takes negative values. Such results suggest that (as is the case with FDI spillovers), absorptive capacity is necessary here. In this case, such capacity is represented by the "Future readiness" factor" of the DCM model, for which Poland is ranked 39th (i.e., in the lower half).

Relationship of stock (R-square = 68.56%, Figure 8.13) and inflows (R-square = = 2.92%) FDI with the "Knowledge" FDI factor takes a reversed parabolic shape. This is also the case with the relationship with the "Technology" factor, but in this case relationship with FDI inflows is stronger (R-squared = 85.53%) than with its stock (R-squared = 3.25%).

While the relationship of FDI with the first two factors of the DCM model is in line with the expectations (especially having regard to the necessity of absorptive capacity), the relationship of FDI with future readiness offers astonishing and ambiguous results. For FDI resources, the relationship examined is represented by a reversed parabola (R-squared = 32.31%), while for FDI flows it is a classical parabola (R-squared = 72.08%). Having regard to the fact that future readiness is a highly endogenous factor for each country, ambiguous results may suggest a higher weight of endogenous elements other than those related to FDI for a relationship between the examined variables, or the existence of moderating, or mediating variables.[7]

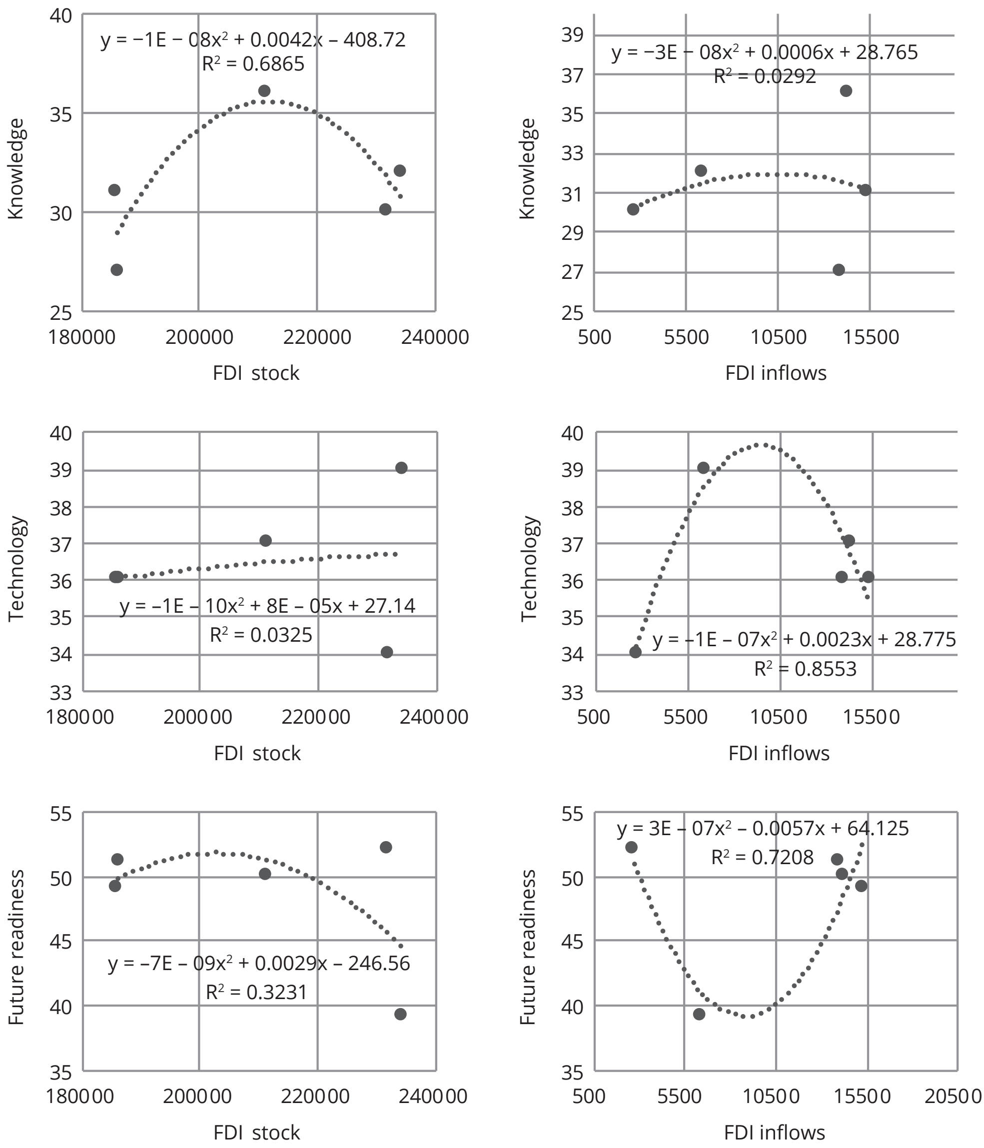
Figure 8.12 Digital competitiveness (vertical axis, position in ranking) and FDI inflows in Poland (horizontal axis, USD millions, constant prices) – Poland



Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

7 Identification of those variables and a further explanation of the phenomenon described goes beyond the framework of this exploratory study and it is left to be tackled by subsequent studies on the subject.

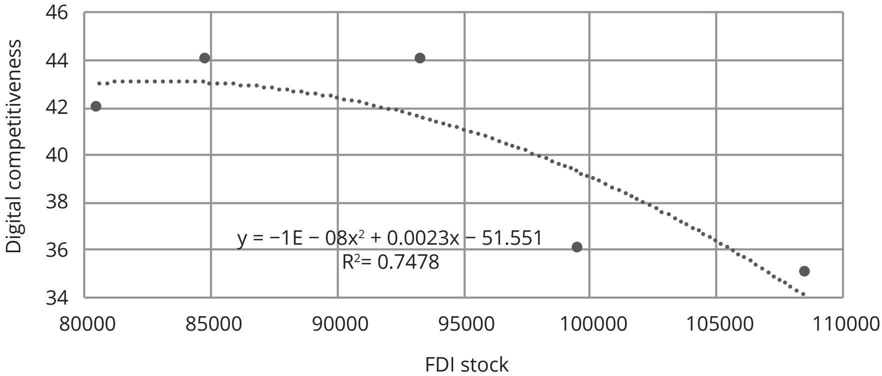
Figure 8.13 Factors of digital competitiveness (vertical axis, position in ranking) and FDI activity (stock and inflows) (horizontal axis, USD millions, constant prices)



Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

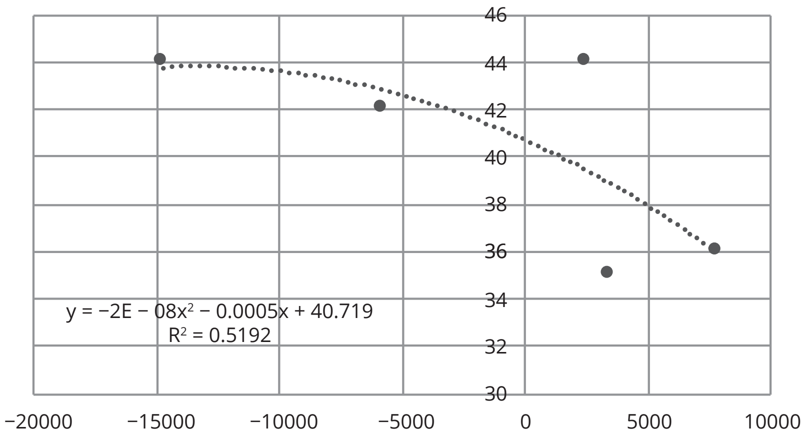
In the case of FDI stock (R-squared = 74.77%; Figure 8.14) and inflows (R-squared = = 51.92%; Figure 8.15) for Hungary, there is a negative relationship of FDI activity with digital competitiveness. Keeping in mind the low value of the "Knowledge" factor and low future readiness of Hungary, even if the Hungarian economy achieves FDI hosting spillovers, it is unable to take advantage of them in building digital competitiveness.

Figure 8.14 Digital competitiveness (vertical axis, position in ranking) and FDI stock (horizontal axis, USD millions, constant prices) – Hungary



Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

Figure 8.15 Digital competitiveness (vertical axis, position in ranking) and FDI inflows (horizontal axis, USD millions, constant prices) – Hungary



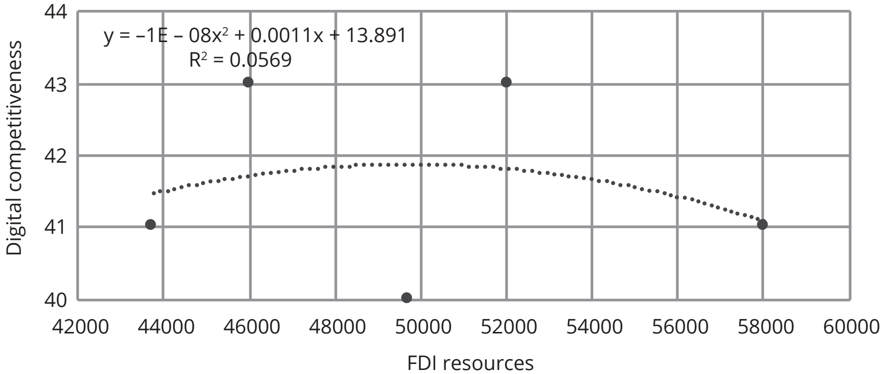
Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

An analysis for Slovakia (Figure 8.16 and Figure 8.17) shows analogous results to those observed for Poland. However, it should be noted that for the relationship of FDI resources with digital competitiveness, the R-squared obtained is very low (5.68%). For the Czech Republic, the examined relationship between FDI resources and competitiveness is (generally) characterized by an upward trend (R-squared = 32.03%;

Figure 8.18). The positive relationship observed between FDI activity and digital competitiveness in the Czech Republic is also visible for the inflows-competitiveness pair (R-squared = 77.63%, Figure 8.19).

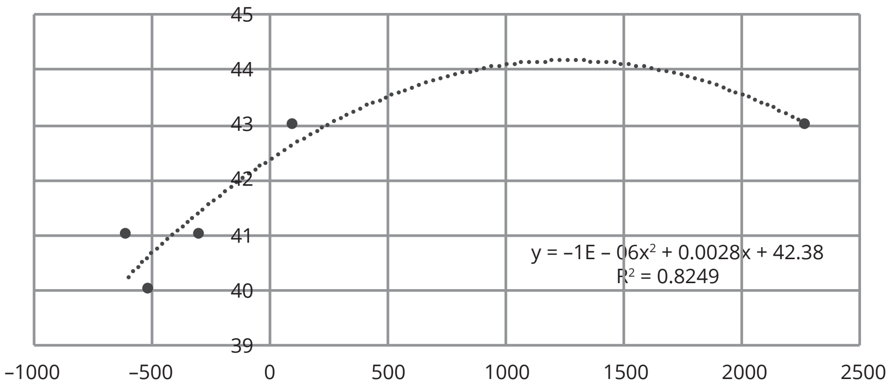
Noting that only for the Czech Republic the examined relationship is positive without a decrease in the value of marginal effects, and that the country is a leader in terms of the "Technology" and "Future readiness" factors, it can be stated that those two factors are of key significance for FDI to be effectively translated into the digital competitiveness of the host country.

Figure 8.16 Digital competitiveness (vertical axis, position in ranking) and FDI stock (horizontal axis, USD millions, constant prices) – Slovakia



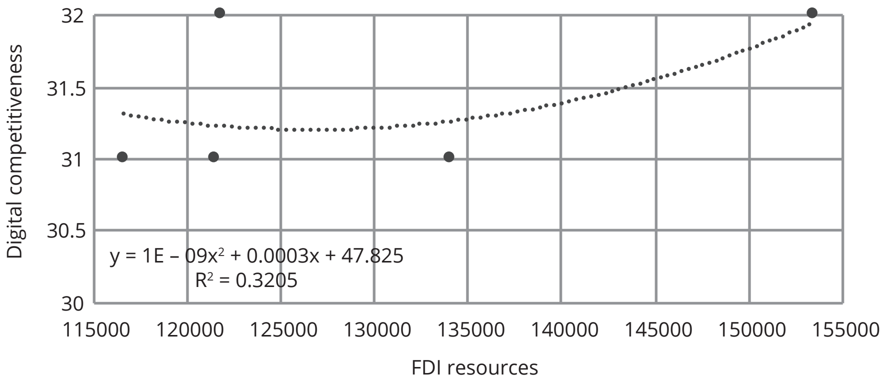
Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

Figure 8.17 Digital competitiveness (vertical axis, position in ranking) and FDI inflows (horizontal axis, USD millions, constant prices) – Slovakia



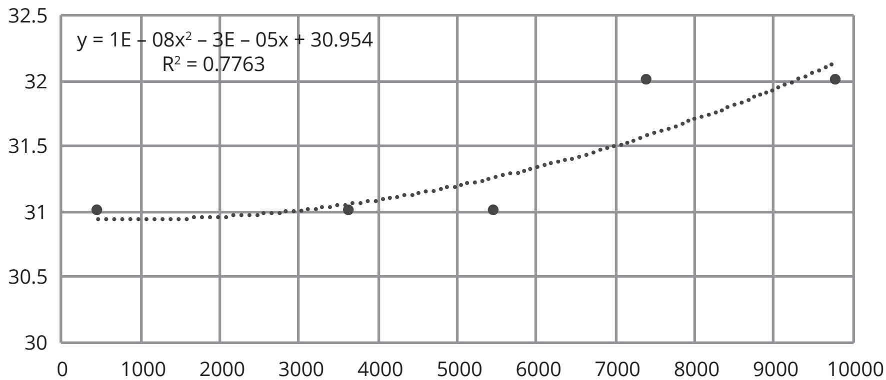
Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

Figure 8.18 Digital competitiveness (vertical axis, position in ranking) and FDI stock (horizontal axis, USD millions, constant prices) – Czech Republic



Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

Figure 8.19 Digital competitiveness (vertical axis, position in ranking) and FDI inflows (horizontal axis, USD millions, constant prices) – Czech Republic



Source: Own study based on IDM [2017] and UNCTAD [2018b] data.

Summary and Conclusions

This paper is an exploratory study and it should be used as a starting point for further research focused on the relationship of Foreign Direct Investment with the digital competitiveness of the host country.

By combining a model describing the digital competitiveness (Digital Competitiveness Model) with the theory of benefits derived by the host country from FDI activity, a model has been designed, which links both issues under study from theoretical perspective. Undertaking the analysis, it is hard to resist the impression that both FDI and digital competitiveness need absorptive capacity of the entities involved.

Referring to the research question posed at the start about the significance of Foreign Direct Investment for the digital competitiveness of the Polish economy, it can be said that, from a theoretical perspective, FDI should have a positive impact on the individual factors of the digital competitiveness model, and thus on competitiveness itself. The analysis of data for Poland shows a positive relationship, but it requires an absorptive capacity and future readiness. Without that, the effect – described in theoretical terms – of FDI activity on the analyzed competitiveness will be vanishing.

It can be concluded from a comparison of Poland with other countries, mainly with the Czech Republic, that two factors of the DCM model are key to obtaining a positive relationship between FDI activity and digital competitiveness: "Technology" and "Future readiness".

Having in mind Poland's high position in terms of future readiness, a policy supporting the transformation of Poland into a digital economy should focus on elements of the "Technology" factor (e.g., access to and speed of the Internet infrastructure, regulatory framework related to high-tech business, immigration law). However, having regard to the UNCTAD [2017b] report, it is very important to ensure that the transformation is phased in gradually while "securing" FDI in Poland (e.g., by preparing new incentives addressing directly digital FDI). The importance of the last-mentioned recommendation is highlighted by the significant role of FDI in fostering the competitiveness of the Polish economy.

As shown by the literature, the relationship between FDI and digital competitiveness is a bilateral relationship, and therefore it may be difficult in this case to determine a causal link (i.e., to identify a dependent variable and an explanatory variable impacting the former), and it is a suggested area for further research on FDI activity in a host country with its digital competitiveness.

Bibliography

Apriliyanti, I.D., Alon, I. [2017], *Bibliometric analysis of absorptive capacity*, "International Business Review", No. 26, pp. 896–907.

Azam, M., Ahmed, A.M. [2015], *Role of human capital and foreign direct investment in promoting economic growth*, "International Journal of Social Economics", No. 42, pp. 98–111.

Crespo, N., Fontoura, M.P. [2007], *Determinant factors of FDI spillovers – What do we really know?*, "World Development", 35(3), pp. 410–425.

Farla, K., De Crombrugghe, D., Verspagen, B. [2016], *Institutions, foreign direct investment, and domestic investment: crowding out or crowding in?*, "World Development", No. 88, pp. 1–9.

Iamsiraroj, S., Ulubaşoğlu M.A. [2016], *Foreign Direct Investment and Economic Growth: A Real Relationship or Wishful Thinking?* "Economic Modelling", 51, pp. 200–213.

McGrattan, E.R. [2011], *Transition to FDI openness: Reconciling theory and evidence*, National Bureau of Economic Research, Working Paper 16774, Cambridge MA.

IMD (2017), *IMD World Digital Competitiveness Ranking 2017*, access: 4.01.2019, https://www.imd.org/globalassets/wcc/docs/release-2017/world_digital_competitiveness_yearbook_2017.pdf

Kim, H-H, Lee, H., Lee, J. [2015], *Technology diffusion and host-country productivity in South-South FDI flows*, "Japan and the World Economy", No. 33, pp. 1–10.

Liu W.S., Agbola F.W., Dzator J.A. [2016], *The impact of FDI spillovers effects on total factor productivity in the Chinese electronic industry: a panel data analysis*, "Journal of the Asia Pacific Economy", No. 21, pp. 217–234.

Napiórkowski, T.M. [2017], *Role of foreign direct investment in economic growth. The production function perspective*, OPTIMUM, "Studia Ekonomiczne", No. 5, pp. 221–236.

Pilbeam, K., Oboleviciute, N. [2012], *Does foreign direct investment crowd out domestic investment? Evidence from the European Union*, "The Journal of Economic Asymmetries", No. 9, pp. 89–104.

Salim, A., Razavi, M.R., Afshari-Mofrad, M. [2017], *Foreign Direct Investment and Technology Spillover in Iran: The Role of Technological Capabilities of Subsidiaries*, "Technological Forecasting and Social Change", No. 122, pp. 207–214.

Smeets, R. [2008], *Collecting the Pieces of the FDI Knowledge Spillovers Puzzle*, "World Bank Research Observer", No. 23(2), pp. 107–138.

Szkorupová, Z. [2015], *Relationship between foreign direct investment and domestic investment in selected countries of Central and Eastern Europe*, "Procedia Economics and Finance", No. 23, pp. 1014–1022.

Temiz D., Gökmen A. [2014], *FDI Inflow as an International Business Operation by MNCs and Economic Growth: An Empirical Study on Turkey*, "International Business Review", No. 23, pp. 145–154.

UNCTAD [2017a], *Methodological note. World Investment Report 2017*, access: 4.01.2019, https://unctad.org/en/PublicationChapters/wir2017chMethodNote_en.pdf

UNCTAD [2017b], *World Investment Report 2017. Investment and the digital economy*, access: 4.01.2019, https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=1782

UNCTAD [2018a], *Sources and definitions. FDI flows. FDI stock*, access: 5.012019, https://unctad.org/en/Pages/DIAE/FDI%20Statistics/Sources-and-Definitions.aspx

UNCTAD [2018b], UNCTADSTAT, access: 5.01.2019, http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=96740

Part III

Key Factors of Competitiveness of the Polish Economy in 2010–2017 in the Context of the Challenges of Industry 4.0

Chapter 9

Directions and Key Challenges of Economic Policy in Poland in the Context of the Fourth Industrial Revolution

Adam Czerniak, Ryszard Rapacki

Introduction

The purpose of this chapter is, firstly, to assess the main directions of economic policy since the Law and Justice (PiS) government came to power, with a particular focus on changes in the institutional environment of the Polish economy underlying the development of Industry 4.0. Secondly, the chapter presents the most important challenges for economic policy three years into the rule of Law and Justice. In this context, we also indicate the potential effects of actions taken in other, non-economic areas of government policy, especially in the field of legal order, which in our opinion had a very strong impact on the conditions for business and investment activities in Poland.

9.1 Directions of Macroeconomic Policy

Having won the election in October 2015, PiS found itself in a very comfortable position in terms of freedom in pursuing its economic policy. The 2016 Budget Act, for the first time in six years, did not have to be consulted with Brussels, and the government could increase expenditure and lower taxes, as well as introduce other measures to make fiscal policy more expansive without the risk of being punished by EU institutions under the excessive deficit procedure. What is more, by auctioning off the LTE frequencies to mobile phone operators, the state earned a one-time windfall of PLN 9.2 bn, and owing to changes in the prices of reserve assets, the National Bank of Poland (NBP) contributed to the budget PLN 7.9 and 8.7 bn from the profit generated in 2016 and 2017, respectively [Council of Ministers, 2016a; 2017b]. Combined with historically low debt service costs, this temporarily opened up ample space to loosen fiscal policy in Poland and implement programs boosting innovation in the economy and development of Industry 4.0.

Having regard to the above, as early as December 2015, the new parliament adopted amendments to the Budget Act and announced the introduction of one of the most expensive social programs in Poland's history, namely the "Family 500+" child benefit program. Under the act, which entered into force on 1 April 2016, the government started disbursing parents a monthly benefit of PLN 500 for the second and each subsequent child, and, for those with a monthly income is below PLN 800 per family member, also for the first child. The program benefitted parents of 3.8 million children [Council of Ministers, 2017a], which costs the government budget PLN 1.9 bn monthly. In addition, the government spends nearly PLN 350 m each year on running the benefit payment system. Overall, the cost of the program amounted to PLN 17,6 bn in 2016 and PLN 23.8 bn in 2017, i.e., 1.2% of GDP (or 6.2% of budget expenditure and 3.1% of general government expenditure) [Council of Ministers, 2017c]. In 2018, the amounts were at an almost identical level as in 2017. Child support benefits represent the sixth largest item in the budget, and the cost of the program exceeds expenditure on higher education, research and development, unemployment benefits, road investments, or justice.

As announced by the government, the program is to stimulate the birth rate, which is, at least partially, to increase the future workforce and, thus, the potential rate of economic growth. The Ministry of Family, Labor and Social Policy (MRPiPS) assumes that thanks to benefit payments, the most optimistic scenario of the 2014 GUS forecast will materialize, that is, the birth rate in Poland will increase to 1.60 in 2025, against 1.30 in the worst-case scenario, and 1.38 in the most likely mid-case scenario. Under the GUS optimistic birth forecast, by 2050 an annual average of 14% more children will be born in Poland than in the mid-case scenario. It is worth noting, however, that the GUS forecasts on which MRPiPS relied did not take into account the changes in family policy implemented in 2014–2016, including the annual parental leave or parental benefit for the unemployed.

In the medium term, however, the impact of the "Family 500+" program on labor supply will be negative, as it will discourage people, especially second earners, with lower wages from taking up or continuing employment. After the first year of the program, the number of economically active women aged 25–49 was lower by 65,000 than in the scenario without the "Family 500+" program, with better educated women being those who left the labor market in the first place. This effect was offset slightly in 2018 owing to the GDP growth rate, the highest since the 2008 global financial crisis, and growth in wages, which reduced the number of economically inactive women to approx. 30–40,000 fewer than in the counterfactual scenario without the benefits paid. Thus, if the government scenario materializes, the impact of the "Family 500+" program on demography and the labor market will strike a balance after more or less 30 years. Only then will a sufficient number of young people, born thanks to the program, start working to offset the decline in the economic activity of their mothers. If the program runs until 2050, an additional 2.5 million Poles will be born [Myck, 2016; Arak, 2016].

The second most important economic policy change implemented by PiS was the reversal of the 2012 pension reform by restoring, as of October 2017, the retirement age to 60 for women and 65 for men. The reversal of the 2012 reform increased pension expenditure, reduced social security contributions and lowered tax revenue. Based on the government's calculations, it can be estimated that in the first full year with the new law in force, the general government deficit was more than PLN 9 bn higher than in the scenario providing for a further gradual rise of the retirement age [Council of Ministers, 2016b]. An additional effect of lowering the retirement age was a decline in the economic activity of people aged 50 and more. In Q4 2017 alone, 313,000 people retired [PAP, 2018], and an additional several tens of thousands did so at the beginning of 2018. According to the results of the Labor Force Survey (LFS), this translated to a significant decrease in the economic activity of women aged 60–64, from 23.8% at the end of the Q3 2017 to 20.8% at the end of Q1 2018, and of men aged 65–69, from 18.8% to 14.6% at the same time. Consequently, the total economic activity rate for population aged over 50 dropped during the period under study from 34.8% to 33.3%, while in the autumn-winter season a year earlier it remained stable.

With the above-mentioned changes taken into account, in 2025 there will be almost 900,000 economically active people fewer than in 2016, and in 2050 – as many as 1.6 million fewer, which means a decrease of the labor force by 11% (GRAPE, 2016). This has a twofold impact on the innovativeness in the economy. Firstly, a great number of people leaving the labor market in the face of growing personnel deficits in enterprises reduces their propensity to invest. In mid-2018, as many as 16.4% of firms had to abandon or limit their investment plans due to personnel shortages [Work Service, 2018], and the percentage is growing steadily. A lower investment propensity of firms affects the innovativeness, especially in industries where shortages are the most acute, that is, in construction and ICT services. Secondly, in the wake of retirement age reduction and the introduction of the 500+ program, workers with the longest work record and usually with higher education leave the labor market in the first place. This also reduces the ability of enterprises to improve productivity by deploying innovative solutions. Therefore, although as many as three-quarters of enterprises experience difficulties with recruiting new employees, only 17.9% of investment plans involve mainly the modernization of production technology, including its automation [NBP, 2019].

Apart from the above-mentioned measures, PiS also has made a number of other smaller-scale changes to fiscal policy. One of the most important ones is the introduction of a progressive tax threshold. Since 2017, individuals with a taxable income up to PLN 6,600 annually are exempt from personal income tax (PIT), while people with income exceeding the second tax threshold (PLN 85,500) have a lower tax threshold than before the change. In 2018, the tax threshold was raised further to PLN 8,000. Thus, the changes have increased the general government deficit by PLN 1 bn in 2018, and are estimated to increase it by a further several hundred million PLN in the following years. In addition to the change in the tax-free amount, the government decided to partially unfreeze wages in the public sector, increase salaries for uniformed personnel, junior doctors and paramedics, and teachers.

The PiS government also adopted a number of changes in economic policy, including measures promoting the development of Industry 4.0. Their framework was outlined in the Strategy for Responsible Development (SRD) [Council of Ministers, 2017d]. However, the document does not contain any specific proposals for legislative arrangements, but it only lists areas that require change, and sets out general goals to be achieved through those changes. The most important measures taken by the government in the field of fiscal policy after the announcement of the SRD included: (1) increasing, from 2018, the amount deductible from income tax from 50% to 100% of total research and development costs, and for R&D centers – to 150%, (2) extending, starting in 2017, the period eligible for the deduction of such costs from tax from three to six years, (3) abolishing, from January 2017, income tax on intellectual property contributed to a company, (4) launching the IP Box, a regulatory arrangement under which income derived by an enterprise from intellectual property rights acquired in the course of R&D activities or R&D services, purchased from other entities but patented by the enterprise concerned will be taxed with a preferential rate of 5%, (5) reduction, from 2019, of CIT for firms with an annual revenue of less than EUR 1.2 m (approx. 430,000 entities) from 15% to 9%, (6) reduction of social security contributions for self-employed with revenue not greater than 2.5 times the minimum wage. According to our estimates, all the above changes will cost the government budget about PLN 3.5 bn annually.

Apart from changes in fiscal policy, to implement the SRD, the government has also been working on a number of changes in the institutional business environment of enterprises, especially the most innovative ones. The most important ones include the introduction of the simple joint-stock company (SJSC) and amendments to the public procurement law. In February 2019, the government adopted a bill introducing the SJSC, which is expected to make it easier for small innovative firms to raise investment funding directly from the capital market. It will be possible to complete the entire SJSC establishment procedure online in 24 hours using template articles of association, and the whole process is to cost PLN 250. Such a company will have a low capital requirement and investors will have a limited influence on its activities. A company of this type will also be subject to more relaxed reporting obligations, but it will not be allowed to be listed on the stock exchange. The act implementing the SJSC is very likely to be adopted even before the autumn parliamentary elections.

The Ministry of Entrepreneurship and Technology has designed a new public procurement law, which is to enter into force in 2020. At the time of writing this report, only assumptions of statutory amendments were known, which included the simplification of the regulations governing public procurement for small and medium-sized enterprises (with contract amounts below EU thresholds), introduction of a catalogue of clauses restricting competition and buyers' rights, new rules for value adjustment remuneration for contract performance, and providing for equal distribution of business risk (e.g., arising from increase in material prices) between the contractor and the contracting authority.

In order to stimulate the innovativeness of enterprises and support the development of Industry 4.0, the government has also established new state institutions and modified the operating rules of the existing ones. The Polish Development Fund has been set up, which is aimed to finance strategic investment projects and support firms in raising capital from venture capital and private equity funds. In January 2019, the act establishing the Industry of the Future Platform Foundation with an annual budget of PLN 20 m. Its goal is to support the development of Industry 4.0 through consulting, accreditation of institutions implementing innovative solutions, assistance in creating innovation clusters, as well as provision of training and education of entrepreneurs. The platform is also to coordinate the activities of different offices supporting the development of industry innovation and digitalization, and also to coordinate the disbursement of EU funds. Besides, a bill has been submitted to the Sejm, establishing the "Łukasiewicz Research Network", intended to be a technological and intellectual resource supporting the administration. The Network is to comprise some of the existing research institutes and the Polish Center for Technology Development. Changes have also taken place at the Patent Office, which has introduced the intellectual property audit service for firms, started supporting entrepreneurs in patent protection mediations within the World Intelectual Property Organization, and is working on the establishment of the National Bank of Intellectual Property, a knowledge sharing platform on patents and patent owners.

The total costs of all reforms launched by PiS for the general government exceeded PLN 35 bn in 2018, and will increase to PLN 40 bn in 2019. They will be covered only partially, by proceeds from small-scale tax increases and increasing tax collection. With effect from February 2016, the government introduced a tax on certain financial institutions (known as “bank asset tax”). It covered banks operating in Poland, insurance companies, savings and credit unions (SKOK) and loan companies, whose assets exceed PLN 2 bn and are not subject to a recovery program. Each of those organizations pays annually 0.44% of the value of its assets less equity and the value of treasury bonds. In 2016, the budget received a total of PLN 3.5 bn – much less than provided for in the Budget Act (PLN 5.5 bn). In 2017, due to a longer taxable period and an increase in asset prices, the related revenue increased to PLN 4.3 bn. In addition to the tax on certain financial institutions, in September 2016 PiS also introduced a turnover tax on retailers, but in response to the European Commission’s objection the Ministry of Finance had to suspend its implementation even before any payments were made to the budget.

The main source of the GG revenue growth, therefore, is the increase in the tax collection rate, in particular for indirect taxes. To this end, the PiS government continued the policy of fighting tax fraud and aggressive tax optimization, initiated towards the end of the PO-PSL rule. Among the measures implemented, the obligation was introduced for enterprises to prepare the uniform control file, which was expanded in January 2018, the road transport monitoring system was deployed, a reverse VAT tax on some goods introduced, the so-called fuel package adopted, and from the latter half of last year the monitoring system of financial transactions of firms (STIR) was launched, as well as the split payment mechanism under which entities’ VAT remittances are held on a special escrow account. This mechanism is to become mandatory in 2019 for certain goods and services. Additionally, the PiS government has modified the functioning of the tax administration with a view to improving its performance.

The effects of these regulatory changes can be seen in the increase in VAT revenue. According to various estimates, they have led to an improvement in VAT and CIT collection rate by PLN 10–15 bn, which means that the taxes covered only in part the costs related to the fiscal policy changes implemented by the government. Thus the reduction of the general government deficit in 2015–2018 from 2.7% to the forecasted 0.9% [European Commission, 2018] was attributable mainly to cyclic effects – a fast growth of tax revenue owing to a very good economic situation. Therefore, as economic slowdown sets in, the costs of the relaxed fiscal policy will manifest themselves in a growing government deficit, which is expected to exceed the threshold of 3% of GDP in the years to come.

9.2 Key Challenges

This sub-chapter overviews the major challenges facing economic policy in Poland. They include two categories of development threats. The first consists of well-known threats, the ones that have been building up for many years, including those arising from omissions and errors committed by previous Polish governments. The second category comprises new challenges that are a direct consequence of the first three years of PiS being in power.

Our overview comprises two interconnected perspectives. The first one includes conceptual, political and institutional factors that form a broadly understood framework of business operations and determine the structure and strength of incentives impacting the behavior and decisions of economic actors. Within the second perspective, we point to those development challenges that are associated with functioning of the economy, its growth factors and macroeconomic performance.

Conceptual, Political and Institutional Challenges

The **first** of the fundamental weaknesses of the economic policy pursued in Poland is the lack of vision of the target model of capitalism that best suits the conditions and development aspirations of the country. The goal of systemic transformation in Poland – both at the beginning of the road leading from plan to market, as well as all along the way – used to be defined in highly abstract terms as creating a liberal market economy (capitalism), without prejudging its specific design.

Among other outcomes, this caused the institutional architecture (model of capitalism) established in Poland to largely bear the characteristics of a „patchwork" construction. Its individual parts derive from different institutional orders, are internally incoherent and show a low level of complementarity. As a consequence, instead of triggering positive synergies and improved operational efficiency, this institutional ambiguity generates rising frictions and increased idle capacity of the entire system.

Secondly, until now Poland's current and future role in the European Union has not been clearly defined – other than being mainly a beneficiary of the EU funds. The necessity of meaningful and effective use of the EU funds (and institutions) is beyond discussion. Directions and ways of using EU funds should be, however, a function of the development strategy adopted (whose outline, i.e., the Morawiecki Plan, has actually has not yet entered the implementation phase after three years of PiS government). Poland has fairly mastered the art of acquiring EU funds, but it has performed much worse when it comes to defining development priorities in using them, as well as producing a full balance sheet of costs and benefits of the various EU programs, in terms of its own national interest.

In this context, the **third development challenge** should be perceived, in the form of the risk of perpetuating the peripheral position of Poland in the European Union. In such a case, our country would be mainly a producer of simple manufactured goods, with a relatively low value added and a small high-tech content, and a subcontractor of more technologically advanced products in global networks of transnational corporations. Using the terminology of the ‚economics of comparative capitalism', Poland would then be a classical example of the „dependent market economy" variety of capitalism [Nölke and Vliegenthart, 2009], or an "FDI based, second-rank market economy" [Myant and Drahokoupil, 2011].

Fourthly, the government failure to create conditions fostering long-term economic development should be considered as one of the greatest challenges, including ensuring positive externalities for the private sector. This mainly concerns the underfunding of the R&D sector, the lack of support for creating and improving the quality of human capital, miscomprehension of the meaning of one of the biggest barriers to the development of the Polish economy, i.e., a low level of social capital and insufficient support for the advancement of information and communication technologies.

Fifth, this weakness results from, among others, a strong redistributive bias in public spending policy at the expense of development expenditures, failure to accomplish the so-called „golden rule" of public finances, a growing scale of rent seeking, and persistence of the unproductive entrepreneurship pattern [cf. Baumol, 1990].

What is more, **sixth**, the symptoms of Myrdalian soft state in Poland persist – the incidence of corruption is still too big, whereas the compliance with the law is too weak, which means, among other things, a strong asymmetry between formal and informal institutions, towards the latter [Rapacki, 2012]. At the same time, there are more and more manifestations of insufficient quantity and decreasing quality of public goods and merit goods supplied by the state (e.g., healthcare and education).

Finally, **seventh**, unlike several other transition countries in our region (Slovakia, the Baltic states), Poland failed to substantially downsize the government and to reduce the scope of its functions in the past 8 years. If the proportion of public expenditure to GDP is adopted as the basic gauge of the size of government, this index has remained stable in Poland since the early 1990s, at above 40%. This is an indicator approximately two times higher than in countries with a similar level of economic development (23–24%), and similar to the average in the European Union and the OECD. This means that we carry a lot more of the state on our shoulders than we are able to bear.

Macroeconomic Challenges

The most important development challenges of a broadly defined macroeconomic nature facing Polish economic policy include:

1. Unfavorable demographic trends – a significant decline in population (over the next 30–45 years), change in the age structure of society, emigration and brain drain, permanent decline in the dependency ratio showing the number of people in the labor force per retiree.
2. Imperfections of the labor market, manifesting themselves in a participation rate of the population in the labor market below the EU average, high unemployment rate among young people and a large share of flexible forms of employment. In addition, the labor market has seen the so-called negative intertemporal feedbacks gaining in strength in the recent years. On the one hand, in the short term, the labor market is becoming increasingly flexible, which facilitates the absorption of asymmetric shocks. However, on the other hand, this tendency perpetuates, in the long run, the existing foundations of the international competitiveness of Polish economy (low costs, low and medium level of processing of exports, low value added), as it undermines incentives to upgrade qualifications and to innovate [Rapacki, 2016].
3. The lowest propensity to save and the lowest investment-to-GDP rate among the Central and Eastern European countries. In the light of the endogenous model of economic growth, it is the investment rate and national savings that finance these investments in the long run and are a prerequisite for fast and sustainable economic growth.
4. Low innovativeness of the economy that has persisted for years. Its many symptoms include a low contribution, of a mere 8%, of high-tech products in the export of manufactured goods, or a huge deficit in the international trade of licenses (the ratio of expenditure on license imports to revenues from license exports being 10:1).
5. A low (or, as some studies show, even decreasing) stock of social capital in Poland. Given that fact, our country would fall into the category of low-trust society [Fukuyama, 1995]. Moreover, while the persisting lack of trust among Poles in the state institutions is strongly conditioned by history, a new phenomenon in Poland is the emergence of a symmetrical distrust in the state-citizen and the state-private entrepreneur relations. Its symptoms include red-tape barriers proliferated by the public administration and increasing the bureaucratic interference into the market economy that may limit the scope of economic freedom already achieved.
6. Another serious development threat has been emerging increasingly clearly in the form of rapidly growing tensions in the national energy balance, resulting,

inter alia, from delayed investment in the development and modernization of the energy base. They are augmented by the prospect of a significant increase in the costs of electricity generation and supply in Poland, stemming from the intergovernmental arrangements in the European Union, adopted in autumn 2014 (climate package), concerning the reduction of harmful emissions and the related need to switch energy production to more environmentally friendly technologies based on renewable energy sources.

New Challenges

This sub-section indicates the most important challenges to economic policy resulting from actions taken by PiS during its first three years in power. In the context of the 2019 parliamentary elections, the direction of those actions is most likely to be continued, which means maintaining an expansionary fiscal policy and a loose monetary policy. We also consider it highly probable that the scenario of institutional changes initiated in November 2015 will be continued, aimed at transforming the foundations of the legal order existing so far in Poland, which may lead to further deterioration of Poland's image abroad, weakening its international position and increasing its marginalization in the European Union. The materialization of this scenario will entail the emergence of new challenges for economic policy in the form of the following developmental threats of a short, medium and long-term nature.

A. Short-Term Effects

- Strong fiscal expansion, mainly due to the increase in budget expenditure on large-family benefits (the „Family 500+" program). As we estimated in the first part of the chapter, the total costs for the general government of all reforms implemented by PiS exceeded PLN 35 bn in 2018. However, meeting all election promises of the ruling party, in terms of social transfers, may mean an increase in additional burdens to the government budget of up to PLN 50 bn a year.
- Increased budget expenditure (mostly intended for consumption) financed from the growing deficit and public debt will also trigger the mechanism of crowding out private investment from the economy, which will consequently lead to a change in the structure of national income distribution (on the demand side) – the private sector's share will fall in favor of the public sector.
- At the same time, as a result of the increase in rigid budget expenditure, which will not be accompanied by a parallel, sustainable increase in the sources of their financing, the structural deficit may also increase.

- The growing general government deficit, indicating an increase in negative government savings, will limit the capability to finance domestic investment from savings of the private sector (firms and households).
- The shrinking stream of private savings will have a similar effect, which will be part of a very probable scenario in 2019: the Monetary Policy Council will maintain a loose monetary policy stance –> a further increase in inflationary expectations and inflationary pressure –> negative real interest rate –> decrease in marginal propensity to save.
- Increase in the perceived (particularly, political and institutional) risk of investing in Poland, which will translate into a rising cost of borrowing in international financial markets.
- The persisting high risk of complete dismantling of the three-pillar pension system by taking over the remaining part of pension assets accumulated in Open Pension Funds, OFE (nationalization of retirement savings). However, even without the nationalization of OFE, the introduction of Employee Capital Plans in 2019 will in fact mean the marginalization of the second pillar of the system.
- The lowering of the statutory retirement age (from 65 to 60 for women and from 67 to 65 for men), effective 1 October 2017. This move will pose an additional constraint to the current and future liquidity of the Social Insurance Fund and the government budget. According to Santander Bank's estimates (January 2019), the total costs of lowering the retirement age amounted to approx. PLN 7 bn in 2018.

B. Medium and Long-Term Effects

Macroeconomic

- Increased inflationary pressure and expectations. This increase will be a derivative of two interrelated factors:
  (1) Significant loosening of fiscal and monetary policy, and
  (2) Almost full utilization of production capacity in the Polish economy (the output gap is estimated at only about –0.6% of potential GDP), as well as a significant deceleration of the potential growth rate (up to a maximum of 2.5% per year).
- This may mean that additional growth stimuli, generated by fiscal and/or monetary expansion (in the form of, e.g., increased lending to SMEs), is likely to result in overheating the Polish economy and – instead of accelerating its growth – lead to accelerated inflation.

- In a slightly longer perspective, the factors likely to slow down the growth of the Polish economy are insufficient propensity to save (currently about 17% of GDP) and insufficient investment rate (18% instead of at least 24–25% of GDP).
- The crowding out effect may have a similar consequence (see above). It will lead to a decrease in the average efficiency of resource allocation in Poland (decrease in the TFP growth rate) and, thus, a further deceleration of the potential growth rate of the Polish economy.
- In this context, it is also worth pointing to the continuing contradiction between the actual actions of the ruling political formation and the most important goals of Strategy for Responsible Development announced by the then Deputy Prime Minister Mateusz Morawiecki in mid-February 2016 (including a significant increase in the rate of domestic savings and the rate of investment, coupled with increased national innovative capacity and support for domestic capital). However, as is well known from the fundamentals of economic theory, the rate of consumption and the investment rate cannot be increased at the same time, assuming that the role of foreign savings in the economy is to be further limited.
- The Morawiecki Plan also displays an internal contradiction of a deeper institutional nature. While the objectives formulated in the plan (e.g., increasing the ability of the Polish economy to innovate) have been transplanted mainly from the model of capitalism called the liberal market economy (or the Anglo-Saxon model of capitalism), the means and ways of achieving them (strong statism and the increase in the importance of non-market forms of coordination, renationalization) come from a completely different institutional order, referred to as a coordinated market economy (or also as the continental European or Nordic model of capitalism).[1]
- The government's acquisition of the remaining part of the OFE assets will result in, among others, replacing (reallocation in time) the official "visible" part of public debt with hidden or "invisible" debt (promise of future pension payments) and a significant increase in the latter form of debt.
- Starting January 2020, the abolition of the limit on pension insurance contributions, currently set at 30 times the average wage in the national economy, will work in a similar direction.
- Lowering the retirement age will reduce the labor supply, drastically lower the replacement rate for future retirees and may at the same time endanger the foundations of the long-term solvency of ZUS and the general government.

[1] This reflection can be further expanded to assess the development strategy being actually implemented in Poland as a peculiar combination of: (1) neoliberal goals, (2) conservative values, and (3) statist means and tools employed by an authoritarian political power, 4) under deep political divisions and lack of social dialogue.

- Similarly, this decision could further weaken the Warsaw Stock Exchange, whose performance has already deteriorated significantly as a result of the nationalization of half of the OFE pension assets by the PO-PSL government in 2014.

Institutional

The first three years of the PiS rule also gave birth to the emergence of new development challenges embedded in the institutional environment. The most important ones include the following:

- Breaking the very foundations of the liberal democracy system based on checks and balances and the separation of the executive, legislative and judiciary powers.
- Increasing centralization of power and intensifying attempts to weaken local self-government.
- Restricting the freedom of actions of the "third sector", i.e., non-governmental organizations.
- Actual dismantling of the civil service.
- Limiting the freedom of the media.
- Deepening of existing divisions in society, disappearance of the sense of community.
- A further decline in the level of trust and willingness to cooperate in society.
- Weakening of incentives for productive entrepreneurship and investment.

Summary – Key Long-Term Consequences

In summary, it is worth pointing out that the cumulative impact of the developmental challenges discussed above, and an insufficient response of economic policy may result in a decline in the international competitiveness of the Polish economy. In particular, it is worth indicating the possibility of the following long-term consequences of this scenario:

1. Consolidation of the imitative and peripheral pattern of development of the Polish economy.
2. Increasing the role of informal institutions at the expense of formal ones.
3. Progressive process of anomie in society.
4. Strengthening incentives for unproductive and destructive entrepreneurship.
5. Further increase in the idle capacity of the institutional system and the progressive erosion of the institutional comparative advantage of Poland

All these factors may give rise to a permanent decline in the potential rate of economic growth. The symptoms of this unfavorable tendency have already appeared in Poland – in the last few years there has been a reduction in the potential growth rate of Polish economy from over 5% to about 2.5% i.e., by half. What is more, according to sources such as long-term projections of the European Commission, OECD and our own forecasts [Matkowski, Próchniak, Rapacki, 2016][2], after 2020, this rate may decrease even further – below 2% per annum.

Bibliography

Arak, P. [2016], *Jak program 500+ wpłynie na rynek pracy*, Polityka Insight, issue of 22.02.2016.

Baumol, W. [1990], *Entrepreneurship: Productive, Unproductive and Destructive*, „Journal of Political Economy", Vol. 98, No. 5.

Council of MInisters [2016a], *Wieloletni plan finansowy państwa na lata 2016–2019*, April, Warsaw.

Council of Ministers [2016b], *Stanowisko Rady Ministrów wobec prezydenckiego projektu ustawy o zmianie ustawy o emeryturach i rentach z Funduszu Ubezpieczeń Społecznych oraz niektórych innych ustaw*, July, Warsaw.

Council of Ministers [2017a], *Wieloletni plan finansowy państwa na lata 2017–2020*.

Council of Ministers [2017b], *Ustawa budżetowa na rok 2018. Uzasadnienie*.

Council of Ministers [2017c], *Sprawozdanie Rady Ministrów z realizacji ustawy o pomocy państwa w wychowywaniu dzieci w latach 2016–2017.*

Council of Ministers [2017d], *Strategia na rzecz Odpowiedzialnego Rozwoju do roku 2020 (z perspektywą do 2030 r.)*.

European Commission [2018]. *Autumn Economic Forecasts*, Brussels.

European Commission [2018], *Autumn Economic Forecasts*, Brussels.

European Commission [2016], *Autumn Economic Forecasts*, Brussels.

GRAPE [2016], *Obniżenie wieku emerytalnego. Jakie będą skutki?* http://grape.org.pl/blog/co-dokladnie-oznacza-obnizanie-wieku-emerytalnego-w-polsce/ [access 25.10.2016]

Matkowski, Z., Próchniak, M, Rapacki, R. [2016], *Real Income Convergence between Central Eastern and Western Europe: Past, Present, and Prospects*, „Ekonomista", No. 6.

Myant, M., Drahokoupil J. [2011], *Transition Economies: Political Economy in Russia, Eastern Europe and Central Asia*, Hoboken, NJ: John Wiley & Sons.

Myck, M. [2016], *Estimating Labour Supply Response to the Introduction of the Family 500+ Programme*, CenEA Working Paper Series 01/16.

NBP [2019], *Szybki Monitoring NBP. Analiza sytuacji sektora przedsiębiorstw*. No. 01/19.

Nölke, A., Vliegenthart, A. [2009], *Enlarging the Varieties of Capitalism: The emergence of dependent market economies in East Central Europe*, "World Politics", 61(4), pp. 670–702.

PAP [2018], *ZUS zdecydował o wypłacie emerytur dla 313 tys. osób*. Article of 5.01.2018.

[2] The latest simulation forecast of the growth trajectory of Polish economy and the income convergence process in relation to the EU-15 countries can be found in Chapter 5 (?) of this Report.

Rapacki, R. [2016], *The Institutional Underpinnings of the Prospective Euro Adoption in Poland*, Chapter 5, in: Y. Koyama (ed.): „The Eurozone Enlargement: Prospect of New EU Member States for Euro Adoption „. New York: Nova Science Publishers, pp. 65–86.

Rapacki, R. [2012], *O szansach i zagrożeniach rozwoju polskiej gospodarki,* w: "Wykłady inaugurujące rok akademicki 2011/2012", Instytut Problemów Współczesnej Cywilizacji, Warsaw, pp. 65–73.

Chapter 10

Significance of the Financial System in Poland in 2010–2017 in the Context of the Challenges Related to Industry 4.0 and Digital Competitiveness

Katarzyna Sum

Introduction

The development of Industry 4.0 and digital competitiveness represent both a significant opportunity and challenge for the Polish economy. The processes involve mainly the automation and data exchange in industry, integration of advanced IT technologies with classical industrial processes, and the emergence of cyber-physical systems which monitor manufacturing processes, create their virtual copies, and take decentralized decisions. The implementation of such solutions allows more flexible models of labor organization to be deployed, thus contributing to enhancing the competitiveness of firms at micro level, and of the economy at macro level.

The significant role of digitalization in supporting Industry 4.0 must be noted. Owing to digital transformation, changes take place in value chains, products, services and business models. Major changes supporting the development of the processes include the volume of available data, mobile communications, and digital channels of access to the consumer [PricewaterhouseCoopers, 2017b]. A visible consequence of the changes currently witnessed is the expansion of the IT sector which is aimed at the production of goods and services that enable the electronic recording, processing, transmission, retrieval or display of information, as well as transformation of the traditional industry driven by the development of digital technologies.

In consequence of the development of Industry 4.0, firms will require changes in production planning, management of production processes, employment, data management and reporting. One of the key challenges facing firms is how to raise sources of financing for increasingly complex and cost-intensive modernization projects.

Corporate expenditure will be related primarily to investment in production infrastructure and IT, employment of skilled staff, and changes in data administration systems.

In order to improve the competitiveness of our economy, it is necessary to find ways of financing the processes concerned. Thus, the financial system has an important role in supporting the development of Industry 4.0 and digital competitiveness. The literature offers a wide range of studies on the development of Industry 4.0 and digital competitiveness in Poland. However, little attention has been devoted to possible ways of financing those projects, and to the system environment designed to support the financing of the Fourth Industrial Revolution.

According to a European Commission report [European Commission, 2017a], the progress of processes related to Industry 4.0 and improvement of digital competitiveness in Poland is moderate compared with other EU member states. The report highlights limitations regarding the financing of such projects. With regard to this fact, this chapter seeks to answer two research questions:

– What are the possible ways of financing Industry 4.0 projects and improving digital competitiveness in Polish enterprises?
– How is the development of innovative technologies in the financial system progressing in the context of challenges related to Industry 4.0 and digital competitiveness in Poland?

The objective of the chapter is to characterize the ways of financing projects related to Industry 4.0 and digital competitiveness in Poland in 2010–2017, and the development of the Polish financial system in this respect. To start with, possible ways of financing innovative projects are reviewed. Particular focus has been placed on the availability of specific instruments in the context of development of the financial system in Poland. Next, the EU programs are characterized, as ways of financing projects related to Industry 4.0 and improving digital competitiveness. Further on, the development of innovative technologies in banks and the FinTech industry is overviewed. Finally, conclusions and recommendations are drawn up regarding the desired directions of development of the methods of financing projects related Industry 4.0 and digital competitiveness in Poland, and the development of the Polish financial system with regard to financial innovations.

10.1 Ways of Financing Enterprises in Poland

Sources of financing projects related to Industry 4.0 and improvement of digital competitiveness can be similar to those for traditional projects undertaken by Polish firms. The Polish financial system provides a range of options for raising funds to support the development of enterprises. Such ways include internal financing (retained profit or sale of assets), borrowing, leasing, factoring, forfaiting, issuing debt or equity instruments on the capital market, venture capital funds, and business angels.

Internal financing capabilities of enterprises, both large and small, depend on the financial condition of each firm and the amount of profit that can be retained. Most enterprises must also use external sources of financing. One of the options is the use of loans and credit facilities offered by commercial banks, which may constitute a source of financing innovative investment projects. The availability of this instrument for individual enterprises is dependent on the commercial bank's willingness to grant credit, and the interest rate it carries. Constraints in access to credit are faced mainly by small and medium-sized firms [Indicator – Centrum Badań Marketingowych, 2018]. For projects related to Industry 4.0 and improvement of digital competitiveness, which are currently supported by political initiatives, the availability of credit to enterprises may be improved through support from public institutions.

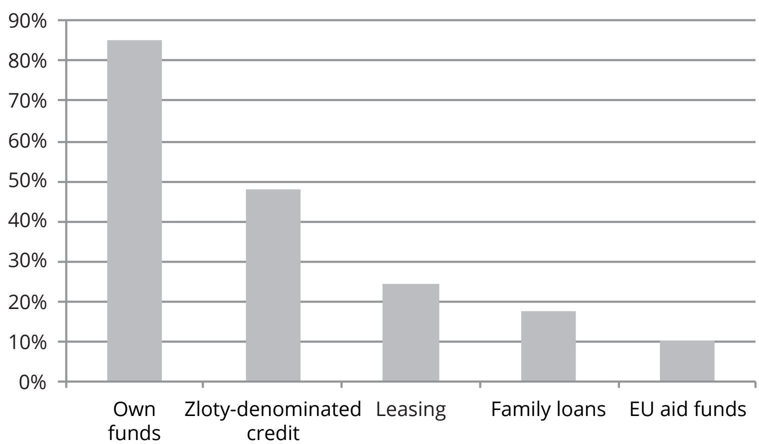
Another possible way of financing business operations is leasing, which involves the use by the enterprise (lessee) of assets owned by the lessor in exchange for lease instalments. The popularity of this way of financing has been growing steadily in Poland owing to its lower cost compared with credit, and favorable tax arrangements. Thus leasing may be one of the ways of financing Industry 4.0 projects, enabling enterprises the use an innovative production infrastructure.

Increasingly often, enterprises in Poland avail themselves of financing through factoring and forfaiting, which consist in selling receivables, at a discount, to a factoring or forfaiting company. Classical factoring and forfaiting concern financing without recourse, which involves a high level of discount, and a high cost of such financing. In practice, factoring and forfaiting with recourse is also used, which allows discount to be reduced. Factoring usually relates to short-and medium-term transactions, while forfaiting involves larger long-term transactions. The advantage of this type of financing is that it increases the liquidity of a firm through the sale of receivables, and in the case of contracts without recourse it eliminates counterparty risk. In particular, factoring can be used to finance Industry 4.0 and digital competitiveness improvement projects, as it will stimulate the firm's liquidity when additional expenditure related to digitalization is incurred.

Another possible way of financing businesses is the issuing of securities on the financial market. It should be noted, however, that because of the high costs of entering the stock market, not all companies have the opportunity to raise funding in this way. An alternative for smaller businesses and start-ups is the issuing of equity instruments on the New Connect market, which is less regulated than the main stock market, and at the same time less liquid.

Enterprises can also use financing offered by venture capital funds. This type of funding consists in the recapitalization of a firm, which is at an early stage of development, by a venture capital fund and the acquisition of part of its shares. The firm can also take advantage of the fund's management consulting support. The availability of this type of funding to companies implementing Industry 4.0 and digital competitiveness improvement projects can be potentially good because the funds favor investments in business that offer competitive products and bode well for significant profits in the future. An alternative option is to use funding by so-called "business angels". Much alike venture capital funds, business angels invest in start-ups. The difference between the two types of funding is that business angels invest their own funds in a business, as opposed to a fund that invests the assets of its members. As with venture capital funds, business angels prefer investing in future-oriented industries, so firms developing Industry 4.0 and digitalization projects have a good chance of benefiting from this type of funding. One constraint is the fact that the venture capital market in Poland is only yet developing; firms seeking this type of financing often have to attract foreign investors.

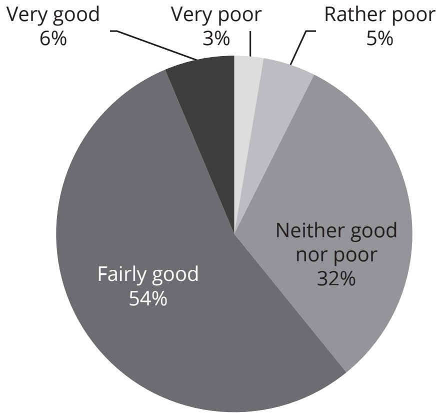
Figure 10.1 Ways of financing small and medium-sized enterprises



Source: Own study based on data from Indicator- Centrum Badań Marketingowych [2018].

The implementation of Industry 4.0 and digitalization projects involves both large and small and medium-sized enterprises. Large companies generally have better opportunities for external financing than smaller businesses. In view of this fact, what poses a significant challenge in the development of Industry 4.0 and digitalization is particularly the mobilization of financing for such projects by small and medium-sized enterprises. The most popular ways of financing small and medium-sized Polish enterprises are own funds (85% of firms), zloty-denominated credit facilities (48% of firms), leasing (25%), family loans (18%), European Union aid funds (10% of firms) (cf. Figure 10.1). As already noted, small and medium-sized enterprises face constraints in access to bank credit. 40% of firms rate the availability of credit as poor, rather poor, or neither good nor poor (cf. Figure 10.2).

Figure 10.2 Rating of the availability of credit for small and medium-sized enterprises in 2018.



Source: Own study based on data from Indicator- Centrum Badań Marketingowych [2018].

Owing to the above-mentioned constraints, it is worth noting possible external sources of financing, created specifically to support Industry 4.0 and digital competitiveness improvement projects. This issue is discussed in the next sub-chapter.

10.2 EU Programs as Ways of Financing Projects Related to Industry 4.0 and Improving Digital Competitiveness

In particular, EU programs as well as national and regional initiatives can be a significant source of funding Industry 4.0 and digital competitiveness improvement projects. Supporting projects of this type is one of the priorities of the EU's development policy, all the more so as, according to European Commission surveys, more than 41% of firms based in the EU have not yet undertaken any measures related to the implementation of Industry 4.0 [European Commission, 2017b]. The desire to deploy digital technologies is declared by 75% of respondents, and 64% of the firms that have implemented such solutions show their positive impact on their business performance [European Commission, 2017A]. In addition, according to the "Welcoming Innovation

Revolution" report developed by GE Global Innovation Barometer 2016, 83% of Polish firms are interested in implementing new technologies [FinTech Foundation Poland, 2017].

In order for firms to be able to use EU programs effectively, it is necessary to provide systemic support in the form of central and local government initiatives. It should be pointed out that the majority of EU member states' governments have launched such initiatives [European Commission, 2017b]. The strategies for funding the Industry 4.0 development projects vary considerably between EU countries, taking the form of funding from public sources, public-private partnerships, as well as the promotion of private funding. Public funding is important in view of the fact that only 25% of respondents to the European Commission's survey declared that they were able to raise external private funding [European Commission, 2017a].

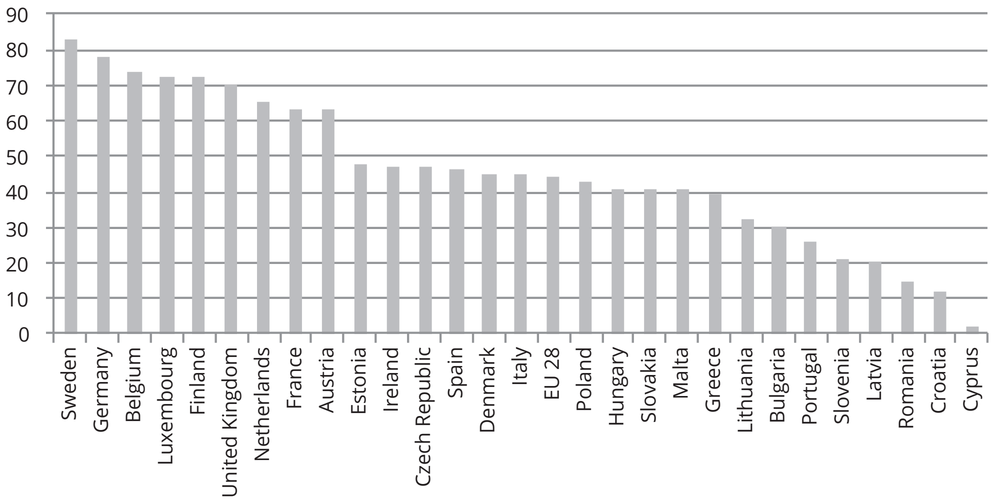
It should be pointed out that the diversity of funding is partly due to the fact that modernization projects involve the deployment of digital technologies in different industries. So far, support initiatives have focused on a wide range of areas: cyber-physical systems, transport, health system, smart cities, artificial intelligence, automotive, electronic, chemical and pharmaceutical industries [European Commission, 2017b]. The initiatives were aimed at both supporting research on the development of Industry 4.0 and the implementation of new solutions. The European Commission's report shows that, in order to increase the efficiency of modernization programs and to facilitate access to their financing, it is necessary to better integrate public initiatives carried out by governments and local authorities, and private ones, pursued by businesses. As announced by the Commission, a growing coordination of national programs at EU level can be expected in the near future, which should contribute to boosting the efficiency of those projects.

According to the Commission's reports, access to financing Industry 4.0 projects in Poland is more difficult than in most member states. Figure 10.3 shows the financing availability index for Industry 4.0 projects in EU countries, based on Eurostat data and the Global Competitiveness Index. The index covers expenditure on research and development in the high-tech industry, the influx of foreign direct investment in the information and communication technology sector, the tax rate, the availability of venture capital, the availability of funding through local markets for equity instruments, and the availability of loans. For Poland, this index is 43, which ranks our country below the average in EU-28, where the index is 44.

A positive aspect in the context of the development of Industry 4.0 and the improvement of digital competitiveness in Poland is a growing number of ICT firms and the establishment by parliamentary act of the Industry of the Future Platform Foundation, which is to be a central information platform for Industry 4.0 initiatives.

Given these facts, mobilization of additional financial resources for this type of projects in our country becomes even more crucial.

Figure 10.3 Access to financing Industry 4.0 projects in EU countries



Source: Own study based on European Commission data.

One of the programs supporting the mobilization of financing for Industry 4.0 projects is the Smart Growth Operational Program. It is administered by the Ministry of Development and supported by the European Regional Development Fund. The program aims to enhance the competitiveness and innovation of the economy by supporting research and development activities of firms and cooperation between entrepreneurs and scientific units. The program also provides the possibility of co-financing expenditure related to innovation in enterprises. Support may take the form of guarantees and direct investment in firms, and financing may relate to projects which fall within the scope of Smart Specializations defined in the list maintained by the Ministry of Development. The program budget is EUR 10 m [European Commission, 2017a].

Another way of support for enterprises willing to implement Industry 4.0 projects is the Innovation Support Loan Fund. It is a support program for small and medium-sized enterprises starting business in innovative industries. Under the program, enterprises can be granted loans at a favorable interest rate. The program is administered by the Polish Agency for Enterprise Development with support from the European Regional Development Fund. The loan amount can range between EUR 46,500 and EUR 446,500 [European Commission, 2017a].

Programs of Bank Gospodarstwa Krajowego (BGK) play an important role in financing Industry 4.0 projects. Possible ways of supporting business ventures include loans for technological innovation and a guarantee fund with interest subsidy. These instruments are encompassed in the Smart Growth Operational Program, where BGK acts as an intermediate body.

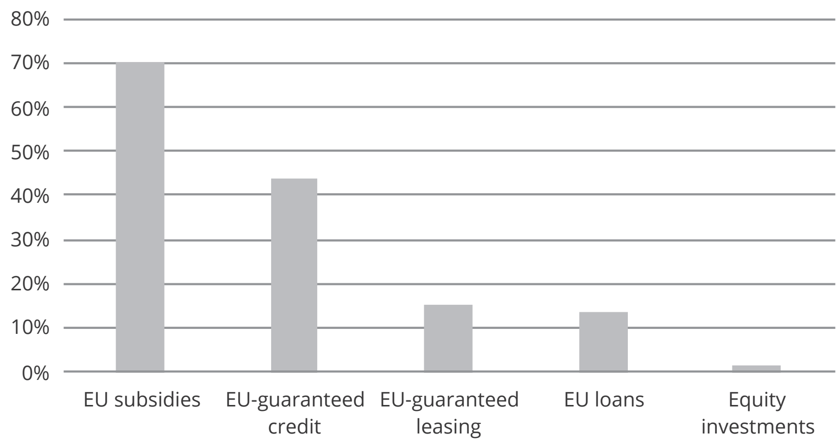
Technological innovation loans are intended for small and medium-sized enterprises implementing identified innovations. The budget of the program is EUR 422 m and the amount of possible co-financing is up to PLN 6 m in the form of the so-called "technology bonus" designed for repayment of an investment loan raised from a commercial bank. An additional benefit for the entrepreneur is a low interest rate on the loan. The guarantee fund with interest subsidy is an instrument designed to secure loan repayment for small and medium-sized firms. The guarantee covers up to 80% of the loan and up to a maximum of EUR 2.5 m for a period of up to 20 years. In addition, the entrepreneur can obtain a subsidy to interest payable under the loan provided that the loan covered by the guarantee is disbursed properly [BGK, 2018].

Other programs available to firms undertaking Industry 4.0-related projects are offered by the National Center for Research and Development (NCBR). An example of such a program is *Fast Track for SMEs*, which aims to support research and development activities. Under the program, projects can be financed which fall within the National Smart Specializations category, and the outcomes of which will be implemented [NCBR, 2018].

The financing of innovative research is also possible under the Horizon 2020 program, which includes: The EU Framework Programme for Research and Technological Development, the Competitiveness and Innovation Framework Programme and the activities of the European Institute for Innovation and Technology. From the point of view of enterprises, the *SME Instrument* is particularly important, under which firms can obtain lump sums for feasibility studies, grants for main stages of an innovation project (demonstration, prototyping, testing, application development). In addition, enterprises are provided with support in bringing a project to market by facilitating access to debt and equity instruments [European Commission, 2014].

Thus, Polish enterprises have a wide range of programs at their disposal to support the financing of Industry 4.0 and digital competitiveness improvement projects. What may pose a problem is the willingness of the firms themselves to use the programs concerned. According to research conducted by the Indicator Marketing Research Center in 2018, 76% of small enterprises and 66% of medium-sized firms have never used any EU financing. The firms that opted for this type of financing used mainly EU subsidies (70% of firms), EU-guaranteed credit (44%), EU-guaranteed leases (15%), EU loans (13.5%) and equity investments (1.5% of firms) (cf. Figure 10.4). Figure 10.5 shows the reasons why enterprises do not apply for EU financing. Data shows that 34% of enterprises do not use EU financing due to lack of need, 28% due to financing application procedures being too complicated, 20.5% due to too many collaterals being required, 20% due to lack of information on possible financing, 17.5% due to difficulties in preparing documentation, 17% due to lack of relevant programs, 13% due to the high cost of consultancy services, 12.5% due to lack of time to prepare the application, and 11.5% due to lack of funding, e.g. for equity contribution. It should also be pointed out that 25% of small and medium-sized enterprises consider their knowledge on the mobilization of financing from EU sources as very poor or rather poor [Indicator, 2018]. This means that convincing firms which implement Industry 4.0 and digital competitiveness projects to use EU funds will require the promotion of programs and assistance in applying for funds and preparing documentation.

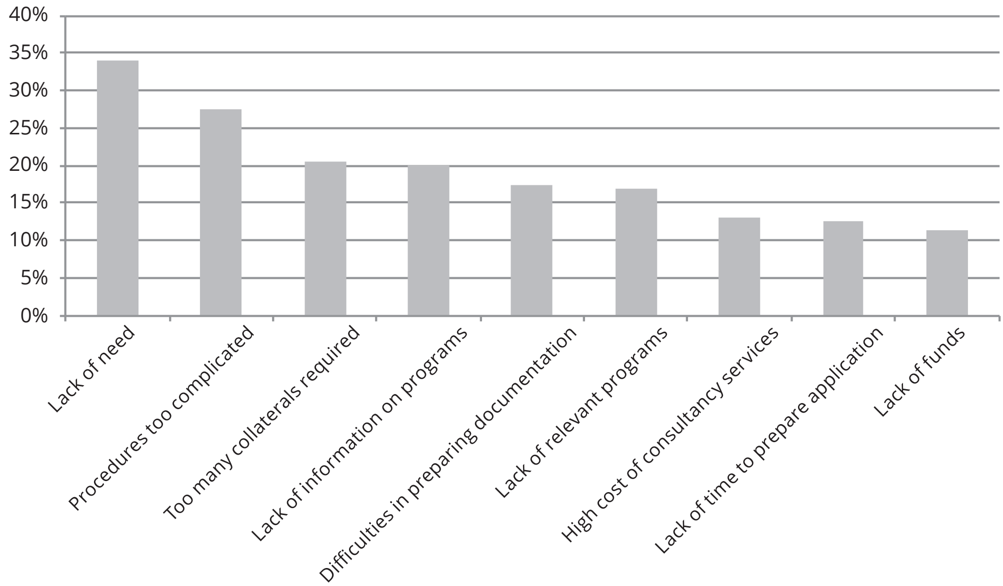
Figure 10.4 Utilization of UE funds in financing enterprises in Poland



Source: Own study based on data from Indicator- Centrum Badań Marketingowych [2018].

Finally, it is worth noting that it is not only the mobilization of financing that poses a significant challenge for firms implementing Industry 4.0 solutions, but also the application of new methods of financial management. The use of digital technologies will significantly affect the functioning of business finance operational models by changing the necessary resource and allocation of funds, ways of reporting financial data (automation of reporting), goodwill disclosure, and the necessary qualifications of personnel dealing with finance. Financial management should allow for faster delivery of relevant information both to managers and to third-party stakeholders, taking into account future prospects for the firm. The digitalization of enterprises and the use of big data combined with robotics and artificial intelligence will create advanced analytical capabilities, such as faster retrieval of information from large amounts of data. In order to enable such progress, it will be necessary to appropriately prepare enterprises for the changes identified, mainly in the operation of new systems and adapting the qualifications of personnel in charge of financial management. Efficient process management under the new conditions should positively affect the financial standing of the firm and facilitate the mobilization of further sources of funding.

Figure 10.5 Reasons for which firms do not seek EU financing



Source: Own study based on data from Indicator- Centrum Badań Marketingowych [2018].

10.3 Digital Technologies in Banks and the FinTech Sector

When analyzing the importance of the financial system in the context of the challenges of Industry 4.0 and digital competitiveness, it is also important to draw attention to the modernization of the financial system itself in terms of the use of digital technologies. As the Polish financial system is mainly based on banks, the use of digital technologies in banking services plays an important role. It should be noted that Polish banks employ very extensively the most advanced technologies; compared with other European countries, they stand out with an advanced level of digitalization [FinTech Foundation Poland, 2017]. Following the recent financial crisis, due to the revealed disadvantages of the banking system, the FinTech (Financial Technology) industry has grown rapidly in our country, offering innovative financial services based on information technology. Formally, the innovative activities of banks and other financial institutions are also included in this sector. However, a significant part of the industry is also creating new, unsupervised firms that offer innovative services to financial institutions [Polish Financial Supervision Authority, 2017). Poland is the largest FinTech market in Central and Eastern Europe, the value of which is estimated at EUR 856 m [Flanders Investment & Trade, 2018]. The activities of FinTech firms include services such as electronic payments, financial platforms, insurance, data analysis, sales channel development, machine learning, robo-consulting and crowdfunding [FinTech Foundation Poland, 2016]. FinTech enterprises in Poland are mostly geared towards cooperating with banks due to the numerous benefits of such cooperation.

In Poland, there are good conditions for further development of the FinTech sector. The strengths of our economy in this regard include an innovative financial sector, a large market size and access to EU markets based on European passporting rights, well-educated staff, and low labor costs. A factor conducive to the development of digital technologies in the Polish financial system is also a strong interest of banks themselves in different forms of cooperation with FinTech companies. Research carried out by FinTech Foundation Poland and consulting firm Obserwatorium.biz sp. z o.o. shows that for 69% of firms the main recipient of innovative financial products is the business customer, for 56% it is a bank, for 50% the retail customer served directly, and for 31% of firms a different financial institution.

Banks invest in innovation in many areas, mainly in online sales, remote customer service, digitalization of outlets, and payment methods. They support FinTech industries through various cooperation models, e.g., by setting up accelerators for new entrants in the financial technology industry, or cooperating with an external accelerator. Examples of accelerators set up by banks include: Alior Bank – HugeThing, ING Bank Śląski – Akcelerator ING, mBank – mAkcelerator, PKO BP – Let's FinTech with PKO Bank Polski, Pekao SA – Społeczny StartUp [FinTech Foundation Poland, 2017]. An alternative way of banks' involvement in the FinTech sector is through acquisition of enterprises operating in the industry. Unlike an accelerator, this solution is used for businesses at a later stage of development, offering mature solutions in line with the business strategy of the bank concerned. Such investments have been made, e.g., by PKO BP and ING Bank Śląski [FinTech Foundation Poland, 2016]. Further possible forms of co-operation between banks and FinTech firms may be innovation laboratories (e.g., Alior Bank's Innovation Lab or Blockchain Lab run by Coinfirm.io.), or cooperation agreements. However, banks and FinTechs also point to barriers in cooperation, notably IT security, regulatory uncertainty, differences in governance and organizational culture, and required financial investments [PricewaterhouseCoopers, 2017a].

The Polish Financial Supervision Authority (KNF) report identified 85 legal, regulatory and supervisory impediments to the development of the FinTech sector on the basis of reports from institutions representing firms operating in the industry. Barriers have been identified in terms of system solutions (29), payment services (17), capital market activities (16), customer service and data processing (14), insurance services (8), and crowdfunding activities (1). The main impediments identified include the fact that the promotion of financial innovation is not among the objectives of financial market supervision, the lack of legal certainty in terms of financial innovation and the lack of a friendly legal and regulatory environment, insufficient dialog with supervisory authorities, excessive national regulation compared to EU rules, long and arduous supervisory processes, and lack of financial support for FinTech development. Regulatory impediments in Poland are assessed as relatively high compared with other countries where FinTech is developing dynamically [FinTech Foundation Poland, 2017]. The KNF report indicates that 68% of the barriers are being removed.

It should be pointed out that the development of financial innovation has become one of our country's economic policy priorities. Communication plays an important role. On the basis of a recommendation from KNF, the Ministry of Development provides information on its website on financial support available to FinTech companies. In order for further development of the sector to take place, it is necessary to provide systemic support to this industry, eliminate regulatory and legal barriers, design a FinTech development strategy with the involvement of the private and public sector, and offer programs to support businesses implementing financial innovations. Consultative bodies composed of both public sector and FinTech representatives, which could also coordinate support programs, play a key role. Programs encouraging entrepreneurs to set up new businesses in the financial innovation industry should be an important element of the strategy. The growth of the FinTech industry will fall in line with the trends in the development of Industry 4.0 and overall digitalization of the economy. Another important element supporting these trends is the education of the relevant human resources, both at academic level and in business practice.

Summary

In Poland, there are good conditions for the development of Industry 4.0 and the improvement of digital competitiveness in both the non-financial and financial sector. The Polish financial system provides a range of opportunities to raise funds for innovative projects. The strengths of our economy in terms of the development of digital technologies include high interest of businesses in introducing new technologies, innovative financial sector, large market size and the access of companies to markets in the EU, well-educated human resources and low labor costs, and significant interest of banks in various forms of cooperation with FinTech companies. Another factor conducive to the development of Industry 4.0 and financial innovation in our country is the fact that it has become one of the priorities of economic policy. Systemic support for projects is to include the statutory establishment of the Industry of the Future Platform Foundation, EU financing programs for innovative projects and measures taken by KNF and the Ministry of Development, aimed at promoting the development of financial innovations and eliminating existing barriers to project implementation.

However, it should be pointed out that access to the financing of Industry 4.0 and digitalization projects is more difficult in Poland than in most EU member states. Regulatory barriers to the financial innovation industry are an additional obstacle to the development of Industry 4.0 and digitalization.

In order to support the development of Industry 4.0 and to improve digital competitiveness in terms of bringing to bear the opportunities offered by the Polish financial system, it is necessary to design a strategy for developing modern technologies with the involvement of the public and private sectors, promote programs supporting enterprises that implement financial innovations, remove identified regulatory and legal barriers, and provide assistance to businesses pursuing innovative projects in applying for funds under EU programs.

Bibliography

BGK [2018], *Finansujemy innowacyjne inwestycje*, Materiały z konferencji *Kształtowanie potencjału rynku dla Przemysłu 4.0 w Polsce*

Flanders Investment & Trade [2018] *FinTech in Poland*

FinTech Foundation Poland [2016], *Polski rynek FinTech – bariery i szanse rozwoju 2016* FinTech Foundation Poland, [2017] *Raport. FinTech Hub Polska. Jak skutecznie zbudować centrum finansowe nowej generacji w Polsce?*

Indicator – Centrum Badań Marketingowych [2018] *Polscy przedsiębiorcy o usługach bankowych*

European Commission [2017a] *Digital Transformation Scoreboard 2017: Evidence of positive outcomes and current opportunities for EU businesses*

European Commission [2017b] *Digital Transformation Monitor. Key lessons from national industry 4.0 policy initiatives in Europe*

European Commission [2014] *Horizon 2020 in brief. The EU Framework Programme for Research and Innovation*

Polish Financial Supervision Authority [2017] *Raport z prac Zespołu roboczego ds. rozwoju innowacji finansowych (FinTech)*

Ludwiniak P., *Finansowanie czwartej rewolucji przemysłowej*, “Obserwator finansowy”, 14.04.2017

NCBR [2018], *Instrumenty wsparcia NCBR, Materiały z konferencji Kształtowanie potencjału rynku dla Przemysłu 4.0 w Polsce*

PricewaterhouseCoopers [2017a] *Banki i fintech-y – małżeństwo z rozsądku*

PricewaterhouseCoopers [2017b] *Przemysł 4.0 – wyzwania współczesnej produkcji*

https://ec.europa.eu/growth/tools-databases/dem/monitor/content/welcome

http://www.leasing.org.pl/

https://www.mpit.gov.pl/strony/aktualnosci/ksztaltowanie-potencjalu-rynku-dla-przemyslu-40-w-polsce/

Chapter 11

Investments and Financing the Fourth Industrial Revolution in Poland

Piotr Maszczyk

Introduction

The amount of investment outlays is a major factor affecting the rate of gross economic growth (GDP) and the competitiveness of economies, and determining the rate of fundamental transformations in the structure of the product generated and the economic model. Domestic funds are the main source of financing investment in Poland, and the inflow of foreign capital, although significant, is steadily decreasing. This chapter includes an analysis of the impact of investment outlays on the competitiveness of the Polish economy and the capability to finance the Fourth Financial Revolution, with a particular focus on changes that took place in 2011–2018, in the context of tendencies witnessed in other EU countries.

11.1 Analysis of Existing Trends

When analyzing the rate and direction of change in investment outlays in Poland in 2010–2018, two key factors that determine this component of global demand should be considered. Firstly, the last eight years were marked by a steady decrease in the adverse consequences of the 2008 crisis in the global economy, especially in the economies of most EU countries. By 2017, there were no more signs of the crisis. This means that exogenous factors had a neutral effect on the pace and level of changes in investment outlays in Poland from 2014 onwards, and a definitely favorable effect in 2017 and 2018. Secondly, 2016 saw a rather fundamental shift in Polish economic policy, which was related to the change of government following the 2015 elections. A thorough revision of fiscal policy combined with specific rhetoric, used in a more or less skillful manner by politicians from coalition parties centered around PiS, meant that endogenous factors were absolutely crucial in the context of new investments.

Of course, this strong negative impact of adaptive expectations of business entities was short-lived, as be inferred from the 2017, and especially 2018 data. This was especially the case, as local elections were held in Poland in 2018, a circumstance conducive to public investment spending owing to the nature of the run-up campaign. Thus, the favorable or negative tendencies witnessed in the global economy, as well as in all Poland's major trading partners, combined with a quickly improving local investment climate, gradually reduced the significance of the adverse factors that had brought about a collapse in the value of investments in 2016. Nevertheless, when assessing investment outlays in the enterprise sector in 2018, it is hard not to admit that their moderately positive dynamics continued to be primarily influenced by variables strongly determined by the relations between the state and the private sector. Especially given that the investment value growth rate was higher in all benchmark countries for Poland (the Czech Republic, Hungary and Slovakia). This lends relativity to the opinion, which is quite common among politicians and analysts sympathizing with the ruling camp, that the growth in investment outlays after the 2016 was a derivative of the beneficial impact of the political environment on the decisions of the enterprise sector in this area.

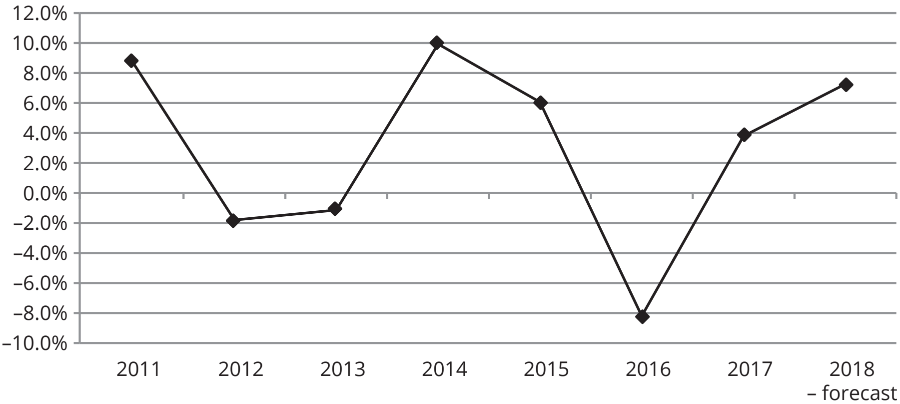
The first three years of the analyzed period (2011–2013) saw a decline in investment value in Poland, with the exception of 2011, when the value of investment increased by nearly 9% along with a significant acceleration of the GDP growth rate. During these three years, negative tendencies in the investment structure were related to the spreading adverse consequences of the 2008 global economic crisis, which started in the US, and expanded to the global economy in the following years. It is worth noting that although the GDP growth rate in 2011 was over 1.5 p.p. higher than in 2014 (5.0% vs. 3.3%), the growth rate of investment outlays was lower by more than 1 p.p. (8.8% vs. 10.0%). Therefore, for as long as the negative consequences of the crisis strongly persisted in the global economy, they substantially reduced the impact of beneficial tendencies witnessed in Poland. It was not until its adverse effects in the Polish economy were finally overcome in 2014 that it became possible to stabilize the positive (though not increasing) rate of growth of investment outlays in two subsequent years. It should, however, be emphasized that just as in the context of GDP, the negative impact of global economic turbulence on the value of investment outlays in Poland was relatively limited compared to the other EU countries. The year-on-year calculation of investment value did not decrease in the analyzed sub-period more than by 1.8%, while in 2007 the amount earmarked for investment increased by as much as 17.6%.

On the one hand, growing investment outlays undoubtedly stimulated the increase of the competitiveness of the Polish economy. On the other hand, Polish enterprises doing increasingly well in the EU markets boosted investments, and thus their production capacity, in order to meet the growing demand at home and abroad. The path of changes in both gross domestic product and global demand and investments in 2010–2018 reaffirms the validity of the stylized facts resulting from the design of the demand model. According to its assumptions, investments are the component of global demand, which reacts to changes in the economic situation much more strongly than its other parts, and contributes to these changes itself by creating a specific feedback mechanism. Thus, investments stimulated both the demand and supply sides of the Polish economy. As indicated by the data analyzed further on in this chapter, such a relationship between investments and the rate of economic growth has been confirmed in the economy over the past 10 years. Despite a slight acceleration of the economic growth rate, a decrease in the growth rate of gross fixed capital formation in 2015 should be treated as a one-off event, being a specific “correction” of the two-digit dynamics from the previous year. However, it should also be viewed as a positive effect of the balance of foreign trade on the rate of economic growth. The rate of changes in domestic demand was nearly 1.5 p.p. lower in 2015 than in the previous year (3.4% compared to 4.7% in 2014), which, according to the assumptions of the Keynesian model, had to result in a lower investment growth rate.

In 2011, GDP increased in Poland by 5%, which – according to the mechanism presented above and described in the demand model – meant a dynamic growth of investment by nearly 9%. The next year, 2012, uncoincidentally called “the year of the second wave of crisis”, showed a sharp decline in the GDP growth rate (only 1.6%) and, as could be expected, a decrease in investment value by 1.8%. It was therefore reasonable to presume that 2013, which saw a decrease in the GDP growth rate of 0.2 p.p. against the previous period, would be another year of decline in the value of investment outlays. The expected effect did occur, and the value of investments decreased by 1.1%. The rate of economic growth accelerated by nearly 2 p.p. in 2014, which, in line with expectations based on the demand model, allowed gross fixed capital formation to be increased by 10%. The GDP growth rate was even faster in 2015 (3.8%), and investment outlays increased again, albeit slower than in the previous year (6.1%, or nearly 4 p.p. slower). However, the decline in the growth rate dynamics of investment outlays in this case was caused in this case, as demonstrated above, by a slower growth rate of domestic demand. In 2016, the economic growth rate decreased by almost 1 p.p. in relation to the previous period, which – as could be expected based on the conclusions arising from the demand model – led to a decrease in the value of investment outlays of almost 8%. Identical tendencies continued in 2017. Acceleration of the economic growth rate to 4.8% (i.e., by more than two percentage points), made it possible not only to reverse the previous negative tendencies, but also to generate a growth in investment outlays by almost 4%.

According to still-preliminary data for 2018, it can be stated that the relationship between rate of changes in investments and GDP is fairly stable. Acceleration of the economic growth rate by another half percentage points (the GDP growth rate forecasted in 2018 reached 5.1% according to GUS data as of the end of January 2019) was correlated with an increase in gross fixed capital formation by a forecasted 7.3%. An attempt to estimate investment outlays in 2019 is discussed in a further part of this chapter, but a slowdown of the current high rate of economic growth, expected by a vast majority of economists, will be accompanied by a decline in the growth dynamics of the value of investment outlays. Thus, this means that the mechanism and dependencies observed in 2010–2017 will be maintained (Figure 11.1).

Figure 11.1 Dynamics of changes in investment outlays in Poland during 2010–2018



Source: Own calculations based on GUS data.

According to preliminary data published by GUS (end of January 2019), the value of investment outlays increased in Poland by over 7% in 2018. It is worth noting, on the one hand, that this value is consistent with the forecasts under the base scenario included in the Competitiveness Report 2017. On the other hand, however, the forecast according to which the minimum investment growth rate was expected to be 6% in 2018 was devised with the reservation that the GDP growth rate in the same period would range at approx. 4–4.5%. Having regard to the fact that the real growth rate of global product in Poland in 2018 was more than 0.5 p.p. higher, the data reflecting the change in gross fixed capital formation can be described as moderately disappointing. Based on the previous year's forecasts, it can be said that both the external and internal situation in Poland was determined by a set of factors enabling a two-digit growth rate of investment to be achieved. GUS data (February 2018) show total investment outlays of PLN 89.5 bn at the end of the third quarter of 2018, i.e., almost 15% higher than at the end of the corresponding period of the previous year. At the same time, according to a preliminary GDP estimate for 2018 released by GUS, it can be expected that the value of investment in the entire economy will reach about PLN 256.7 bn, i.e., a 7.3% increase compared to the previous period (the value of investment outlays in the entire economy decreased by 3.9% in 2017). Therefore, the investment rate in the national economy (the relation of gross fixed capital formation to GDP in current prices) in 2018 increased (for the first time since 2015) and reached, according to GUS preliminary estimates, 18.1%, compared to 17.7% in 2017 and 18.1% in 2016. It should be stressed, however, that 2015 the rate still exceeded 20%.

Acceleration of the rate of growth in the value of investment outlays in Poland in 2018 was mainly a consequence of endogenous factors. The growing dynamics was primarily attributable to a growth in public investment related to the political business cycle and local government elections which were held in Q4 2018. Nevertheless, the share of private business investment also increased, related to the necessitated expansion of the production potential. However, a question can be posed about the extent to which the policy pursued by the authorities – which maintains a high level of risk associated with possible changes in the tax system, coupled with the aggravation of the severity of control mechanisms of fiscal administration – has reduced the investment growth rate in the private business sector. Especially given a very high level of utilization of production factors (around 80%) and the record-high value of current assets in bank deposits in the enterprise sector. Having regard to the above values, as well as a record-low unemployment rate and negative real interest rates that could be used to "leverage" credit, enterprises should increase investment at a double-digit rate. However, this was not the case, which testifies to a negative impact of the political risk factors on the amount and rate of change in investment outlays in 2018. In this context, the decline in the dynamics of investment growth in Q4 2018 may also be concerning. While at the end of Q2 2018 the investment growth rate was above 13% (10.3% in the first half of the year), it was only 9.9% in Q3 and probably even less in the fourth quarter if the value forecasted by GUS for the whole year only slightly exceeded 7%. The results recorded at the end of June 2018 induced many economists and analysts to come up with the opinion that a rapid increase in investment, especially in machinery and equipment, will make it possible to gradually upgrade the machinery fleet of Polish enterprises and increase the degree of its mechanization and robotization, which was supposed to be a way of dealing with supply constraints in the labor market. Thus, the favorable tendencies that could be observed in the first half of 2018 could be regarded as shy harbingers of the Fourth Industrial Revolution in Poland. Unfortunately, Q4 2018 data, certainly much less optimistic, will revise these expectations. Despite the undoubtedly positive trends in investment over three consecutive quarters (Q4 2017 and the first two in 2018), one cannot but notice the earlier period of almost six years of stagnation or even a decline in the value of investment outlays. It is therefore hard to prejudge whether we are faced with the beginning of a lasting trend, which can mean, in a longer run, the beginning of not only quantitative but also qualitative changes in the Polish economy, or rather an event of a short-term nature.

The value of direct foreign investment (FDI) flowing into Poland in 2018 had a moderately negative impact on gross fixed capital formation in the same period. According to estimates presented by the Ministry of Entrepreneurship and Technology in February 2019 and based on data of the National Bank of Poland, the inflow of direct investment to Poland decreased in 2018 to PLN 33.4 bn, i.e. by approx. PLN 1.3 bn year-on-year. This means a reversal of the favorable tendencies from the previous year, when the growth in the value of the FDI inflow reached approx. 5%. While according to NBP data the net value of foreign direct investment was more than 40% lower in 2017 than in the record year 2016 (PLN 61.8 bn), such a steep decline in the net value of FDI was partly attributable to the "repolonization" of *Bank Pekao SA*. In June 2017, *PZU* and *PFR* acquired a PLN 10.6 bn shareholding in *Bank Pekao* from the Italian group *UniCredito*. As a result of that transaction, Italian divestments (i.e., the situation where foreign entities withdraw more capital than invested) amounted to PLN 8.4 bn in 2017. In addition, very large capital amounts (PLN 13 bn) were withdrawn from the Polish market by Dutch investors (which was probably related to transactions around the acquisition and sale of the *Allegro* auction service). In 2017, Dutch divestments reached PLN 7.2 bn. In relations with other countries, the capital inflow balance was usually positive in 2017. The largest amounts were invested in Poland by entities from Germany (PLN 12.8 bn), Luxembourg (PLN 12.4 bn) and Cyprus (PLN 5.5 bn). During that period, investment concentrated mainly in industrial processing (PLN 15.6 bn) and in finance and insurance (PLN 12.4 bn). Income of foreign firms derived in Poland is the source of a vast majority of FDI. In 2017, reinvested profits amounted to as much as PLN 38.1 bn, which is a record level. According to NBP data, the largest amounts are reinvested in Poland by companies from Germany (PLN 8.7 bn), the Netherlands (PLN 6 bn), and Luxembourg (PLN 4.2 bn).

In 2018, the Polish Investment and Trade Agency (PAIH) closed 70 projects with a value of EUR 2.13 bn. By comparison, a year earlier there were 61 projects with a value of EUR 2.08 bn. This means that 9 projects more were closed than in 2017, but the average value of one project decreased slightly, from approx. EUR 34 m to approx. EUR 30 m. According to data provided by PAIH, as many as 92% of investors consider Poland as a good place for investing. Exactly the same percentage declared they would choose our country if they were to decide again where to invest. According to studies conducted by the Polish Investment and Trade Agency, it can be stated that the investment climate in Poland is conducive to attracting foreign businesses, which develop technological innovations in Poland and generate new jobs for highly-skilled specialists. Hence their activities have a positive impact in terms of the capacity to undertake the Fourth Industrial Revolution in Poland. In this context, it is worth stressing that the sector that stands out most clearly in the PAIH portfolio is the automotive industry, or, to be exact, electro-mobility, that is, the segment of the industry which is the most advanced technologically. As emphasized by PAIH representatives, the largest investment served by the Agency in 2018 was a project by the Belgian company *Umicore* with a value of EUR 320 m (factory in Nysa, where components for batteries installed in electric vehicles are manufactured).

Foreign investors declare that challenges related to the recruitment of employees, which might potentially impede the implementation of investment projects in Poland, have been offset by positive factors, e.g. a good economic situation, which is highly appreciated by the survey participants. Apart from economic stability, which the respondents believe has been improving, the high attractiveness of the Polish investment offering is also shaped by the size of the internal market availability of materials and components, and cooperation with local administration. Employees are also Poland's strength. Three elements: labor productivity, organizational culture and loyalty were ranked among the top five by investors. The respondents also appreciate the quality of infrastructure, which in their opinion is one of the elements defining Poland's investment strengths that have been improving the fastest in the recent years. Among factors that limit the attractiveness of Poland, the surveyed representatives of foreign entities point to insufficient stability and predictability of law, low efficiency of the commercial judiciary and not so much the rates of taxes themselves as the formalities related to them.

What had a definitely positive impact on the growth rate and level of investment outlays in Poland in 2018 was a growing absorption rate of structural funds flowing into Poland from the EU budget. While the situation in this area is obviously far from satisfactory, the utilization rate of EU aid funds significantly improved in 2018. Delays in the implementation of funds under most operational programs, which ranged around 12 months in Q1 2017, or more than 20 months for railway projects, were reduced significantly at the end of last year, although the targets under earlier plans had yet to be achieved. Local government enterprises, which were particularly affected by the slowdown, started to gradually increase the number of contracts put out to tender, mainly in construction, as the local government election campaign was gaining momentum

Unfortunately, upon the end of the previous financial perspective, the Ministry of Development ceased the regular publication of data on the value of eligible expenses of beneficiaries, resulting from submitted payment applications. According to the partial data available[1], an estimated 122.7 thousand payment agreements were successfully signed with the beneficiaries as at the end of January 2019, with the co-financing from the EU funds amounting to PLN 79.7 bn. This represents 25.7% of allocations under the 2014–2020 financial perspective (the amount in the Polish national envelope under the European Social Fund and the European Regional Development Fund is approx. PLN 310 bn)[2]. The utilization rate of these funds appears to be extremely small, given that payments under the current financial perspective can only be made until the end of 2022. Corresponding indicators at the end of 2017 were nevertheless almost 50% lower. The number of payment agreements signed with the beneficiaries was lower by as much as 53 thousand (only 69.7 thousand agreements were signed), with PLN 39.3 bn in co-financing from the EU funds. Thus, during 2018, the amount attributable to EU funds in the payment applications was increased by as much as PLN 39.4 bn. In order to lend additional strength to this moderately optimistic picture, it is worth noting that the total value of beneficiaries' eligible expenditure, resulting from the payment applications submitted, reached the following respective amounts at the end of the settlement period under the previous financial perspective: PLN 52.5 bn in 2015 (compared to PLN 64.2 bn in 2014), with the EU co-financing of PLN 37.8 bn (PLN 45.4 bn in 2014).

A comparison of the rate of changes in investment outlays in 2011–2018 in Poland, the Czech Republic, Slovakia and Hungary, countries that have traditionally been our main competitors in the absorption of investment in the region, clearly shows that although the level and dynamics of accumulation in all Central and Eastern European countries which joined the EU in 2004 are primarily under the influence of exogenous factors (global crisis, EU membership, economic situation in Germany), they differ quite significantly.[3] More precisely, a progressive convergence of trend and dynamics of investment outlays can be seen in Poland, the Czech Republic and Slovakia, while a relatively uniform pattern for this group begins to increasingly differ from the mechanisms taking shape in Hungary.

During the entire analyzed period, the value of investment in the Czech Republic was seen to increase in 2011, 2014–2015, and again in the 2017–2018 period. Thus, the direction of changes in the value of investment outlays fell in line with the trend observed in Poland over the eight years relevant to this study. The amplitude of

1 See www.funduszeeuropejskie.gov.pl

2 Using an artificial conversion rate of 4 PLN/EUR.

3 Investment outlays in the Czech Republic and Hungary in 2011–2018 on the basis of Eurostat data published on the website: http://epp.eurostat.ec.eu.int. Annual data have been estimated based on quarterly statements. Values for Slovakia have been estimated based on information provided by IMF: ww.imf.org.

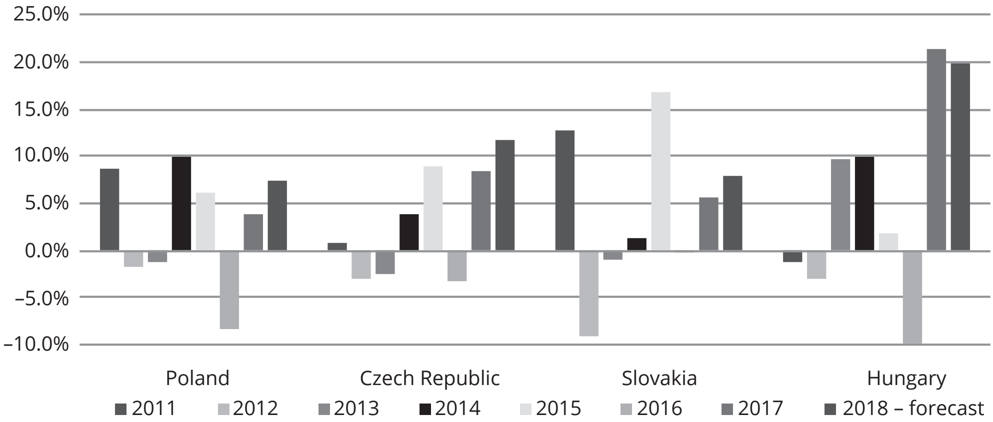
fluctuations in the value of investment in the Czech Republic and Poland was also similar. With the value of investment increasing, the growth rate in each of these countries exceeded 10% only once (in 2014 in Poland, and in 2018 in the Czech Republic), whereas with investment value falling the growth rate did not exceed 5%. The year 2016 was an exception from this rule, when the value of gross fixed capital formation decreased by almost 8%. In addition, the Czech Republic not only failed to achieve a stable upward trend in this component of demand, spanning three years, as was the case in Poland, but it was also unable to return to the level of investment recorded before the 2008 crisis.

Slovakia is the country where the pace and dynamics of investment outlays followed, until recently, a change pattern which was the most similar to Poland's. In the analyzed period, just as in the context of the Czech Republic, the direction of investment changes was consistent with the pattern observed in Poland as many as eight times. However, the amplitude of fluctuations in the value of investment in Slovakia was much higher than in Poland and the Czech Republic – both for the years in which investment outlays grew, and when this component of global demand was seen to decrease.

Hungary (like Poland, Slovakia and the Czech Republic) not only managed to achieve a positive growth rate of investment outlays in 2018, but it also boasted an impressive double-digit figure (19.8%, with the 2017 growth rate of 21.5%). Such a significant difference in this component of the global demand growth rate additionally aggravates the divergent tendency in investment in Hungary in relation to Poland, the Czech Republic and Slovakia. That said, it should also be kept in mind that this impressive growth rate followed an equally dynamic decline in investment outlays in 2016 (by 16%). What is more, Hungary experienced a decline in investment also in 2011, when this component of global demand increased both in Poland and in the Czech Republic and Slovakia. On the other hand, the value of investment in Hungary increased not only in 2014 and 2015 (as in other countries of the Visegrad Group), but also in 2013. The impressive investment growth rate in 2017–2018 clearly shows that the negative impact of the public finance crisis on the investment level faced by the Hungarian economy until recently has actually run out, even though the increase in this component of global demand in 2015 was symbolic (by 1.9%), followed by a steep decrease in 2016.

A comparison of investment growth in Poland and in the other new EU member states in 2010–2018 is presented in Figure 11.2.

Figure 11.2 Comparison of investment growth in Poland, the Czech Republic, Slovakia and Hungary in 2010–2018



Source: Own calculations based on Eurostat and IMF data.

11.2 Investment Dynamics – a Forecast Attempt

Given the set of factors described above, which contributed to an accelerated growth in investment value in 2018, forecasting the direction of this component of global demand in 2019 seems to be a fairly easy task carrying little risk. This is especially the case as the majority of analytical institutions expect that the favorable tendencies in investment outlays will continue, whereas the investment growth rate will slightly slow down.

Trends on the supply side of the Polish economy, mainly in capital productivity, have been the subject of analysis in previous editions of the Competitiveness Report many times. To conclude these considerations, it can be reminded that the hypothesis on the correlation of a high growth rate of investment outlays with equally high dynamics of the GDP growth rate has been subject to explicitly positive empirical verification for many years in Poland. When a downward tendency in fixed capital formation appears (e.g., in 1997–2003), a decrease in the GDP growth rate can almost automatically be observed. The same tendency could be seen in the context of the GDP index when there is a reversal of the downward tendency of the capital expenditure growth rate (2004–2008 as well as 2017). A specific "business cycle" can even be said to exist in this context, in which the periods of rapid growth in investment outlays and decline in productivity intertwine with periods when capital and labor outlays decrease, while the TFP value grows, keeping GDP growth at a positive level.

Based on that, the data published by GUS [2019], as well as an analysis of quarterly changes in GDP, global demand and its major components, combined with business cycle studies, allow one to hope for just a slight deceleration in economic growth (by about 0.6 p.p.) in 2019. In addition, if the government manages to implement the reform package announced in February 2019 (extension of the "Family 500 Plus" program to include every first child, doubling the tax-deductible expenses for taxpayers filing the PIT tax return form, income tax exemption for persons under 26 years of age, and lowering the second tax bracket from 18 to 17%), this will mean a rapid loosening of fiscal policy, as the total amount of revenue depletion and increased general government expenditure in the wake of the changes announced is likely to exceed PLN 20 bn in 2019. In such a situation, it may turn out that the GDP growth rate will not decline in 2019 at all, and instead – driven by the rapidly increasing household consumption – it may even rise.

Importantly, however, the structure of global demand, which determines the output volume, will then certainly change. In 2018, growth was driven equally by increasing investment outputs and by consumption growth. The loosening of fiscal policy will cause consumption expenditure of the household sector to become again the main driver of GDP growth in Poland.

Given the projected economic growth rate of 4.5% (with an acceptable fluctuation band of +/–0.5 p.p.), all of these signs suggest that a growth rate of investment in Poland in 2019 will be not less than 5%, with the possibility of this value being exceeded by as much as 3 p.p., especially since endogenous factors limiting the growth rate ceased to play a significant role as early as the fourth quarter of 2017. It seems that in the face of the forthcoming European and national parliamentary elections the prospect of a profound income tax reform, which would, by nature, entail a tax rise for selected taxpayer groups, has been postponed to an unspecified future. The severity of new tools used to "seal" the tax system has also been assimilated and accepted by most entrepreneurs. Given the stable stance of the Monetary Policy Council (MPC), which rules out, in principle, an interest rate hike in 2019 and probably in the first half of 2020, and a further boost in public investment co-financed from the EU funds, which will take place in the first and second quarters (the upcoming local elections will act as a strong accelerator of this process), this year will see a continuation of the existing favorable trends in financing investment outlays. The financial situation of Polish businesses is good, the financing conditions are favorable, and the capacity utilization in the economy remains high, and therefore investment is necessary to meet growing demand.

The forecasts presented above are based on the assumption that the European and global economy will be developing in line with a relatively conservative base scenario, under which no positive or negative unexpected factors are to emerge in 2019, and internal political risk in Poland will remain at the current level. Under this scenario, Polish exports will be growing slightly slower than before (with a simultaneous fast growth in imports), which will be a consequence of a slower economic growth in the Euro area, especially in Germany, a decline in global foreign trade turnover in the wake of the trade war between the US and China, and Brexit. On the other hand, the persisting undervaluation of the zloty will partly offset a decline in foreign demand in 2019. Of course, the neutral stance of the MPC, indicated as an element that lends probability to a favorable scenario, stimulating an increase in the value of credit for enterprises under conditions of negative real interest rates, will be possible only if the existing trend preventing a sustained rise in prices of energy resources does not reverse rapidly, and the relaxation of fiscal policy does not increase inflationary pressure to a level that will force the MPC to increase interest rates.

The amount of investment outlays in the Polish economy would also be adversely affected by economic or political disturbances in the United States. If the US–China deal is not reached, and the US decides to step up protectionist measures in foreign trade, the global economy may slow down rapidly, which would not only entail repercussions for the economic growth in Poland, but also a growing global aversion to risk and the weakening of the zloty. Under this scenario, the MPC would probably sooner change its stance in monetary policy from neutral to restrictive, and an interest rate hike would be seen as early as the fourth quarter of 2019 instead of the latter part of 2020, as expected by most analysts.

On the other hand, an improved economic situation (or at least a lower-than-expected negative rate of GDP growth) in the EU countries (mainly in Germany), deferment, or even abandonment of the United Kingdom's exit from the EU (an apparently increasingly likely prospect at the end of February/beginning of March 2019), and a continuing relatively high growth rate in the US would mean a positive impact of exogenous factors on the GDP and investment growth rate in Poland. However, in the first quarter of 2019, it is hard to assess the probability of either the positive or the negative scenario.

Bibliography:

Eurostat [2019], *www.ec.europa.eu/eurostat/*.

GUS [2019], *Biuletyn Statystyczny*, No. 1, February. Warsaw: GUS.

NBP [2019], National Bank of Poland, www.nbp.pl

PAIH (2019), Polska Agencja Inwestycji i Handlu, www.paiz.gov.pl.

www.funduszeeuropejskie.gov.pl

Chapter 12

Development of Human Resources in the Context of the Challenges of Industry 4.0 and the Digital Economy in Poland

Anna Maria Dzienis

Introduction

The publication of "Re-imagining work, Green Paper Work 4.0" by the German Federal Ministry of Labor and Social Affairs in April 2015 launched a consultation process on the concept originating from the discussion on Industry 4.0 (I4) – Work 4.0. The consultations concluded in March 2017 with an issue of "Re-imagining work, White Paper Work 4.0", giving an insight into future work perspectives, scenarios and opportunities. The document underlines that the debate on Work 4.0 is an essential extension of the discussion about the digitalization of the economy or the Fourth Industrial Revolution (4IR).

Besides German papers, there exist several reports providing useful data and indexes related to the future of jobs and skills in a dynamically changing reality, delivered by such institutions as the Organization for Economic Cooperation and Development (OECD), World Bank (WB), World Economic Forum (WEF) and others.

This article aims at describing the situation of the Polish labor market in the perspective of changes in labor supply and demand triggered by socio-economic factors on the one hand and by advancing automation related factors on the other hand. By means of various datasets and simple computation the author seeks an answer to the following question: what are the key challenges for skills in Poland in the light of the fourth revolution?

The paper is organized as follows: first, home and foreign literature concerning the I4 and more precisely Work 4.0 problem will be revised. This will be accompanied by the analysis of the Global Competitiveness Index (2018) in the area of human capital and labor market components, which will allow Poland's shortcomings and advantages in these fields to be identified in relation to other countries, particularly to the Czech Republic and Germany. Then, focus will be set on the Poland's labor market characteristics depicted in more detail by means of national and international data. Finally, main conclusions of this research will be formulated.

12.1 Literature Review

Bringing technology into the discussion on what factors nowadays have impact on skills, wages and employment was a key issue to Brynjolfsson and McAfee [2011]. In their book "Race Against the Machine" they pointed out that in case of the US labor market the lack of jobs is caused not only by cyclical weak demand but also by the high speed of technological innovation, hard to keep up with for organizations, institutions, policies, etc. They name the time of computerization we are in a Great Restructuring. The authors agree that the advancement of digital pattern recognition abilities eliminate low-skilled routine jobs, however they stress that this process may also put at risk some high-skilled jobs, e.g., in legal industry. Brynjolfsson and McAfee [2011] focus their recommendations on four areas: education, entrepreneurship, investment, and laws, regulations and taxes. They particularly underline that better educational level of labor force and entrepreneurial energy that fosters organizational innovation help to mitigate negative impacts from automatization

Similarly, while studying the destruction effect of technology on employment, Frey and Osborne [2013] argue that advanced algorithms particularly in health care and legal and financial services are gradually replacing humans' non-routine tasks by the capability of processing big data. Based on O*NET data (online service developed for the US Department of Labor) the authors define the following bottlenecks to computerization: perception and manipulation, creative intelligence and social intelligence and conclude that the extent of computerization will depend on the capacity to overcome these engineering bottlenecks [Frey and Osborne 2013, pp. 34, 41]. Further, they analyze the distribution of occupational employment over the probability of computerization with a share in three categories: low, medium and high probability. According to their findings almost half of occupations in the US is in the high-risk group, which includes, i.a., workers in service, office and administrative support, sales and related, production, and transportation and logistics. The lowest probability of computerization was discovered for e.g. health, management and business or education [Frey and Osborne 2013, pp. 37–38].

Through their results they confirm that educational attainment has a strong negative relationship with the probability of computerization. The authors conclude that the twentieth century computer revolution made the number of middle-income jobs to shrink. Nowadays, for low-skill and low-wage workers acquiring creative and social skills is the most important factor to survive and stay in employment [Frey and Osborne 2013 pp. 45, 48].

Kagermann [2015] stresses the importance of digitization, *the networking of people and things and the convergence of the real and virtual worlds that is enabled by information and communication technology (ICT)* [Kagermann 2015, p. 24], and its role in transforming such spheres as energy (smart grid, smart meters), mobility (smart mobility, smart logistics), healthcare (smart healthcare, smart seniors) and manufacturing (smart factory, smart products). The application of the Internet of Things (See: Table 12.1), data and services in the fields mentioned before will provide various opportunities, e.g., economic, environmental and social. More precisely, in Germany it is the manufacturing industry that is said to be the key receiver of the economic opportunities stemming from more accurate data and forecasts allowing real-time information circulation. Besides, the manufacturing big data provides the opportunities for new services and innovative business models. Furthermore, older workers can be assisted in their work by smart systems and stay in employment longer [Kagermann 2015 p. 34]. Kagermann [2015] sees the environmental opportunities in energy efficiency, resource optimization and in a sharing economy, while the social opportunities the author associates with improving the quality of life through e.g. achieving a better work-life balance [Kagermann 2015, p. 35]. Finally, Kagermann (2015) identifies the challenges produced by digitization and warns against not reacting to them as early as possible. These are industrial policy with a focus on increased networking and integration via dynamic value networks, and training and continuing professional development [Kagermann 2015, p. 35].

Table 12.1 Converging technological developments

The Internet of Things	**The Internet of Data and Services**
+IP capability	**Big Data** **Cloud computing** **Smart Devices** *1 user, several computers*
Cyber-Physical Systems (CPS)	
+Connected with the Internet +Connected with each other (M2M) Wireless communication Semantic description	
Embedded Systems	**Data Warehouses** **Internet, PC** *1 user, 1 computer*
+Sensors, actuators +Integration of powerful microcomputers	
Physical objects, devices,...	**Mainframer** *several users, 1 computer*

Source: Own study based on: Kagermann [2015], p. 25.

The Polish literature concerning the Industry 4.0 labor market related issues includes papers by, e.g., Bendkowski [2017], Męcina [2018] or a report by Arak and Bobiński [2016].

Bendkowski [2017] conducts an analysis of articles written by German researchers in which it is stressed that manufacturing industry workers will have to improve their skills and qualifications not only in production itself but also in planning, change management and continuous improvement [Bendkowski 2017, p. 27]. The author presents two, a positive and a negative, visions of the I4 development. The former one refers to the situation in which a new, better work environment putting a human and human needs at the center would be created. This would mean more attractive work content, opportunities to improve competences or increase in the autonomy of employees. The latter assumes the domination of technology over a human resulting, among other things, in uncertainty of employment, professional degradation of certain groups of employees or too high expectations towards the labor force productivity growth [Bendkowski 2017, p. 31].

Regarding the competences required in a digital economy Arak and Bobiński [2016] devised the so-called country digitalization index composed by three pillars: economy digitalization index, business environment index and digital competences index. The description of the third element provides an overview of key social competences in Poland. According to the report, Poland is ranked 6th among the European countries in the digital skills improvement category. The authors stress that the state should participate in building digital infrastructure and provide digital education [Arak and Bobiński 2016, p. 5, 7]. They find that in the development of digital skills in Poland is still too low among workers, resulting in, e.g., unsatisfactory use of the Internet platform by the business. On the other hand, lower labor costs deliver new job opportunities e.g. for freelancers. [Arak and Bobiński 2016].

All these challenges should be accounted for while constituting a new labor code in Poland [Męcina 2016]. In the context of digitalization Męcina [2016, p. 332] particularly points to regulations concerning a remote work which should be relaxed to allow for more flexible forms of work.

The above-mentioned examples of the literature on the Industry 4.0 concept and its repercussion on future work converge on the following issues:

- stance that low-skilled routine jobs are being put at risk, and that inequalities between the low-skilled and high-skilled are growing,
- assumption that even high-skilled jobs in such industries as legal service, health and financial service and manufacturing are subject to advancing automation,

- presumption that computerization brings new opportunities in terms of forms of work, allowing for more flexibility and a higher standard of work-life balance, and that the number of self-employed will grow,
- conviction that continuous education and skill upgrading already is an essential element in a worker's daily life.

The authors identify the following challenges stemming from digital transformation. In the field of education they point to the necessity of programs tailored to the market needs, which means teaching suitable skillsets on the one hand and devising appropriate teaching methods for particular target groups (elderly people, children) on the other hand. As regards the labor market, they indicate the growing need of a new scheme of social security regarding, i.a., new fragmented forms of employment.

12.2 Poland Against the Background of Global Trends

According to the Global Competitiveness Report 2018, Poland is a part of a rising north-east region countries group, being a leader followed by the Czech Republic and the Baltic countries [WB 2018, p. 28]. The country was ranked 37th out of 140 analyzed countries in the 2018 Global Competitiveness Index 4.0. The newest edition of the Report issued in October 2018 introduced a new version of the index, not comparable with the previous editions – Global Competitiveness Index 4.0. (GCI 4.0), as *the Fourth Industrial Revolution (4IR) and the consequences of the Great Recession are redefining the pathways to prosperity* [WB 2018, p. v]. The twelve pillars of competitiveness, among which skills (within the area of human capital) and labor market (within the area of markets) constitute the 6th and 8th pillars, respectively, have remained the same. However, the new index also includes factors related to the areas that grow and will grow in significance as the 4IR progresses: human capital, innovations, economic agility and resilience.

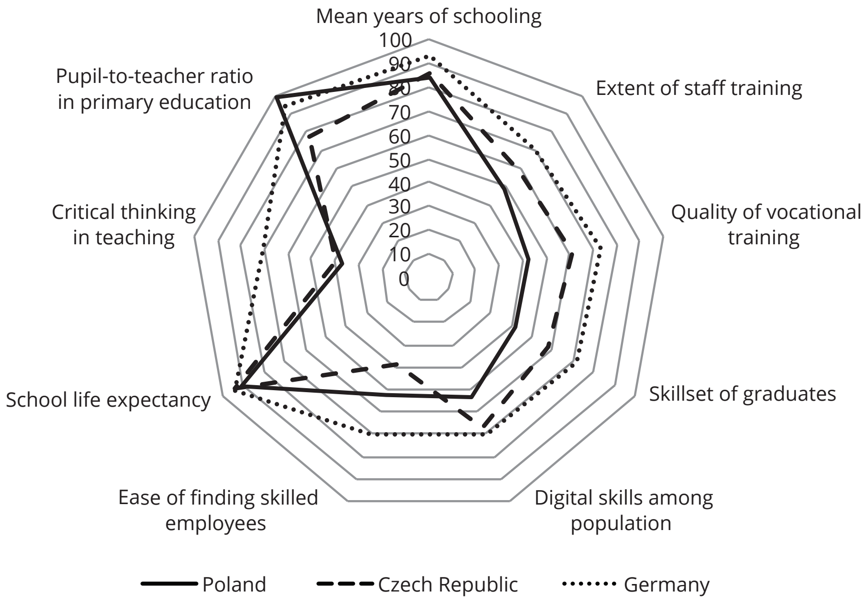
As the Report says, the GCI 4.0 analyzed from the perspective of the above-mentioned newly introduced factors allows the index to be interpreted as an aggregate measure of the Fourth Industrial Revolution readiness (4IR-readiness):

1. In terms of resilience: the skills pillar captures workers` capacity to learn and adapt to changing world.
2. Agility: labor market flexibility implies agility through easier re-allocation of talent across sectors and firms.
3. Innovation: business dynamism and innovation capability need to be complemented by high levels of human capital (health, education and skills), optimal allocation of skills (labor market functioning).

4. Human capital: education measures the skills human need to succeed in the 4IR. The labor market pillar includes measures of talent reward and respect of workers' rights [WB 2018, p. 38].

Figure 12.1 and Figure 12.2 show the distribution of scores in the 6th and 8th pillars achieved by Poland and two other economies with the overall better performance: Czech Republic, ranked 29th in the overall GCI 4.0, and Germany, placed as high 3rd, for comparison.

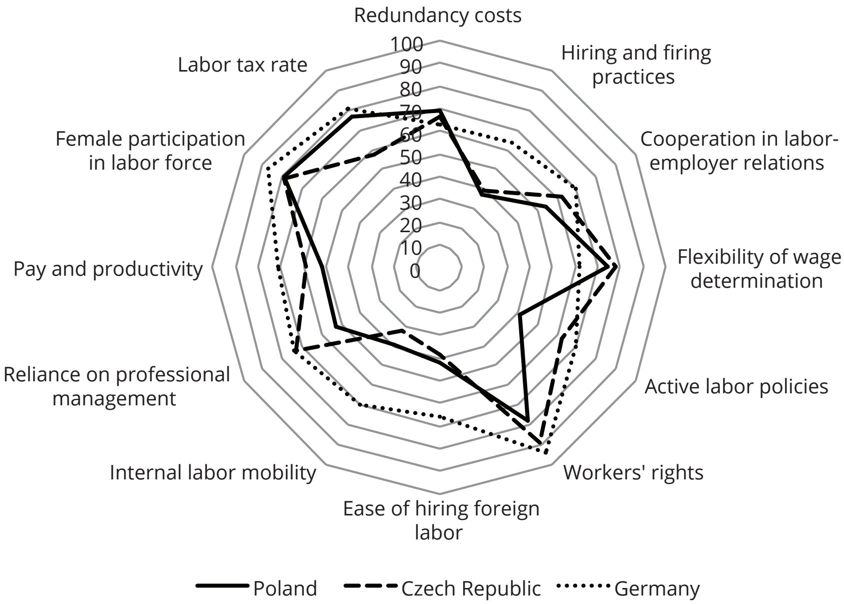
Figure 12.1 Skills, the 6th pillar of the GCI 4.0, as exemplified by the Czech Republic, Germany and Poland, scores 1–100



Source: Own study based on: WB 2018, pp. 189, 241, 469.

Poland scored highest for pupil-to teacher ratio in primary education and mean years of schooling, which gave the country a position among the top 15 countries within these sub-pillars. At the other end of the scale there were scores for quality of vocational training and skillset of graduates, putting Poland behind the 100 best performers. Together with critical thinking in teaching, which was given the lowest score in the 6th pillar and was eventually ranked 83rd, these three sub-pillars seem to contradict Poland's readiness for the 4IR in terms of the current and future workforce. Also, rankings for the following indicators: ease of finding skilled employees (67th) and digital skills among population (68th) are far from satisfactory levels of performance. Germany outperforms Poland in all (but for pupil-to teacher ratio in primary education) skills pillar sub-categories while the Czech Republic falls short of critical thinking in teaching too and struggles with more serious labor shortages.

Figure 12.2 Labor market, the 8th pillar of the GCI 4.0, as exemplified by the Czech Republic, Germany and Poland, scores 1–100



Source: Own study based on: WB 2018, p. 189, 241, 469.

In case of the labor market, Poland gained the highest scores in female participation (45th), workers' rights (41st) and the amount of taxes and mandatory contributions on labor paid by the business as a percentage of commercial profits (although ranked 109th) sub-pillars, outperforming the Czech Republic in the first and the third one. The least number of points was granted to Poland in hiring and firing practices (113th), internal labor mobility (130th), which showed a slightly better performance than in the Czech Republic, and active labor policy (64th), being far less effective than in the Czech Republic and Germany. This means that labor market policies do not accurately address such problems as, e.g., reskilling, retraining or skill matching practices, making it difficult for job candidates to move across the workers' groups resulting in insufficient utilization of available talent. The situation is aggravated by the little geographical mobility of workers. These obstacles, along with a problematic process of hiring foreign labor (113th), impede the flexibility of Poland's labor market.

To sum up, Poland, compared to digitally more advanced countries, has a number of shortcomings in the area of human capital, especially in skills formation and supply, and in the field of labor market. Those are: a style of teaching stripped of creativity, mismatch between the skillset of graduates and market needs, unsatisfactory level of digital skills of population, insufficient investment by companies in staff development, lack of sufficient quality vocational training, inadequate active labor policies, low internal labor mobility of workers and too restrictive regulations concerning hiring foreign workforce. With a high number of teachers in primary schools and long years of schooling that a child receives Poland has a potential to work on most of the above-mentioned issues with success. The more that high-order cognitive and sociobehavioral skills need to be invested in as early as the initial stage of education [WB 2019]. Solving other problems requires a cooperation between labor market stakeholders: the government, local authorities, business and education representatives etc. However, in the meantime, there is a strong need of promotion of lifelong learning and vocational education and training as digital transformation changes jobs to a great extent [Federal Ministry of Labor and Social Affairs 2017].

12.3 Poland's Labor Market Performance and Digital Transformation

According to Eurostat, the activity rate in Poland (the percentage of active persons in relation to the comparable total population, Eurostat) stood at 70.7% in the third quarter of 2018, compared to 76.8% in the Czech Republic and 79% in Germany. The highest rate of approx. 87% was recorded for population in the 35–44 age group. There are also some gender and regional discrepancies in the level of the population activity rate: males participate in the labor market more often and the population is more active in regions with higher economic growth and larger business expansion. Although the overall activity rate did not improve significantly over the past few years, the rate for 55–64 aged population grew by nearly 10 pp over the past ten years. Another positive development is that the level of education among the economically active people is steadily increasing. Nevertheless, participation of adults in learning stays in Poland at comparatively low level. In 2017, only 4% of adults took part in education and training in the last four weeks, compared to 9.8% for the Czech Republic and 8.4% for Germany.

At the same time the unemployment rate in Poland fell to an unprecedented low level: 3.5% in December 2018 (Eurostat). In the Czech Republic and in Germany the indicator reached 2.1% and 3.3%, respectively, which placed the three countries at the top of record low readings. The analysis of the unemployment rate by education (GUS) points to an interesting phenomenon: during the past few years people with secondary and lower education were leaving the pool of unemployed faster than people with more advanced education attained. The reasons for this can be twofold: firstly, elderly people with poorer education retire, secondly, there is a relatively high demand for blue collar workers.

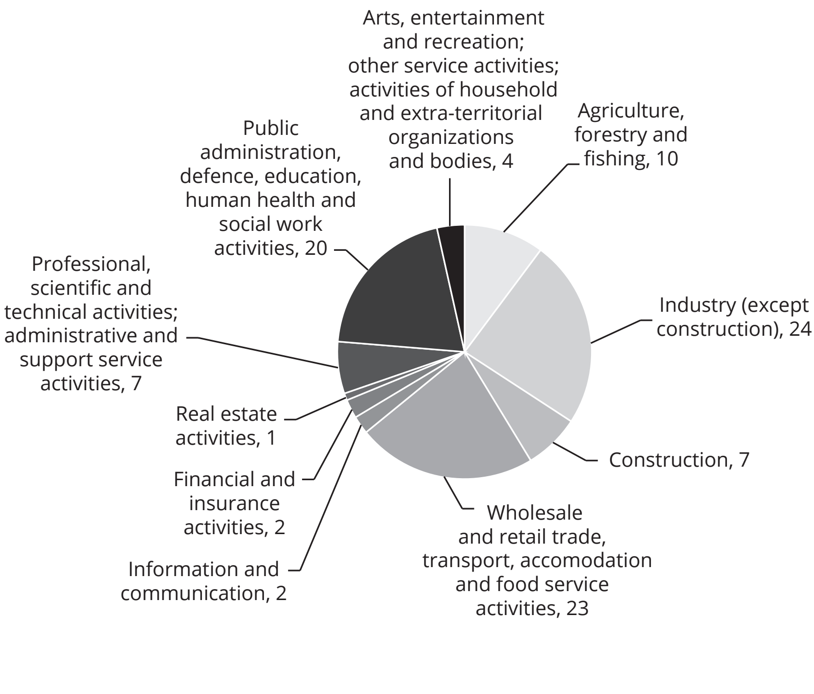
The total job vacancy rate in Poland was in 2017 at 1%, compared to the rate of 3.9% in the Czech Republic and 2.7% in Germany. In 2017 the highest labor shortages were recorded in sectors including construction, information and communication, transportation and storage, and manufacturing. The most wanted occupations were craft and related trades workers and plant and machine operators and assemblers.

According to the data by the WB, employment in industry (as a percentage of total employment) fell in Poland between 1991 and 2018 by more than 6 pp (to 31% in 2018), while in the Czech Republic it decreased by 10 pp (to 37%) and in Germany by almost 14 pp (to 27%). During the time employment in services increased in the countries in question as follows: by nearly 20 pp (to 59% in 2018) in Poland, by 15 pp (to 60%) in the Czech Republic and by 16 pp (to 71%) in Germany. This phenomenon confirms the gradual shift from employment in industry to services, particularly being true for the high-income economies [WB 2018].

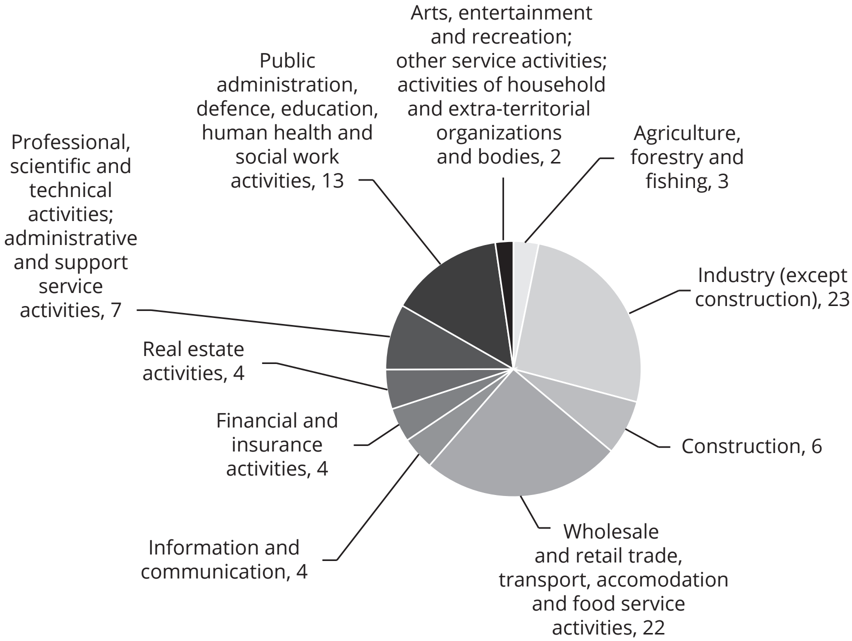
A closer insight into the structure of employment during the recent e.g. ten years may allow the eventual shifts to be observed in the Polish labor market patterns.

Figure 12.3 Employment by industry breakdowns and gross value added as a percentage of GDP by industry breakdowns, 2017

a) Employment by industry breakdowns



b) Gross value added by industry breakdowns



Source: Own study based on: Employment by A*10 industry breakdowns, https://ec.europa.eu/eurostat/web/products-datasets/-/nama_10_a10_e, accessed 25.01.2019, Gross value added and income by A*10 industry breakdowns, https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a10, accessed 25.01.2019.

The share of employment in industry (See: Figure 12.3a) in Poland decreased by 0.1 pp in 2017 compared to 2008 (1.1 pp and 0.4 pp drop in Germany and in the Czech Republic), while in manufacturing it increased by 0.4 pp during the same time (it shrank by 1.1 pp in Germany and by 0.2 pp in the Czech Republic), with a visible, temporary drop between 2010 and 2012. The share of the employed persons in the information and communication sector in Poland grew by 0.4 pp from 2008 to 2017. It also rose by 0.4 pp in the Czech Republic but declined by 0.1 pp in Germany during the same period, again with a visible, temporary fall in 2010 and 2011. The highest gain in the share of employment from 2008 to 2017 was recorded in the professional, scientific and technical activities sector, calculated together with the administrative and support service activities sector, which resembles the European trend: an increase of 0.5 pp and 1.5 pp in the Czech Republic and Germany, respectively. The wholesale and retail trade, transport, accommodation and food service activities sector which constitutes 22.8% of the total employment in Poland gained 0.5 pp between 2008 and 2017, which also fits the EU trend. Eurostat runs also separate statistics on the digital economy and society, according to which employment in the information and communication technology

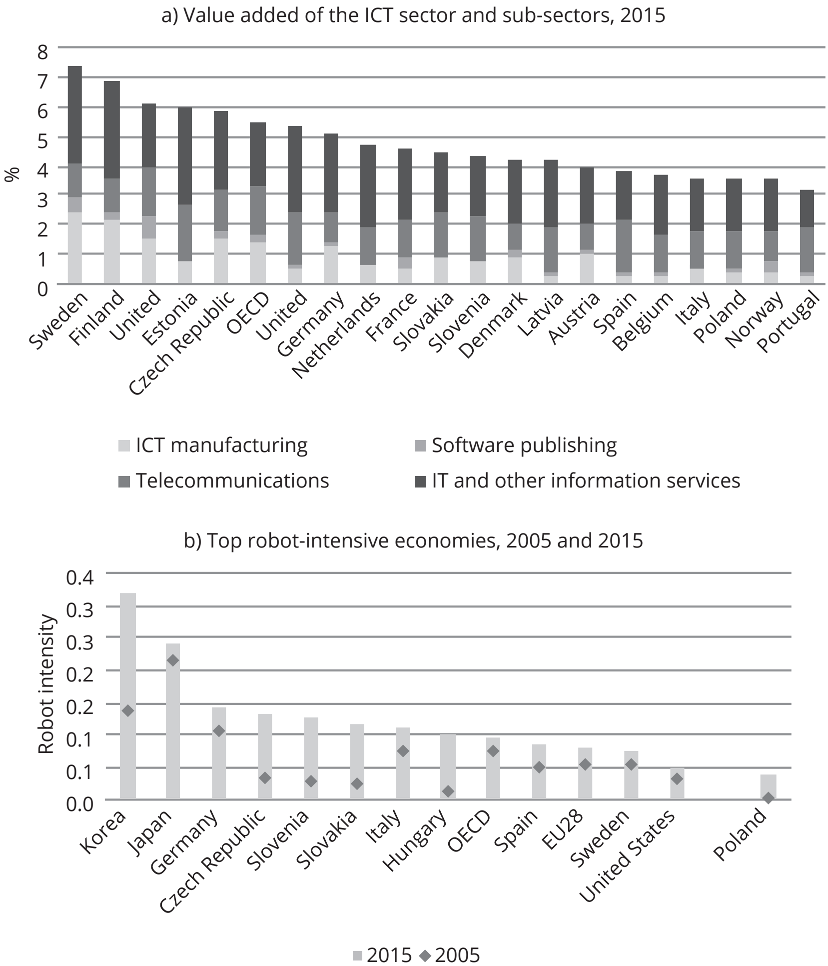
(ICT) sector in total employment stood at 2.3% in Poland in 2016 (the newest data available), up from 2009 (the oldest data available) by 0.7 pp, constituting a higher growth than in the Czech Republic – 0.2 pp, and in Germany – 0.5 pp. However, the level of employment in ICT in Poland is generally lower – 0.3% in ICT manufacturing (0.5% in the Czech Republic and 0.3% in Germany) and 2% in ICT services (2.5% both in the Czech Republic and in Germany).

As the OECD [2017b] points out the digital transformation is now affecting all sectors of the economy, though to varying degrees. A new classification of digital-intensive sectors proves that telecommunications and IT services are at the top in terms of digital intensity, while agriculture, mining and real estate are at the bottom. Other sectors show more heterogeneity across the various indicators, pointing to different rates of transformation [OECD 2017b, p. 14]. Gross value added (GVA) (See: Figure 12.3b) of the total NACE sections as a percentage of GDP in Poland is lower than in the Czech Republic and Germany (90% both) being at 88% in 2017. Industry's share of the GVA in GDP improved between 2008 and 2017 by 0.9 pp and remains at 22.8%, while in the Czech Republic the share is at 28.4% and in Germany at 23.6%. The manufacturing industry itself creates 17.6% of the GVA of GDP (increase of 1.3 pp between 2008 and 2017) whereas in the Czech Republic – 24.1% and 21.1% in Germany. Poland has a visibly lower level of the information and communication GVA standing at 3.7%. In the Czech Republic, the same indicator amounts to 4.7%, and in Germany it stands at 4.2%. The GVA in this industry is at the same level as in 2008. Besides, Poland has a relatively high level of GVA generated by the wholesale and retail trade, transport, accommodation and food service activities sector – 22.2% (17% in the Czech Republic and 14.6% in Germany) of the total GDP.

According to the data provided by OECD [2017a], Poland stood at the 18th position in terms of the value added of the ICT sector as a percentage of total VA (the newest data available for 2015). ICT manufacturing generated 0.5% of total value added, software and publishing 0.1%, telecommunications 1.3% and IT and other information services 1.8%. It is worth noticing that the Czech Republic outperformed Germany with regard to the VA of the ICT and was ranked 5th with the ICT manufacturing at 1.5% (See: Figure 12.4a).

Moreover, as OECD (2017b) points out, some of the Eastern European countries emerge as intensive robot users (See: Figure 12.4b), which most probably reflects their specialization within the manufacturing value chains, e.g., robot intensity in the Czech Republic increased over four times from 2005, to 0.13 in 2015. Robot intensity in Poland grew approx. five times between 2005 and 2015, however, its status at 0.04 is far behind the frontrunners [OECD 2017b, p. 36].

Figure 12.4 Value added of the ICT sector and sub-sectors, 2015 (as a percentage of total value added at current prices) and the top robot-intensive economies (2005 and 2015)



Source: Own study based on: OECD 2017a, OECD 2017b.

In conclusion, looking at the Poland's labor market against the background of the selected industries, it is hard to spot any spectacular changes related to the ongoing digital transformation. The employment in industry, particularly in manufacturing, is stable, with the outlook to further growth since many job vacancies are reported. However, intensive demand for the blue-collar workers proves that the Poland's manufacturing sector is rather a traditional one with a still low level of the ICT value added and robot intensity. Improving labor force participation rate together with growing share of people with tertiary education constitute a sound ground for implementing measures preparing the workforce for the 4IR. The significance of investment in human capital to be able to benefit from economic opportunities that Industry 4.0 brings cannot be underestimated. Labor market will need advanced cognitive skills and skill combinations that are predictive of adaptability. *Building these skills requires strong human capital foundations and lifelong learning* [WB 2019, p. 3].

12.4 Is Poland Ready for the Fourth Industrial Revolution?

There exist several indicators that may help to identify if a country is ready to respond to 4IR. Among them there are indexes relating to selected industries, readiness for innovation, ICT utilization or key sector ratios [Flynn, Dance and Schaffer 2017, p. 3]. As repeated by various sources [WB 2019, Kergroach 2017, OECD 2017b], digital transformation and its consequences for industries require from the workforce reskilling and the ability to adapt to new business models. Flynn, Dance and Schaffer [2017] argue that the countries generating high value added with a small labor input are already advanced in a process of new technologies implementation and are able to use automation and ICT to improve production capability. Indicators in Table 12.2. shows that Germany is a leader in terms of productivity in all three analyzed industries: industry (except construction), manufacturing itself and information and technology. Poland lags behind the two peers, being approx. three and a half times less productive in industry and in manufacturing and over twice less efficient in information and technology than Germany. Similarly, Germany and the Czech Republic seem to be more resistant to the future technological unemployment since the non-routine employment in manufacturing industry or market service industry occupies a visibly higher share of employment there.

According to OECD [2017b], Poland is ranked 24th among the 28 analyzed countries in terms of the level of the ICT task intensity of jobs in manufacturing industry and 26th in the ICT task intensity of jobs in market service industry [OECD 2017b, p. 37]. This indicator captures the use of ICT on the job and mirrors labor productivity. A worker in job that is 10% more ICT-intensive than the average job is assumed to earn 4% more [OECD 2017b, p. 108].

Another measure that helps to evaluate a country's readiness to the forth industrial revolution is a Networked Readiness Index (NRI) or Technology Readiness Index. It reflects a country's potential of using development opportunities delivered by ICT. The 2016 index that assesses the factors, policies, and institutions that enable a country to benefit from ICT efficiently, is calculated for 139 economies [WEF 2016, p. 3]. Poland is positioned among the top 50 countries of the NRI. More precisely, in 2016

Poland climbed from 50th in 2015 to 42nd place, the Czech Republic moved up to 36th rank from 43rd in 2015, while Germany descended from 13th in 2015 to 15th position (See: Table 12.3).

Table 12.2 Levels of gross value added per head (thousands of euros at constant prices/person, 2017) in selected industries and the level of routine

Gross value added per head in:	Czech Republic	Germany	**Poland**
Industry (except construction)*	35.1	94.3	**27.2**
Manufacturing	32.3	90.6	**24.3**
Information and technology	61.2	107.3	**45.2**
Share of non-routine employment: average manufacturing industry (%)	28.29	28.37	**19.46**
ICT task intensity[1] of jobs: average manufacturing industry	44.69	49.71	**40.53**
Share of non-routine employment: average market service industry (%)	42.46	44.14	**33.90**
ICT task intensity of jobs: average market service industry	54.84	54.20	**50.58**

* Including manufacturing.

Source: Own study based on: Eurostat, https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a10, accessed 29.01.2019, OECD (2017b).

Table 12.3 Networked Readiness Index 2016, ICT value added 2017 and the demand for the ICT skills 2014

	Czech Republic	Germany	**Poland**
Networked Readiness Index	4.7 (36th rank)	5.6 (15th rank)	**4.5 (42nd rank)**
ICT value added as a % of value added	5.3	4.6	**4.2**
Demand for ICT generic skills (CIS)*	46.3	50.0	**36.8**
Demand for ICT generic skills (OPS)**	32.4	38.3	**25.7**

* Share of employed individuals using communication and information search (CIS) daily at work (%).
** Share of employed individuals using office productivity software (OPS) daily at work (%).

Source: Own study based on: Eurostat https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a10, accessed 28.01.2019, WEF 2016, OECD 2017a.

As the OECD [2016] New Skills for the Digital Economy report points out the proportion of workers using ICT at work daily differs significantly across countries, ranging among the 19 analyzed states between 43% in the United Kingdom (38% in Germany and 32% in the Czech Republic) and 26% in Poland for OPS. As regards

1 ICT task-intensive jobs are jobs that have a 10% higher ICT task intensity than the average job in the country OECD 2017b, p. 108.

the share of individuals using OPS daily, the numbers differ between 37% in the Netherlands and 17% in Poland [OECD 2016, pp. 4, 6]. However, in 2014 the demand for OPS skills in Poland was higher by 1.4 pp than in 2011. The growth was greater only for Norway, France and Sweden, while Germany and the Czech Republic ranked 7th and 10th, respectively.

The share of individuals using CIS daily at work grew in Poland in 2014 by 1.7 pp compared to 2011, constituting the third highest increase after Norway and France among the surveyed countries. Germany and the Czech Republic occupied 9th and 11th position, respectively.

Lastly, Table 12.4 presents the ratios between sector workforce for three sectors: information and communication, education and science and technology, as proposed by Flynn, Dance and Schaefer [2017, p. 5]. The calculations were made with the use of the OECD data on employment and Eurostat data on education in training with a focus on workforce in tertiary education. The ratio manufacturing by education as specified by NACE Rev. 2 nomenclature refers to the overall education sector.

Table 12.4. Ratios between sector workforce, 2016

	Czech Republic	Germany	**Poland**
Manufacturing/information and communication	9.91	6.08	**8.95**
Manufacturing/education by NACE Rev. 2 activity	4.3	2.9	**2.8**
Manufacturing/tertiary education workforce	37.1	9.4	**16.9**
Manufacturing/science & tech.	3.07	1.28	**3.18**

Source: Own study based on: Flynn, Dance and Schaefer 2017, OECD https://www.oecd-ilibrary.org/fr/economics/data/aggregate-national-accounts/population-and-employment-by-main-activity_data-00003-en; for tertiary education workforce: Eurostat, https://ec.europa.eu/urostat/web/education-and-training/, accessed 28.01.2019.

The reasoning behind the above-mentioned ratios is that not only the workforce of the education sector but also that of the information and communication, and the science and technology sectors need to support the process of digital transformation in manufacturing. Flynn, Dance and Schaefer [2017] argue that a country with large manufacturing workforce, low non-routine intensity, and an insufficient education, information and communication or science and technology sectors will find it difficult to respond to 4IR challenges [Flynn, Dance and Schaefer 2017, p. 5]. In the context of this study, Germany demonstrates the most balanced ratios, while the Czech Republic shows the least proportion between the workforce of manufacturing and the rest of evaluated sectors.

Summing up, according to indicators shown in this section Poland turns out to be more than three times less productive in industry and in manufacturing than Germany, which, due to less automation and use of ICT in these sectors can result in future technological unemployment. A relatively low level of non-routine employment in analyzed sectors in Poland seems to support this assumption. Additionally, Poland's 42nd rank in the Networked Readiness Index together with a still-not-too-high demand for ICT generic skills suggests that the country needs to work on more effective and efficient application of ICT in work environment. Finally, Poland's ratios between the workforce of manufacturing and the workforce of other selected industries are more balanced than in case of the Czech Republic, however, compared to Germany, show asymmetry between the labor in manufacturing and, e.g., in tertiary education.

Conclusions

This study investigates the Poland's labor market in the perspective of the fourth industrial revolution. The country is presented against the background of globally used indicators related to digital transformation as well as measures chosen to grasp specific characteristics of a workforce in the context of its readiness for the challenges of Industry 4.0.

With a high number of teachers in primary schools and long years of schooling that a child receives Poland has a potential to develop skills in accordance to the market needs. However, the style of teaching along with the education content need to be improved. Similarly, a growing activity rate together with augmenting share of people with tertiary education constitute a sound ground for digital skills promotion. Hence, adult learning, vocational education and training systems should be given more attention as they may help to use available talents more efficiently and balance labor shortages.

Moreover, further research in the field of Poland's workforce readiness for I4 might be beneficial. Identifying most-likely areas and occupations for technological unemployment as well as more detailed studies on the country's skills shortcomings would enable the authorities to react to job changes fast enough.

Bibilography

Arak, P., Bobiński, A. [2016], *Czas na przyspieszenie. Cyfryzacja gospodarki Polski*, Polityka Insight Research, Warsaw: https://zasoby.politykainsight.pl/politykainsight.pl/public/Czas-na-przyspieszenie--Cyfryzacja-gospodarki-Polski.pdf.

Arntz, M., T. Gregory and U. Zierahn [2016], *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis*, "OECD Social, Employment and Migration Working Papers", No. 189, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jlz9h56dvq7-en.

Bendkowski, J. [2017], *Zmiany w pracy produkcyjnej w perspektywie koncepcji „Przemysł 4.0"*, „Zeszyty Naukowe Politechniki Śląskiej", Organizacja i Zarządzanie series, issue 112, serial No. 1990.

Brynjolfsson, E., McAfee A. [2011], *Race against the machine: how the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy*, Digital Frontier Press, Lexington, Massachusetts.

Flynn, J., Dance, S., Schaffer, D. [2017], *Industry 4.0 and its Potential Impact on Employment Demographics in the UK*, University of Liverpool.

Frey, C., B., Osborne M., A. [2013], *The future of employment: how susceptible are jobs to computerisation?*, Oxford.

Kagermann H. [2015], *Change Through Digitization—Value Creation in the Age of Industry 4.0*, Springer Fachmedien Wiesbaden 2015, H. Albach et al. (eds.), "Management of Permanent Change", DOI 10.1007/978–3–658–05014-6_2.

Kergroach, S. [2017], *Industry 4.0: New Challenges and Opportunities for the Labour*, Vol. 11 No. 4, Foresight and STI Governance.

Męcina, J. [2018], *Polityka społeczna i rynek pracy 4.0 a przyszłość prawa pracy, czyli aksjologiczny i pragmatyczny wymiar wyzwań w pracach nad nowym kodeksem pracy*, University of Warsaw, „Studia z Zakresu Prawa Pracy i Polityki Społecznej 2018", 25, No. 4: 323–335 doi: 10.4467/25444654SPP.18.020.8948 www.ejournals.eu/sppips.

OECD [2016], *New Skills for the Digital Economy. Measuring the Demand and Supply of ICT Skills at Work*, 2016 Ministerial Meeting on the Digital Economy, Technical Report, OECD Publishing, OECD Digital Economy Papers No. 258.

OECD [2017], *OECD Digital Economy Outlook 2017*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264276284-en.

OECD [2017], *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264268821-en.

Federal Ministry of Labor and Social Affairs [2015], *Re-imagining work, Green Paper Work 4.0*, Berlin, https://www.bmas.de/SharedDocs/Downloads/DE/PDF-Publikationen/arbeiten-4–0-green-paper.pdf;jsessionid=D0CEA1122F47B9A80A55634630B1E1DA?__blob=publicationFile&v=2.

Federal Ministry of Labor and Social Affairs [2017], *Re-imagining work, White Paper Work 4.0* https://www.bmas.de/SharedDocs/Downloads/EN/PDF-Publikationen/a883-white-paper.pdf?__blob=publicationFile&v=3.

World Bank [2019], *World Development Report 2019: The Changing Nature of Work*, Washington, DC: World Bank. doi:10.1596/978–1-4648-1328–3. License: Creative Commons Attribution CC BY 3.0 IGO.

World Economic Forum [2018], *The Global Competitiveness Report 2018*, “Insight Report”, Geneva, http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf

World Economic Forum [2016], *The Global Information Technology Report 2016*, “Insight Report”, Geneva, http://www3.weforum.org/docs/GITR2016/WEF_GITR_Full_Report.pdf.

Eurostat Digital Economy and Society: https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/database

Eurostat Labor Force Survey: https://ec.europa.eu/eurostat/web/lfs/data/database

Eurostat Education and training: https://ec.europa.eu/eurostat/web/education-and-training/eu-benchmarks

GUS BDL

OECD: https://www.oecd-ilibrary.org/fr/economics/data/aggregate-national-accounts/population-and-employment-by-main-activity_data-00003-en

World Bank Open Data: https://data.worldbank.org

Chapter 13

Changes in Total Factor Productivity in the Fourth Industrial Revolution Era

Mariusz Próchniak

Introduction

The analysis of total factor productivity will be carried out using growth accounting. Growth accounting is an empirical exercise aimed at determining to what extent economic growth results from changes in the measurable production factors and from changes in the level of technology, measured by the growth rate of total factor productivity (TFP). The 2013 edition of the study presented the estimates of total factor productivity in individual sectors of the economy for Poland and selected countries of Central and Eastern Europe as well as Western Europe (including 10 sectors according to NACE-2 classification) [Próchniak, 2013]. In the 2012 and 2014 editions of the study, in addition to the basic growth accounting model, we estimated an extended model including human capital [Próchniak, 2012; 2014].

This analysis covers 11 countries of Central and Eastern Europe, namely the EU-11 group (Poland, Bulgaria, Croatia, the Czech Republic, Estonia, Lithuania, Latvia, Romania, Slovakia, Slovenia, and Hungary) and the period 2009–2018. To assess the dynamics of changes in total factor productivity in the analyzed years, we also present the average TFP growth rates for the following sub-periods: 2009–2011, 2012–2014, 2015–2017, and for 2018.

In interpreting the results, we will seek to refer them to the impact of Industry 4.0 and the Fourth Industrial Revolution on the dynamics of total factor productivity.

13.1 Changes in Total Productivity – Theoretical Background

The origins of growth accounting date back to the first half of the 20th century. The concept of total productivity and the view that labor is not the only production factor, and that in measuring wealth of nations and productivity one should take into account other factors such as capital and land, were discussed in the economic literature in the 1930 s [Griliches, 1996]. The first mentions of the input-output ratio appeared in Copeland's paper in 1937 [Griliches, 1996]. In the 1940s and 1950s, many studies were published – to large extent independently – which included results of empirical research on TFP measurement. The first such study, conducted by Dutch economist Jan Tinbergen, was published in 1942. In the following years, further studies appeared, in which the authors examined the relationship between the volume of output and the inputs [see, e.g. Tintner, 1944; Barton, Cooper, 1948; Johnson, 1950; Schmookler, 1952; Abramovitz, 1956; Kendrick, 1956; Ruttan, 1956].

Robert Solow was the first economist to formalize growth accounting [Solow, 1957]. Using the macroeconomic production function and differential calculus, he showed how the rate of economic growth can be divided into the part resulting from an increase in factors of production and the remaining part, referred to as Solow's residual. The latter shows what part of economic growth cannot be attributed to individual factors. Thus, it is a measure of technological progress, or TFP growth.

In the following years, further studies on growth accounting appeared, introducing new approaches and extensions of previously conducted research, and containing new elements of empirical analysis [see, e.g., Solow, 1962; Griliches, 1964; Jorgenson, Griliches, 1967].

The decomposition of economic growth initiated by Solow forms the basis of modern growth accounting. The starting point of such an analysis is the macroeconomic production function. Its general form is as follows:

$$Y(t) = F(A(t), Z_1(t), \ldots, Z_n(t)), \tag{13.1}$$

where Y – output (GDP), A – level of technology, $Z_1, \ldots, Z_n$ – measurable factors of production. Two or three measurable factors of production are usually taken into account in empirical research, namely: labor, physical capital, and possibly human capital.

The analysis in this edition of the report will be carried out for two measurable factor inputs: labor and physical capital. The production function (13.1) therefore takes the following form:

$$Y(t) = F(A(t), L(t), K(t)). \tag{13.2}$$

In order to decompose the rate of economic growth into individual components, equation (13.2) should be transformed into a form representing the growth rate of Y. For this purpose, we differentiate (13.2) with respect to time and then divide by Y. As a result, we obtain:

$$\frac{\dot{Y}}{Y}=\frac{\frac{\partial F(A,L,K)}{\partial A}\dot{A}}{Y}+\frac{\frac{\partial F(A,L,K)}{\partial L}\dot{L}}{Y}+\frac{\frac{\partial F(A,L,K)}{\partial K}\dot{K}}{Y}. \tag{13.3}$$

After multiplying the individual components on the right-hand side of equation (13.3) by A/A, L/L and K/K, respectively, we get:

$$\frac{\dot{Y}}{Y}=\frac{\frac{\partial F(A,L,K)}{\partial A}A}{Y}\frac{\dot{A}}{A}+\frac{\frac{\partial F(A,L,K)}{\partial L}L}{Y}\frac{\dot{L}}{L}+\frac{\frac{\partial F(A,L,K)}{\partial K}K}{Y}\frac{\dot{K}}{K}. \tag{13.4}$$

Equation (13.4) shows that the GDP growth rate is the weighted average of growth rates of three factors: technology, labor and physical capital. The weights are the shares of individual factors in GDP, measured as the marginal product of the factor (at the level of the entire economy) multiplied by the amount of a given factor and divided by the volume of output.

13.2 Method

The research method in this chapter is economic growth accounting. In order to be able to calculate the TFP growth rate in an empirical study, additional assumptions should be made to equation (13.4) that shows the essence of economic growth accounting.

We assume, firstly, that the production function is characterized by Hicks-neutral technological progress. Therefore, this function can be described as follows:

$$F(A,L,K)=A\cdot f(L,K). \tag{13.5}$$

As can be seen, Hicks-neutral technological progress means that variable A, representing the level of technology, occurs in the product with production function f, making the production volume dependent on measurable inputs. Technological progress augments both production factors to the same extent, without changing the marginal rate of technological substitution between them. For the production function (13.5), the share of technology in income, i.e. the component $(\partial F/\partial A)\ A/Y$ in equation (13.4), equals 1. Equation (13.4) can then be written as:

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+\frac{\frac{\partial F(A,L,K)}{\partial L}L}{Y}\frac{\dot{L}}{L}+\frac{\frac{\partial F(A,L,K)}{\partial K}K}{Y}\frac{\dot{K}}{K}. \tag{13.6}$$

The above equation shows that the rate of economic growth equals the sum of technological progress (increase in TFP) and the average growth rate of labor and physical capital, weighted by the shares of both factors in income.

An additional assumption should also be made, regarding the marginal products of both factors. The marginal product of labor and capital at the level of the entire economy is in fact nonmeasurable. We therefore assume that all markets are perfectly competitive and that no externalities exist. In this case, the marginal product of capital $\partial F/\partial K$ equals the price of capital r, while the marginal product of labor $\partial F/\partial L$ equals the wage rate w. By using s_K to describe the capital share in income (rK/Y), and s_L to describe the share of labor (wL/Y), equation (13.6) can be written as:

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+s_K\frac{\dot{K}}{K}+s_L\frac{\dot{L}}{L}. \tag{13.7}$$

Let us make an additional assumption that all income can be assigned to one of two factors of production: labor or physical capital, i.e.: $Y = wL + rK$. In this case, the shares of labor and physical capital in income add up to 1: $s_K + s_L = 1$. Thus, formula (13.7) takes the following form:

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+s_K\frac{\dot{K}}{K}+\left(1-s_K\right)\frac{\dot{L}}{L}. \tag{13.8}$$

Equation (13.8)[1] is the basis for standard growth accounting. From this equation, the TFP growth rate can be calculated as the difference between the GDP growth rate and the weighted average growth rate of both factors of production:

$$\text{TFP growth} \equiv \frac{\dot{A}}{A}=\frac{\dot{Y}}{Y}-\left[s_K\frac{\dot{K}}{K}+\left(1-s_K\right)\frac{\dot{L}}{L}\right]. \tag{13.9}$$

13.3 Empirical Evidence

For the purpose of the analysis, we have gathered data that form the following time series: (a) the rate of economic growth, (b) the rate of change in labor inputs, (c) the rate of change in physical capital input. The rate of economic growth is the annual growth rate of total real GDP, sourced from the IMF database [IMF, 2019]. The rate of change in labor inputs is measured by the employment dynamics provided by the International Labor Organization [ILO, 2019]. The data for 2018 cover the first

1 This equation is in fact a Cobb-Douglas production function.

three quarters (in order to avoid seasonality, the rate of change in labor inputs for 2018 is calculated by comparing the employment level in the first three quarters of 2018 with the employment level in the first three quarters of 2017). We calculated the time series of the physical capital stock on the basis of the perpetual inventory method using the World Bank data [World Bank, 2019]. This method requires many assumptions to be taken into account. We assumed that the depreciation rate is 5%, and the initial capital/output ratio is 3. In the perpetual inventory method, the initial year should be a little earlier than the years for which TFP is being calculated; in our study, we start calculations in 2000, which is the year to which the assumption of capital to output ratio of 3 applies. As investments, we use a variable measuring gross fixed capital formation. The shares of labor and physical capital in income equal $^1/_2$.

In this edition of the study, we have updated all the time series of the analyzed variables. All steps of the analysis have been recalculated. Therefore, the documentation of the results has been fully presented in the text of the study and it does not duplicate the information contained in the previous editions of the Competitiveness Report [Próchniak, 2018].

13.4 Interpretation of Results – Changes in Total Factor Productivity and Competitiveness

Table 13.1 presents detailed results of economic growth decomposition, while Tables 13.2 and 13.3 summarize the data from Table 13.1.

Poland recorded the highest TFP growth rate over the entire period. It equaled 1.5% annually. At the same time, it was higher by as much as 1 p.p. than the TFP growth rate observed in Bulgaria and Slovakia, which took a joint second place in productivity. Poland's results should be considered a major success. If taken as an approximate measure of technological progress, TFP changes make us a leader among the EU-11 countries in creating new technologies. A fast growth of output, much above the value arising from the accumulation of basic factors of production, is undoubtedly related to a strong impact of the Fourth Industrial Revolution and technological progress on the rate of economic growth. Consequently, TFP calculated using the residual method is very high.

Apart from Poland, which was a technological leader of the EU-11 group, and Bulgaria and Slovakia, a positive productivity growth rate in 2009–2018 was also recorded by five other EU-11 countries: Latvia, Lithuania and Romania, where TFP was seen to grow at an average rate of 0.4% annually, as well as Slovenia (0.3%) and Estonia (0.2%). In the other three EU-11 countries, the productivity growth rate was

Table 13.1 The contribution of labor, physical capital and TFP to economic growth in 2009–2018

		2009			2010			2011			2012			2013		
		growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)
Bulgaria	L	–3.2	–1.6	44	–5.5	–2.8	–208	–3.6	–1.8	–93	–1.0	–0.5	–1,686	0.0	0.0	2
	K	8.2	4.1	–115	5.1	2.5	192	2.9	1.4	76	2.3	1.2	3,761	2.3	1.1	133
	TFP	–6.1	–6.1	171	1.5	1.5	116	2.3	2.3	118	–0.6	–0.6	–1,974	–0.3	–0.3	–35
	GDP	–3.6	–3.6	100	1.3	1.3	100	1.9	1.9	100	0.0	0.0	100	0.9	0.9	100
Croatia	L	–0.8	–0.4	5	–3.8	–1.9	129	–3.8	–1.9	566	–3.6	–1.8	79	–2.7	–1.3	273
	K	4.9	2.4	–33	3.1	1.5	–104	1.6	0.8	–241	1.4	0.7	–30	1.1	0.5	–109
	TFP	–9.3	–9.3	128	–1.1	–1.1	75	0.8	0.8	–224	–1.2	–1.2	51	0.3	0.3	–64
	GDP	–7.3	–7.3	100	–1.5	–1.5	100	–0.3	–0.3	100	–2.3	–2.3	100	–0.5	–0.5	100
Czech Republic	L	–1.4	–0.7	14	–1.0	–0.5	–22	–0.2	–0.1	–7	0.3	0.2	–22	1.0	0.5	–99
	K	4.8	2.4	–49	3.4	1.7	74	3.2	1.6	90	3.0	1.5	–189	2.5	1.3	–263
	TFP	–6.5	–6.5	135	1.1	1.1	48	0.3	0.3	17	–2.5	–2.5	311	–2.2	–2.2	462
	GDP	–4.8	–4.8	100	2.3	2.3	100	1.8	1.8	100	–0.8	–0.8	100	–0.5	–0.5	100
Estonia	L	–9.5	–4.7	32	–4.4	–2.2	–97	6.2	3.1	41	2.0	1.0	23	1.0	0.5	25
	K	5.6	2.8	–19	1.4	0.7	30	1.1	0.6	7	3.1	1.6	36	3.9	1.9	101
	TFP	–12.8	–12.8	87	3.8	3.8	166	4.0	4.0	52	1.7	1.7	41	–0.5	–0.5	–26
	GDP	–14.7	–14.7	100	2.3	2.3	100	7.6	7.6	100	4.3	4.3	100	1.9	1.9	100
Hungary	L	–2.6	–1.3	20	–0.4	–0.2	–31	0.7	0.4	22	1.8	0.9	–55	1.7	0.9	41
	K	2.9	1.5	–22	2.1	1.0	151	1.3	0.6	38	1.1	0.5	–33	0.9	0.4	20
	TFP	–6.8	–6.8	102	–0.1	–0.1	–19	0.7	0.7	40	–3.1	–3.1	188	0.8	0.8	39
	GDP	–6.6	–6.6	100	0.7	0.7	100	1.7	1.7	100	–1.6	–1.6	100	2.1	2.1	100
Latvia	L	–13.8	–6.9	48	–6.4	–3.2	81	1.3	0.6	10	1.6	0.8	20	2.1	1.0	42
	K	6.9	3.5	–24	2.4	1.2	–31	0.8	0.4	6	2.2	1.1	27	3.0	1.5	62
	TFP	–10.9	–10.9	76	–2.0	–2.0	50	5.3	5.3	83	2.1	2.1	53	–0.1	–0.1	–4
	GDP	–14.4	–14.4	100	–3.9	–3.9	100	6.4	6.4	100	4.0	4.0	100	2.4	2.4	100
Lithuania	L	–7.7	–3.9	26	–5.2	–2.6	–160	0.5	0.2	4	1.8	0.9	23	1.3	0.7	19
	K	5.8	2.9	–20	1.3	0.6	38	1.3	0.6	10	2.4	1.2	32	2.1	1.1	30
	TFP	–13.9	–13.9	94	3.6	3.6	222	5.2	5.2	86	1.7	1.7	45	1.8	1.8	51
	GDP	–14.8	–14.8	100	1.6	1.6	100	6.0	6.0	100	3.8	3.8	100	3.5	3.5	100
Poland	L	0.4	0.2	8	–2.5	–1.2	–35	0.6	0.3	6	0.2	0.1	6	–0.1	–0.1	–5
	K	4.0	2.0	71	3.4	1.7	47	3.1	1.6	31	3.6	1.8	111	3.1	1.6	113
	TFP	0.6	0.6	22	3.1	3.1	87	3.2	3.2	63	–0.3	–0.3	–17	–0.1	–0.1	–7
	GDP	2.8	2.8	100	3.6	3.6	100	5.0	5.0	100	1.6	1.6	100	1.4	1.4	100
Romania	L	–1.3	–0.7	11	–5.7	–2.9	102	–2.1	–1.1	–52	0.9	0.5	36	–0.7	–0.3	–9
	K	10.7	5.3	–90	4.1	2.0	–73	3.7	1.9	92	3.9	2.0	159	3.9	1.9	55
	TFP	–10.6	–10.6	179	–2.0	–2.0	71	1.2	1.2	60	–1.2	–1.2	–95	1.9	1.9	54
	GDP	–5.9	–5.9	100	–2.8	–2.8	100	2.0	2.0	100	1.2	1.2	100	3.5	3.5	100
Slovakia	L	–2.8	–1.4	26	–2.1	–1.0	–21	–0.1	0.0	–2	0.6	0.3	18	0.0	0.0	0
	K	4.9	2.4	–45	2.7	1.3	26	3.0	1.5	53	3.7	1.9	113	2.7	1.3	90
	TFP	–6.5	–6.5	119	4.7	4.7	94	1.4	1.4	48	–0.5	–0.5	–31	0.2	0.2	10
	GDP	–5.4	–5.4	100	5.0	5.0	100	2.8	2.8	100	1.7	1.7	100	1.5	1.5	100
Slovenia	L	–1.5	–0.8	10	–1.5	–0.8	–62	–3.1	–1.6	–239	–1.3	–0.6	24	–1.9	–1.0	86
	K	5.1	2.6	–33	2.5	1.2	101	1.3	0.7	103	0.9	0.5	–18	0.4	0.2	–16
	TFP	–9.6	–9.6	123	0.8	0.8	61	1.5	1.5	236	–2.5	–2.5	94	–0.3	–0.3	30
	GDP	–7.8	–7.8	100	1.2	1.2	100	0.6	0.6	100	–2.7	–2.7	100	–1.1	–1.1	100

		2014			2015			2016			2017			2018		
		growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)	growth (%)	contribution (p.p.)	contribution (%)
Bulgaria	L	1.6	0.8	59	1.7	0.9	24	–0.5	–0.2	–6	4.4	2.2	62	–0.6	–0.3	–8.6
	K	2.2	1.1	81	2.2	1.1	31	2.3	1.1	29	1.6	0.8	23	1.7	0.9	24.2
	TFP	–0.5	–0.5	–40	1.6	1.6	45	3.1	3.1	77	0.5	0.5	15	3.0	3.0	84.5
	GDP	1.3	1.3	100	3.6	3.6	100	3.9	3.9	100	3.6	3.6	100	3.6	3.6	100.0
Croatia	L	2.8	1.4	–1,566	1.2	0.6	25	0.3	0.2	4	2.2	1.1	40	0.4	0.2	6.4
	K	1.1	0.5	–618	0.9	0.4	18	1.0	0.5	15	1.4	0.7	24	1.5	0.8	26.9
	TFP	–2.0	–2.0	2,284	1.4	1.4	57	2.9	2.9	81	1.0	1.0	36	1.9	1.9	66.8
	GDP	–0.1	–0.1	100	2.4	2.4	100	3.5	3.5	100	2.8	2.8	100	2.8	2.8	100.0
Czech Republic	L	0.7	0.4	14	1.4	0.7	13	1.9	1.0	39	1.6	0.8	19	0.8	0.4	13.7
	K	2.2	1.1	40	2.3	1.1	22	2.9	1.4	58	2.5	1.2	29	2.7	1.3	43.8
	TFP	1.3	1.3	46	3.5	3.5	65	0.1	0.1	2	2.2	2.2	52	1.3	1.3	42.5
	GDP	2.7	2.7	100	5.3	5.3	100	2.5	2.5	100	4.3	4.3	100	3.1	3.1	100.0
Estonia	L	0.6	0.3	11	2.6	1.3	76	0.6	0.3	15	2.2	1.1	22	0.0	0.0	0.0
	K	3.7	1.8	64	2.6	1.3	79	2.2	1.1	54	2.0	1.0	21	2.8	1.4	37.2
	TFP	0.7	0.7	25	–0.9	–0.9	–56	0.6	0.6	31	2.8	2.8	57	2.3	2.3	62.8
	GDP	2.9	2.9	100	1.7	1.7	100	2.1	2.1	100	4.9	4.9	100	3.7	3.7	100.0
Hungary	L	5.3	2.7	63	2.7	1.3	39	3.4	1.7	76	1.6	0.8	20	0.8	0.4	10.1
	K	1.4	0.7	16	2.1	1.0	31	2.1	1.0	46	1.2	0.6	15	2.1	1.1	26.7
	TFP	0.9	0.9	21	1.0	1.0	30	–0.5	–0.5	–23	2.6	2.6	65	2.5	2.5	63.2
	GDP	4.2	4.2	100	3.4	3.4	100	2.2	2.2	100	4.0	4.0	100	4.0	4.0	100.0
Latvia	L	–1.0	–0.5	–27	1.2	0.6	21	–0.3	–0.2	–8	0.2	0.1	2	1.9	0.9	25.3
	K	2.3	1.2	62	2.1	1.1	36	2.0	1.0	44	0.8	0.4	9	1.7	0.8	22.6
	TFP	1.2	1.2	65	1.3	1.3	43	1.4	1.4	63	4.0	4.0	89	1.9	1.9	52.1
	GDP	1.9	1.9	100	3.0	3.0	100	2.2	2.2	100	4.5	4.5	100	3.7	3.7	100.0
Lithuania	L	2.0	1.0	28	1.2	0.6	30	1.9	1.0	42	–0.4	–0.2	–6	1.5	0.8	21.8
	K	2.6	1.3	36	2.8	1.4	69	2.9	1.5	63	2.7	1.3	35	3.0	1.5	42.7
	TFP	1.3	1.3	35	0.0	0.0	2	–0.1	–0.1	–4	2.7	2.7	71	1.3	1.3	35.4
	GDP	3.5	3.5	100	2.0	2.0	100	2.3	2.3	100	3.9	3.9	100	3.5	3.5	100.0
Poland	L	1.9	0.9	29	1.4	0.7	18	0.7	0.4	12	1.4	0.7	15	0.7	0.3	7.5
	K	2.8	1.4	43	3.4	1.7	44	3.6	1.8	60	2.6	1.3	28	2.7	1.4	31.1
	TFP	0.9	0.9	29	1.5	1.5	38	0.8	0.8	28	2.6	2.6	57	2.7	2.7	61.4
	GDP	3.3	3.3	100	3.8	3.8	100	3.0	3.0	100	4.7	4.7	100	4.4	4.4	100.0
Romania	L	0.8	0.4	11	–0.9	–0.5	–12	–1.0	–0.5	–10	2.6	1.3	19	0.1	0.0	1.0
	K	3.1	1.5	45	3.1	1.5	40	3.4	1.7	36	3.1	1.6	23	3.3	1.6	41.0
	TFP	1.5	1.5	44	2.8	2.8	72	3.6	3.6	75	4.1	4.1	59	2.3	2.3	58.0
	GDP	3.4	3.4	100	3.9	3.9	100	4.8	4.8	100	6.9	6.9	100	4.0	4.0	100.0
Slovakia	L	1.5	0.7	27	2.6	1.3	34	2.8	1.4	42	1.6	0.8	23	1.4	0.7	18.1
	K	2.4	1.2	44	2.5	1.2	32	3.7	1.9	56	2.7	1.4	40	2.7	1.4	35.2
	TFP	0.8	0.8	30	1.3	1.3	35	0.1	0.1	2	1.3	1.3	37	1.8	1.8	46.7
	GDP	2.8	2.8	100	3.9	3.9	100	3.3	3.3	100	3.4	3.4	100	3.9	3.9	100.0
Slovenia	L	1.2	0.6	20	0.0	0.0	0	–0.2	–0.1	–3	4.8	2.4	48	1.6	0.8	18.4
	K	0.5	0.3	9	0.6	0.3	12	0.4	0.2	7	0.2	0.1	2	0.7	0.4	8.3
	TFP	2.1	2.1	71	2.0	2.0	88	3.0	3.0	97	2.5	2.5	50	3.3	3.3	73.3
	GDP	3.0	3.0	100	2.3	2.3	100	3.1	3.1	100	5.0	5.0	100	4.5	4.5	100.0

Source: Own calculations.

negative (mainly due to negative TFP growth rates during the global crisis). Over the entire 10-year period, the Czech Republic and Hungary reported an average decline in TFP by 0.2%, and Croatia by 0.5% annually.

Table 13.2 TFP growth rates (%)

Country	Entire period 2009–2018			2009–2011	2012–2014	2015–2017	2018
	Average	Minimum	Maximum	Average	Average	Average	
Bulgaria	0.5	–6.1	3.1	–0.8	–0.5	1.7	3.0
Croatia	–0.5	–9.3	2.9	–3.2	–1.0	1.7	1.9
Czech Republic	–0.2	–6.5	3.5	–1.7	–1.2	1.9	1.3
Estonia	0.2	–12.8	4.0	–1.7	0.7	0.8	2.3
Hungary	–0.2	–6.8	2.6	–2.1	–0.5	1.0	2.5
Latvia	0.4	–10.9	5.3	–2.5	1.1	2.2	1.9
Lithuania	0.4	–13.9	5.2	–1.7	1.6	0.9	1.3
Poland	**1.5**	**–0.3**	**3.2**	**2.3**	**0.2**	**1.6**	**2.7**
Romania	0.4	–10.6	4.1	–3.8	0.7	3.5	2.3
Slovakia	0.5	–6.5	4.7	–0.1	0.1	0.9	1.8
Slovenia	0.3	–9.6	3.3	–2.4	–0.2	2.5	3.3

Source: Own calculations.

Table 13.3 Contribution of TFP to economic growth (%)

Country	Entire period 2009–2018		
	Average	Minimum	Maximum
Bulgaria	–142	–1,974	171
Croatia	249	–224	2,284
Czech Republic	118	2	462
Estonia	44	–56	166
Hungary	51	–23	188
Latvia	57	–4	89
Lithuania	64	–4	222
Poland	**36**	**–17**	**87**
Romania	58	–95	179
Slovakia	39	–31	119
Slovenia	92	30	236

Source: Own calculations.

We assume in this chapter, that TFP growth is treated as an approximate measure of technological progress. However, TFP calculated as residual on the basis of growth accounting has its drawbacks as an indicator of technological growth, which should be kept in mind when interpreting results. For example, the part of TFP which results from increased labor productivity should be partially considered as contribution of human capital to economic growth. Due to the difficulties in calculating this type of capital for the analyzed group of countries, TFP in our approach also includes the impact of human capital on economic growth.

Poland's best results in terms of changes in total factor productivity compared with the EU-11 are a great success. The Baltic states were the leaders in TFP dynamics in the analyses prepared a few years ago. Prior to the global crisis, they showed a very fast economic growth, which was difficult to explain by changes in labor and physical capital, which is why it was attributed to TFP. The position of Poland in those analyses was moderate – not as good as that of the Baltic states, nor was it trailing the group. The extension and shifting of the time horizon significantly changed the outcomes for individual countries in favor of Poland, while deteriorating the relative position of the Baltic states. Elements of the Fourth Industrial Revolution, such as business and social networks, the Internet of Things and Services, as well as the development of big data were among the drivers of the fast productivity growth in Poland.

Industry 4.0 would not have a positive impact on the Polish economy without an appropriate level of human capital. As shown above, the part of TFP which results from increased labor productivity may be partially considered as contribution of human capital to economic growth. Thus, Poland's best results in terms of changes in total factor productivity compared with the EU-11 are indicative of a relatively good position of Poland among the analyzed countries in terms of human capital development.

The Baltic states and Romania were characterized by the highest variance in TFP growth rates in the years under study. The differentiation of the dynamics of productivity changes in these countries results mainly from large spreads of GDP growth rates. The Baltic states were most deeply affected by the global crisis, as in 2009 the decline in their GDP reached a two-digit level. As a result, the variance in TFP growth rates in the Baltic states were the highest in the EU-11 group – the difference between the largest and the lowest TFP growth rate was 19.1 p.p. in Lithuania (the lowest rate was –13.9%, and the highest 5.2%) and 15–17 p.p. in the other two Baltic republics and Romania. In other countries of Central and Eastern Europe, except for Poland, the spread of TFP growth rates ranged from 11–13 p.p. in Slovenia, Croatia and Slovakia to 9 p.p. in Hungary and Bulgaria. For its part, Poland, which showed a fairly steady increase in production in 2009–2018 and was at the same time the only EU country that avoided recession during the global crisis, recorded the smallest spread of TFP growth rates at 3.5 p.p. The latter result is another reason why Poland's achievements regarding changes in the total factor productivity should be viewed as a positive development. In addition to the fact that Poland recorded the fastest growth rate of productivity in the last 10 years, it was also the most stable in the whole group of Central and Eastern European countries. In Poland, the lowest TFP growth rate in the analyzed period occurred in 2012 (–0.3%), and the highest – in 2011 (3.2%).

It is worth analyzing the dynamics of the total factor productivity in individual subperiods. The global crisis brought about dramatic changes in this respect, as is evident from aggregated data for 2019–2011. In the years 2009–2011, the countries of Central and Eastern Europe, with the exception of Poland, recorded negative TFP dynamics. The Baltic states, which saw high TFP growth rates before the crisis, performed very poorly during the crisis in terms of productivity dynamics, and as a result TFP growth rates were negative for the 2009–2011 period in these countries and amounted to: –2.5% in Latvia, and –1.7% in Lithuania and Estonia. Equally weak results were achieved in 2009–2011 by: Romania (–3.8%), Croatia (–3.2%), Slovenia (–2.4%), Hungary (–2.1%) and the Czech Republic (–1.7%). Poland was the only country with positive dynamics of total productivity of 2.3% in 2009–2011.

In 2012–2014, all the EU-11 countries except Poland improved their situation in relation to the years 2009–2011 in terms of TFP dynamics. In the Baltic countries, there were again positive TFP growth rates and, in addition, the highest in the EU-11 group, amounting to 1.6% in Lithuania, 1.1% in Latvia and 0.7% in Estonia. Poland maintained a positive (but slightly slower) growth rate of total factor productivity at 0.2% per annum, ranking fourth in the EU-11 group in terms of TFP changes in the period 2012–2014. Bulgaria, Slovakia and Romania also recorded positive TFP growth rates of 0.7% and 0.1%, respectively. Over the same period, Slovenia, Bulgaria, Croatia and the Czech Republic showed a negative growth rate of productivity ranging between –0.2% and –1.2% annually.

In 2015–2017, all the EU-11 countries improved their position in relation to the years 2012–2014 in terms of TFP dynamics. One exception is Lithuania, with a slight decrease in the TFP growth rate. Nevertheless, in all countries the average TFP growth rate was positive in that timeframe. The TFP growth rate in Poland amounted to 1.6% in 2015–2017, i.e., it accelerated markedly compared with the previous period 2012–2014. Six EU-11 countries achieved higher TFP growth rates than Poland in 2015–2017: Romania (3.5%), Slovenia (2.5%), Latvia (2.2%), the Czech Republic (1.9%), and Bulgaria and Croatia (1.7%). For their part, Hungary, Lithuania, Slovakia and Estonia recorded much smaller increments in TFP, at less than 1% annually.

In 2018, there was a further acceleration of the growth rate of total factor productivity in the EU-11 group (although some countries saw their performance deteriorate in terms of TFP dynamics compared to the years 2015–2017). Poland recorded a TFP growth rate of 2.7% annually in 2018, ranking third. Productivity growth rates higher than Poland's were achieved by Slovenia (3.3%) and Bulgaria (3.0%), By contrast, lower TFP change rates were noted in Hungary (2.5%), in Romania and Estonia (2.3%) and in Latvia, Croatia, Slovakia, the Czech Republic and in Lithuania (1.3–1.9%).

As regards TFP contribution to economic growth, the numerical values for the period under study are highly distorted, *inter alia*, by the fact that positive TFP dynamics during recession means a negative TFP contribution to economic growth (example of Croatia in 2011). On the other hand, when there is a strong economic slowdown and the GDP growth rate is close to 0%, a change of a few percent in total factor productivity translates into a several thousand percent TFP contribution to economic growth. Nevertheless, certain trends and regularities can be determined on the basis of aggregated results for the whole period.

As indicated by the data presented in Table 13.3, the percentage contributions of TFP to economic growth in most countries (except Croatia, the Czech Republic and Bulgaria) ranged between 36% and 82% in 2009–2018. This confirms the important role of TFP in the economic growth of the analyzed countries in the past decade. In Poland, the TFP contribution to GDP growth averaged 36% in 2009–2018.

It is worth adding that research on the decomposition of economic growth and TFP estimates for Poland was also carried out by other Polish authors (apart from our studies already quoted).[2] For example, Florczak and Welfe [2000] and Welfe [2001] calculate TFP in Poland in 1982–2000 on the basis of standard growth accounting, taking into account two factors of production: labor and physical capital (machinery and equipment or total fixed assets). In their study, the elasticity of production in relation to fixed assets, i.e., the share of physical capital in income, is calibrated at 0.5 or estimated on the basis of the production function. In another study by Welfe [2003], the author estimates the TFP for Poland in 1986–2000 using various alternative values of the physical capital share in income (from 0.25 to 0.7). Florczak [2011], in turn, estimates, using the Wharton method, the TFP values cleared of short-term demand fluctuations for Poland in 1970–2008, and then examines the determinants of total factor productivity. TFP estimates for Poland were also conducted, among others, by: Zienkowski [2001], Rapacki [2002], Piątkowski [2004], and Ptaszyńska [2006]. Roszkowska [2005] and Tokarski, Roszkowska and Gajewski [2005] performed growth accounting for voivodships in Poland. Zielińska-Głębocka [2004] estimated TFP for

2 Due to volume constrains, the results contained in those studies will not be described in detail.

100 industries in Poland, Ciołek and Umiński [2007] calculated the TFP growth rate in Polish domestic and foreign enterprises, while Doebeli and Kolasa [2005] used the index number decomposition method in growth accounting for Poland, the Czech Republic and Hungary.

Conclusions

The results show that changes in productivity played a significant role in the economic growth of Poland and the other EU-11 countries. In Poland, the average TFP growth rate amounted to 1.5% annually between 2009 and 2018, which was the best result in the EU-11 group. TFP growth in Poland should be interpreted as an improvement of the competitiveness of the Polish economy. Higher efficiency of production factors means an increase in management efficiency and a better competitive position in the international environment. In particular, it should be emphasized that the highest TFP growth rate obtained by Poland in the entire EU-11 group in 2009–2018 implies that the competitive position of the Polish economy measured by the dynamics of total factor productivity increased the most among the new EU member states during the last 10 years. Industry 4.0 undoubtedly played a significant role in the growth of total factor productivity.

Bibliography

Abramovitz, M. [1956], *Resource and Output Trends in the United States since 1870*, "American Economic Review", Vol. 46, pp. 5–23.

Barton, G.T., Cooper, M.R. [1948], *Relation of Agricultural Production to Inputs*, "Review of Economics and Statistics", Vol. 30, pp. 117–126.

Ciołek, D., Umiński, S. [2007], *Transfer technologii przez zagranicznych inwestorów*, "Ekonomista", No. 2, pp. 221–234.

Doebeli, B., Kolasa, M. [2005], *Rola zmian cen dóbr handlowych we wzroście dochodu krajowego Polski, Czech i Węgier*, "Gospodarka Narodowa", No. 9, pp. 25–45.

Florczak, W. [2011], *Ekonometryczna analiza makro-uwarunkowań wzrostu gospodarczego Polski*, "Prace i Materiały Wydziału Zarządzania Uniwersytetu Gdańskiego", No. 4/8, pp. 75–92.

Florczak, W., Welfe, W. [2000], *Wyznaczanie potencjalnego PKB i łącznej produktywności czynników produkcji*, "Gospodarka Narodowa", No. 11–12, pp. 40–55.

Griliches, Z. [1964], *Research Expenditures, Education, and the Aggregate Agricultural Production Function*, "American Economic Review", Vol. 54, pp. 961–974.

Griliches, Z. [1996], *The Discovery of the Residual: A Historical Note*, "Journal of Economic Literature", Vol. 34, pp. 1324–1330.

ILO [2019], *Ilostat Database*, www.ilo.org/ilostat, accessed 20.02.2019.

IMF [2019], *World Economic Outlook Database, October 2018* (updated January 2019), www.imf.org, accessed 20.02.2019.

Johnson, D.G. [1950], *The Nature of the Supply Function for Agricultural Products*, "American Economic Review", Vol. 40, pp. 539–564.

Jorgenson, D.W., Griliches, Z. [1967], *The Explanation of Productivity Change*, "Review of Economic Studies", Vol. 34, pp. 249–283.

Kendrick, J.W. [1956], *Productivity Trends: Capital and Labor*, "Review of Economics and Statistics", Vol. 38, pp. 248–257.

Piątkowski, M. [2004], *Wpływ technologii informacyjnych na wzrost gospodarczy i wydajność pracy w Polsce w latach 1995–2000*, "Gospodarka Narodowa", No. 1–2, pp. 37–52.

Próchniak, M. [2012], *Total Factor Productivity*, in: Weresa M.A. (ed.), *Poland. Competitiveness Report 2012. Focus on Education*, World Economy Research Institute, Warsaw School of Economics, Warsaw, pp. 189–203.

Próchniak, M. [2013], *Changes in Total Factor Productivity*, in: Weresa M.A. (ed.), *Poland. Competitiveness Report 2013. National and Regional Dimensions*, World Economy Research Institute, Warsaw School of Economics, Warsaw, pp. 175–201.

Próchniak, M. [2014], *Changes in Total Factor Productivity in 2004–2013 and the Competitiveness of the Polish Economy*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2014. A Decade in the European Union*, World Economy Research Institute, Warsaw School of Economics, Warsaw, pp. 192–204.

Próchniak, M. [2018], *Changes in Total Factor Productivity*, in: M.A. Weresa, A.M. Kowalski (eds.), *Poland. Competitiveness Report 2018. The Role of Cities in Creating Competitive Advantages*, World Economy Research Institute, Warsaw School of Economics, Warsaw, pp. 157–170.

Ptaszyńska, B. (2006), *Wzrost gospodarczy w Polsce w latach transformacji systemowej*, "Wiadomości Statystyczne", No. 2, pp. 44–53.

Rapacki, R. [2002], *Możliwości przyspieszenia wzrostu gospodarczego w Polsce*, "Ekonomista", No. 4, pp. 469–493.

Roszkowska, S. [2005], *Kapitał ludzki a wzrost gospodarczy w ujęciu wojewódzkim*, "Wiadomości Statystyczne", No. 4, pp. 46–67.

Ruttan, V.W. [1956], *The Contribution of Technological Progress to Farm Output: 1950–75*, "Review of Economics and Statistics", Vol. 38, pp. 61–69.

Schmookler, J. [1952], *The Changing Efficiency of the American Economy, 1869–1938*, "Review of Economics and Statistics", Vol. 34, pp. 214–231.

Solow, R.M. [1957], *Technical Change and the Aggregate Production Function*, "Review of Economics and Statistics", Vol. 39, pp. 312–320.

Solow, R.M. [1962], *Technical Progress, Capital Formation, and Economic Growth*, "American Economic Review", Vol. 52, pp. 76–86.

Tintner, G. [1944], *A Note on the Derivation of Production Functions from Farm Records*, "Econometrica", Vol. 12, pp. 26–34.

Tokarski, T., Roszkowska, S., Gajewski, P. [2005], *Regionalne zróżnicowanie łącznej produktywności czynników produkcji w Polsce*, "Ekonomista", No. 2, pp. 215–244.

Welfe, W. [2001], *Czynniki wzrostu potencjału gospodarczego Polski*, "Ekonomista", No. 2, pp. 177–200.

Welfe, W. [2003], *Łączna produktywność czynników produkcji a postęp techniczny*, "Studia Ekonomiczne", No. 1–2, pp. 99–115.

World Bank [2019], *World Development Indicators Database*, databank.worldbank.org, accessed 20.02.2019.

Zielińska-Głębock,a A. [2004], *Analiza produkcyjności polskiego przemysłu. Aspekty metodyczne i empiryczne*, "Ekonomista", No. 3, pp. 335–358.

Zienkowski, L. [2001], *Wydajność pracy i kapitału w Polsce*, "Wiadomości Statystyczne", No. 2, pp. 36–49.

Part IV

Development of Industry 4.0 in Poland

Chapter 14

Industry 4.0 State of Play and Barriers in Poland

Marzenna Anna Weresa

Introduction

The aim of this chapter is to benchmark the position of Poland against selected EU member states, especially those in the Central and Eastern European region, in terms of the state of play in the development of Industry 4.0, and to identify barriers to this process. Such a diagnosis can provide a basis on which to draw up conclusions and recommendations for an innovative policy geared towards supporting the creation and implementation of new technologies based on the use of digital solutions.

When analyzing the new era of industry, it is broadly referred to as the Fourth Industrial Revolution, which involves the digital transformation of manufacturing processes based on information and communication technologies (ICT). This has diverse consequences for enterprises, new business models emerge, leading to systemic, social and cultural changes.

This chapter will analyze various dimensions of Industry 4.0. Those coming to the fore in the literature include: the Internet of Things, automation, robotization, artificial intelligence, use of big data in production and management, cloud processing, or manufacture with the use of 3D printing [Kagermann et al., 2013; Schwab, 2016; Armengaud et al., 2017]. In this context, an answer is sought to the following research questions:

- What is the competitive position of Poland compared with other European Union countries in terms of the digitalization of the economy?
- How advanced is Poland in creating technologies for Industry 4.0?
- To what extent have enterprises in Poland entered the digital world, applying an innovative ICT-based approach to production and management?
- In which of the dimensions of Industry 4.0 have Polish firms been successful?
- What are the barriers to the development of Industry 4.0 in Poland?

An analysis of these issues is the subject of the following sub-chapters of this study.

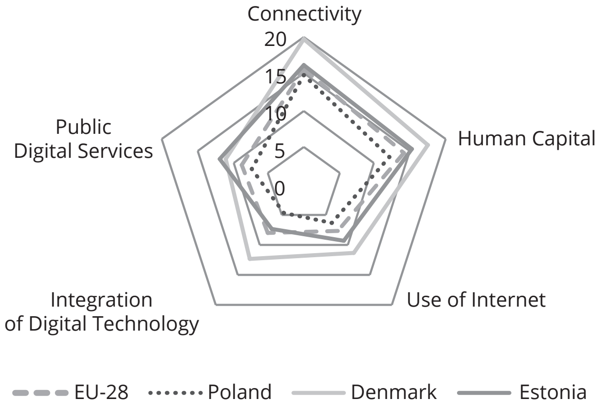
14.1 Competitive Position of Poland in Digitalization Compared with Other European Union Countries in 2010–2018

A general picture of the development of digital economy in Poland compared with EU economies can be derived from an analysis of the Digital Economy and Society Index (DESI). The index is a weighted average of five dimensions including Connectivity (25%), Human Capital (25%), Use of Internet (15%), Integration of Digital Technology (20%) and Digital Public Services (15%). Each of the dimensions is composed of several indicators, their total number being 34. The index is one of the ways of measuring digital competitiveness; it allows not only the assessment of progress in digitalization and identification of areas in which performance can be improved in individual member states, but also comparative studies of EU member states in terms of digitalization [DG for Communications Networks, Content and Technology 2018a, pp. 3–4].

EU member states can be ranked according to the DESI level and growth rate. In 2018, Denmark ranked first among the EU member states, and the best-scoring EU country from Central and Eastern Europe was Estonia. Poland ranks only 24th in the EU in terms of digitalization measured by the DESI, and it belongs to the group of countries lagging behind in digital competitiveness. The DESI value for Poland has been rising at a rate close to the EU average rate, yet its level is significantly below the EU average, which means that for the time being we are unable to catch up not only with the digital leaders, but even with the EU average. A situation similar to Poland's is also witnessed in countries such as: Hungary, Slovakia, Romania, Bulgaria, Croatia, Cyprus, Italy, Greece [DG for Communications Networks, Content and Technology, 2018b, p. 2].

Figure 14.1 allows the position of Poland to be compared using DESI 2018 in five dimensions of competitiveness with the values of those indicators achieved by the EU leader, Denmark, and the leader of the CEE group of EU member states, Estonia. The results are presented against the average values for the entire European Union. The distance between Poland and the EU leader is enormous in all the dimensions of digital competitiveness. Also the distance between Poland and Estonia (the digitally most advanced country of the Central and Eastern European region) is large for most of the indicators of digital competitiveness. When benchmarking Poland's position against the average values of those indicators in the EU, it should be noted that Poland lags the farthest behind the EU average in Integration of Digital Technology, while the smallest distance concerns the Connectivity dimension

Figure 14.1 Dimensions of digital competitiveness: Poland compared with selected EU countries according to DESI 2018



Source: Own study based on DESI 2018 data, https://digital-agenda-data.eu/datasets/desi#download, access date: 2019.01.18.

As regards changes in the components of DESI, since 2015 Poland has moved upwards in the digital competitiveness ranking of EU member states in terms of two DESI dimensions – Connectivity and Human Capital, whereas in terms of the Use of Internet and Digital Public Services, it has lost its position reached in the previous years [DG for Communications Networks, Content and Technology, 2018b].

14.2 Industry 4.0 in Poland – Creating New Solutions

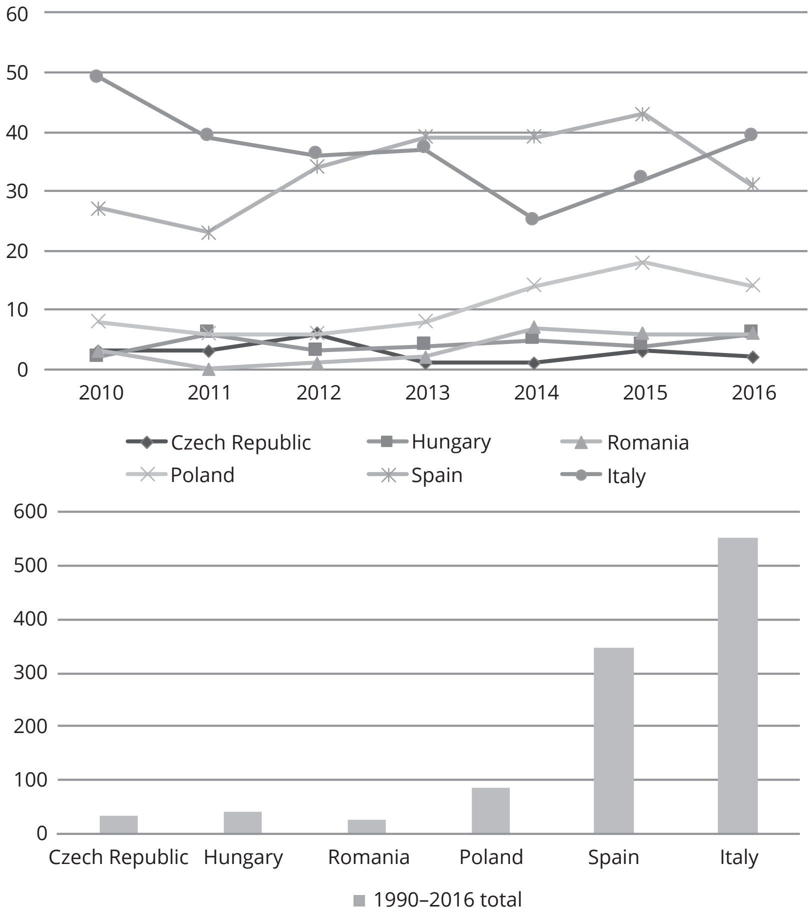
The Fourth Industrial Revolution is driven by innovations implemented in new technological areas related to digitalization. The process can operate in a two-fold manner – by creating and implementing new knowledge in a given country in the field of digital economy, or through the transfer of that knowledge from abroad and its application in the domestic market. Patented inventions are one of the ways of measuring the contribution of individual countries to the creation of new knowledge. The European Patent Office has developed criteria for separating out the patent applications that refer to digital economy. They allow inventions to be selected that combine computing functions, connectivity, data exchange and smart devices. Inventions are divided between three main groups described as "core technologies", "enabling technologies" and "application domains", each of which is subdivided into several technology fields [Ménière, Rudyk, Valdes, 2017, p. 23]. Using the above classification, the European Patent Office (EPO) identified 48,069 inventions relating to the Fourth

Industrial Revolution, for which patent applications were submitted to the EPO in 1979–2016. The number of patent applications for Industry 4.0 technologies started growing dynamically in the 2010s, but they still represent a mere 3.3% of all European patent applications to the EPO [Ménière, Rudyk, Valdes, 2017, p. 29]. There is a very strong geographical concentration of patents. About 30% of patent applications come from EU inventors. Germany is the leader in Europe, followed by France and the United Kingdom, and then Sweden and Finland. Poland is among the lowest-ranked countries in the EU in this category. In 1990–2016, only 86 Polish patent applications related to Industry 4.0 were registered with the EPO, while, e.g., Spain, with a similar population size, registered four times more, and Italy as many as six times more [Ménière, Rudyk, Valdes, 2017, pp. 96–97]. A comparison of Poland's patent activity with selected EU countries (Figure 14.2) shows that creation of Industry 4.0 knowledge which is new on a global scale is one of the weaknesses of the Polish economy, although it is worth noting a gradual upward trend in Polish patent applications since 2013.

Creation of new knowledge necessary for the development of Industry 4.0 is financed both from the national research and development (R&D) budget and under the EU framework programs. A comparison of EU member states in terms of the utilization of funds under the Seventh Framework Programme (7FP) for the development of new solutions in Industry 4.0 leads to the conclusion that research activities in this area is strongly concentrated in the European Union in several countries such as: Germany, Spain, Italy and United Kingdom. Unfortunately, Poland has no significant achievements in this field and is ranked among EU countries lagging behind in terms of research on Industry 4.0 and financed from the EU budget. What is more, in all EU member states there are significant regional differences in the utilization of 7FP funds for R&D in Industry 4.0. In Poland, most voivodship are classified into a group with low involvement in R&D in Industry 4.0. Only one voivodship, Mazowieckie, is included among the regions a with medium-low level research activity in Industry 4.0. [Ciffolilli, Muscio, 2018].

However, a more detailed analysis of the individual technologies enabling Industry 4.0 shows a high differentiation of specializations among EU member states. The specialization is measured by two indicators – absolute advantage and revealed comparative advantage, and the design of these indicators is analogical to traditional measures of specialization in trade (Ciffolilli, Muscio, 2018). In terms of the value of those indicators calculated for the individual types of technology related to Industry 4.0, Poland has no absolute advantages in R&D in any Industry 4.0 area. However, it has comparative advantages in R&D involving big data analysis, cyber-security, industrial use of the Internet of Things and computing cloud [Ciffolilli, Muscio, 2018, p. 12). Thus, it is in those domains that Poland might specialize in future when it comes to Industry 4.0. They should become a priority for Polish policy addressing the development of Industry 4.0.

Figure 14.2 Number of Industry 4.0 patent applications: Poland compared with selected EU countries in 2010–2016.

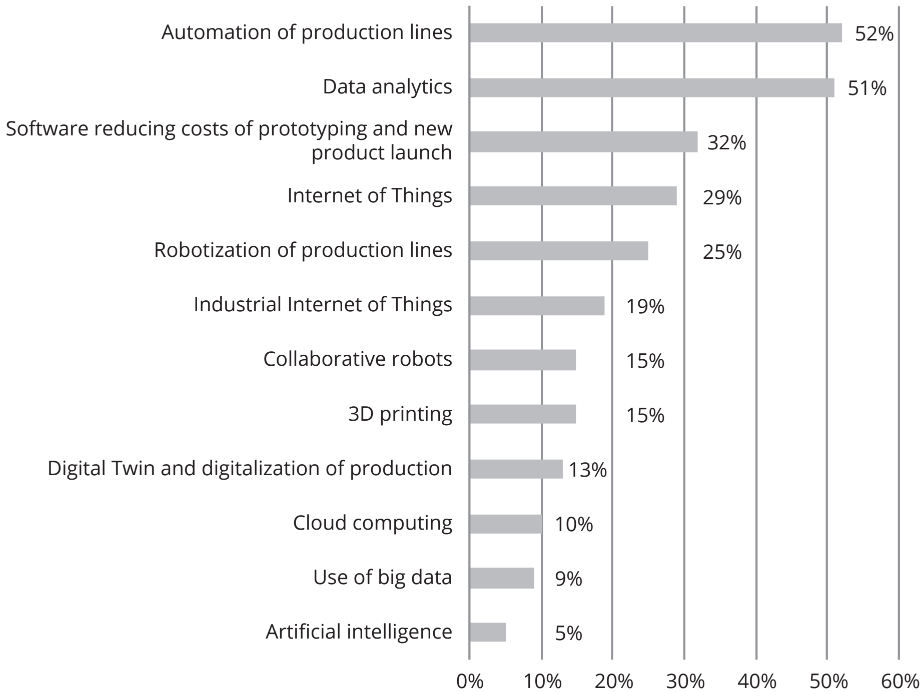


Source: Own study based on data from: Ménière Y., Rudyk I., Valdes J. [2017], *Patents and the Fourth Industrial Revolution. The inventions behind digital transformation*, European Patent Office Munich, pp. 94–97.

14.3 State of Play of Industry 4.0 Development in Polish Enterprises in Poland

This sub-chapter is focused on the development of Industry 4.0 in Polish enterprises according to the state of play in 2016–2018. The analysis includes business entities that create and offer new digital technologies, as well as enterprises that buy and implement those technologies. The issues subject to analysis concern digital innovations implemented by Polish enterprises leading to application in the digital technology manufacturing process. The statistical data used in this analysis come from computer assisted telephone interviews (CATI technique) performed in April 2018 by Kantar Millward Brown. The sample consisted of 200 enterprises from all over Poland, employing fewer than 250 persons, representing different industrial branches [Ministry of Entrepreneurship and Technology / Siemens 2018, p. 14]. The survey results indicate an uneven development of the individual elements of Industry 4.0. Automation of manufacturing lines and big data analytics are found to be of primary interest to Polish enterprises – more than half of the firms surveyed declared their involvement in this type of digital economy activity. About 1/4 of the respondents are involved in developing software supporting the reduction of innovation costs, robotization and the Internet of Things. In contrast, only a small percentage of the enterprises surveyed (a mere 5%) undertake the development of artificial intelligence (Figure 14.3).

Figure 14.3 Industry 4.0 technologies used by Polish SMEs – state of play in 2018 (number of enterprises surveyed N= 200)

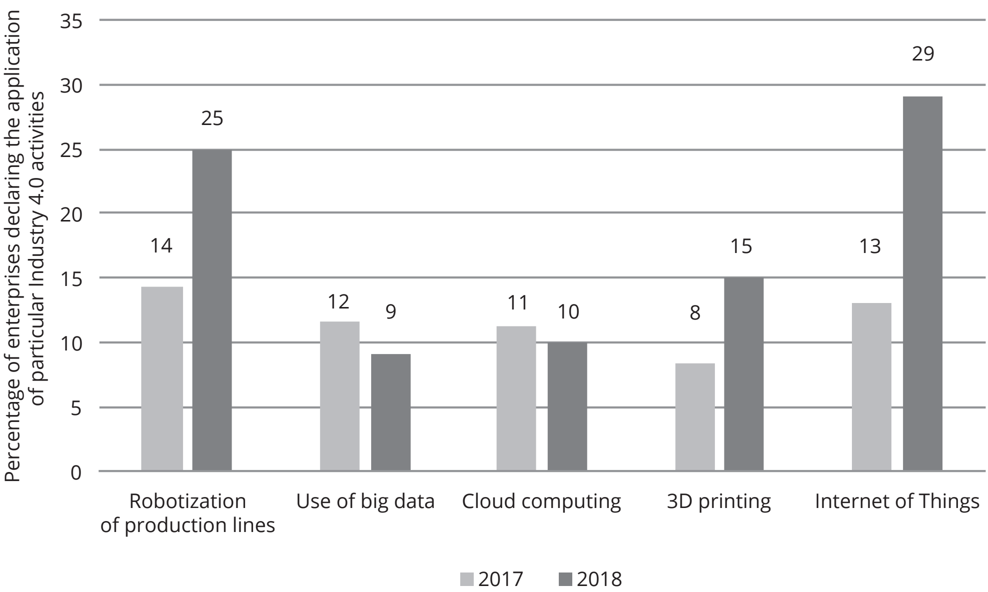


Source: Own study based on: Ministry of Entrepreneurship and Technology / Siemens [2018], *Smart Industry Polska 2018. Innowacyjność w sektorze mikro oraz małych i średnich przedsiębiorstw produkcyjnych w Polsce – Raport z badań,* https://publikacje.siemens-info.com/ebook/165/raport-smart-industry-polska-2018,.

It is worth juxtaposing the results obtained with those of two previous editions of the survey from 2016 and 2017, but due to certain differences in methodological assumptions and sample selection the picture of changes is only indicative, failing to offer full comparability of results.

Figure 14.4 shows the application of selected elements of Industry 4.0 in Polish small and medium-sized enterprises in 2017 and 2018. According to the SMEs surveyed, the most popular element of Industry 4.0 used by them in business operations is the Internet of Things, followed by the robotization of manufacturing. The 2018 survey showed that the use of the Internet of Things is declared by as many as 29% of the enterprises surveyed, and 25% declare the use of robots. Based on the opinions of the enterprises surveyed in 2017 and 2018, it can also be noted that robotization of production lines and the use of the Internet of Things as well as 3D printing saw the highest growth. Small declines were recorded, however, when it comes to the use of big data and cloud computing (Figure 14.4), but it should be noted that the comparisons are indicative only owing to certain differences in sample size, size structure of the firms surveyed, and survey design.

Figure 14.4 Industry 4.0 in Polish small and medium-sized enterprises – a comparison of selected elements in 2017 and 2018

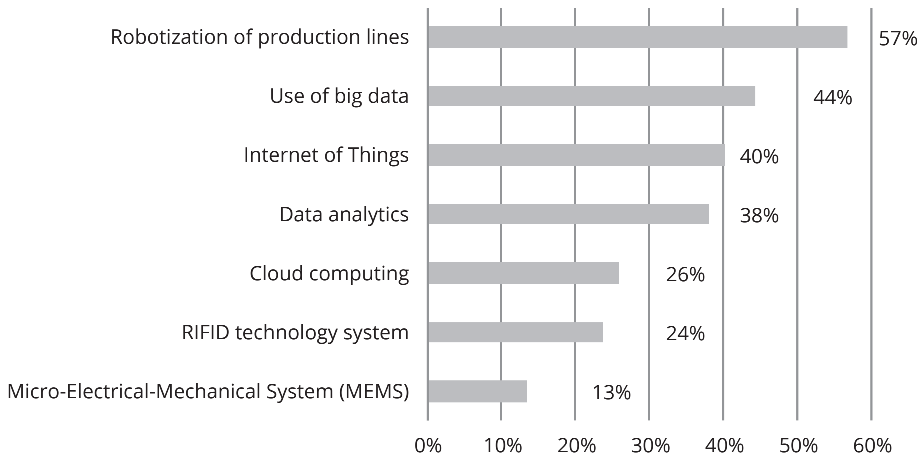


Note: The data are not fully comparable owing to differences in sample size (N=251 in 2017; N=200 in 2018) and selection of the firms surveyed (e.g., in 2017, medium-sized firms represented approx. 1/3, and in 2018 1/4 of the enterprises surveyed); there are also some differences in survey design.

Source: Own study based on reports of the Ministry of Entrepreneurship and Technology / Siemens [2018], *Smart Industry Polska 2018*, p. 35 and *Smart Industry Polska 2017*, p. 40.

The digitalization of large processing industry enterprises operating in Poland (employing at least 250 persons) presents a similar picture, but the scale of Industry 4.0 application is much greater here. A questionnaire survey study conducted by PwC on a sample of N=100 managers of large manufacturing companies in Poland showed that digital technologies used in manufacturing processes included mainly the robotization of production lines (indicated by 57% of respondents), the use of big data (44% of respondents), and the Internet of Things (40% of respondents) (Figure 14.5). However, almost half of the respondents pointed out that digitization was used in selected business projects and it was not yet a systematic business practice [Siemens, 2016, p. 19].

Figure 14.5 The use of information processing and management technologies by large enterprises operating in Poland (sample size N=100)



Source: Own study based on the report: Siemens [2016], *Smart Industry Polska 2016*, p. 19.

The progress of digitalization of Polish enterprises was also assessed through a survey conducted by PwC and discussed in the reports *Global Industry 4.0 Survey: Building the digital enterprise* [PwC, 2016a] and *Przemysł 4.0, czyli wyzwania współczesnej produkcji* [PwC, 2016b]. Polish enterprises proved to be more optimistic in assessing their digitalization level compared with the average global rating. A PwC survey conducted among 2,000 senior executives from industrial companies, including 50 from Poland, showed that Polish firms declared a high level of digitalization in the development of new products and technologies, customer access and integration of value chains (Table 14.1).

Table 14.1 Digitalization – Polish enterprises vs. the world (percentage of enterprises declaring a high level of digitalization in their particular business areas)

Digitalization application areas	Poland	World
Vertical value chains	52%	41%
Horizontal value chains	46%	34%
Digital business models	36%	29%
Development of products and technologies	53%	42%
Customer access, sales channels and marketing	47%	35%

Note: the data in the table show the percentage of senior executives surveyed declaring a high level of digitalization (digitalization level of at least 4 measured on a five-point scale). The survey was conducted among 2,000 senior executives from industrial companies, including 50 from Poland.

Source: PwC (2016b), "Przemysł 4.0, czyli wyzwania współczesnej produkcji", https://www.pwc.pl/pl/pdf/przemysl-4–0-raport.pdf, p. 32.

14.4 Barriers to the development of Industry 4.0 in Poland

Despite a fairly optimistic assessment of their own digitalization potential, Polish enterprises indicate a number of barriers that impede the development of Industry 4.0. A survey carried out in 2017 among 251 SMEs in Poland revealed that the main obstacles to deploying new technologies in manufacturing enterprises are:

- red tape (40.6% of replies),
- lack of encouragement from public authorities (36.7%),
- limited capability to finance digital investments (33.9%),
- lack of access to skilled personnel (32.3%),
- return on investment risk (31.9%).

A similar picture emerges from PwC studies both in Poland and worldwide. In a global survey conducted by PwC, approx. 40% of the enterprises surveyed stated they had no clear vision of digitalization of their business and. what is more, had no sufficient support to digitalization from the state [PwC, 2016a]. Another major barrier is the financing of digital development. The global PwC survey showed that high financial investment requirements were perceived as a challenge by 36% of respondents. In Poland, the financing of digital investments was also considered as a key barrier to the development of Industry 4.0. About 34% of the companies surveyed by Siemens stated that limited financial resources impeded their investments in new technologies. A lack of digital culture and training is also one of the greatest challenges to the development of Industry 4.0. Nearly 32% of the surveyed Polish enterprises complained about a lack of access to skilled personnel, and in a survey carried out by

PwC insufficient access to skilled and talented employees was viewed as a challenge to digitalization by 25% of the respondents [PwC, 2016a].

The conclusions are also confirmed by other analyses, which have shown, among other things, that the key challenges to the development of Industry 4.0 are a lack of skilled personnel and insufficient access to capital. The challenges and the way in which they will be dealt with by economic policy are bound to impact Poland's international relations, including with its largest trade partner, Germany [Götz, Gracel, 2017].

14.5 Summary

Industry 4.0 combines digital and traditional technologies, leading to developments which include the emergence of artificial intelligence, robotization, the Internet of Things, big data processing and storage, and cloud computing. All those changes are made to increase operational flexibility and speed of adjusting to changing demand, and thus to improve the efficiency and competitiveness of enterprises.

The analysis carried out for the purposes of this chapter shows that Poland's position in terms of digital competitiveness measured by the Digital Economy and Society Index (DESI) is relatively low compared to most EU member states and the EU average value of this index. What is more, the distance has not been reduced over recent years. Poland's weaknesses include low outlays on R&D in Industry 4.0, which results in a small number of patents in technologies related to Industry 4.0. Poland has no absolute advantages in R&D in any Industry 4.0 area. What may be become an opportunity to strengthen its position are comparative advantages in research on big data, cyber-security, as well as the application of the Internet of Things and the use of cloud computing. These are the areas where Poland's future specialization in Industry 4.0 can be sought. Prospects for their development may be boosted by increasing support to R&D by means of relevant tools of research and innovation policy Measures supporting the development of Industry 4.0 in Poland are also needed by enterprises that point to financial burdens related to the implementation of new technologies and insufficient skills as barriers slowing down the development of Industry 4.0. An important area of state policy is the creation of an institutional framework necessary to take advantage of the achievements of the Fourth Industrial Revolution, including the issue of digital security, development and implementation of digital standards and certification.

However, not only technological aspects of the Fourth Industrial Revolution are important, but also its social and cultural effects [Schwab, 2016]. They require consistent efforts not only at national but also at global level.

Bibliography

Armengaud E., Sams C., von Falck G., List G., Kreiner C., Riel A. [2017], *Industry 4.0 as Digitalization over the Entire Product Lifecycle: Opportunities in the Automotive Domain*, in: Stolfa J., Stolfa S., O'Connor R., Messnarz R. (eds.) *Systems, Software and Services Process Improvement*, EuroSPI 2017, "Communications in Computer and Information Science", Vol. 748. Springer, Cham, pp. 334–351.

Ciffolilli A., Muscio A. [2018], *Industry 4.0: national and regional comparative advantages in key enabling technologies*, "European Planning Studies", DOI:10.1080/09654313.2018.1529145

DG for Communications Networks, Content and Technology [2018a], DESI 2018. Digital Economy and Society Index. Methodological Note, European Commission, Brussels.

DG for Communications Networks, Content and Technology [2018b], Digital Economy and Society Index (DESI) 2018. Country Report Poland, European Commission, Brussels.

Götz, Gracel [2017], *Przemysł czwartej generacji (Industry 4.0) – wyzwania dla badań w kontekście międzynarodowym*, "Kwartalnik Naukowy Uczelni Vistula", 1(51), pp. 217–235

Kagermann, H., Helbig, J., Hellinger, A., Wahlster, W., [2013], *Recommendations for Implementing the strategic initiative INDUSTRIE 4.0: securing the future of German manufacturing industry*; final report of the Industrie 4.0 working group, Forschungsunion.

Ménière Y., Rudyk I., Valdes J. [2017], *Patents and the Fourth Industrial Revolution. The inventions behind digital transformation*, European Patent Office Munich.

Ministry of Entrepreneurship and Technology / Siemens [2018], *Smart Industry Polska 2018. Innowacyjność w sektorze mikro oraz małych i średnich przedsiębiorstw produkcyjnych w Polsce – Raport z badań*, https://publikacje.siemens-info.com/ebook/165/raport-smart-industry-polska-2018.

Ministry of Development / Siemens [2017], *Smart Industry Polska 2017. Adaptacja innowacji w działalności mikro oraz małych i średnich przedsiębiorstw produkcyjnych w Polsce. Raport z badań*, Warsaw, https://publikacje.siemens-info.com/webreader/00131–000758-raport-smart-industry-polska-2017/index.html.

PwC [2016a], *Global Industry 4.0 Survey: Building the digital enterprise*, https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf

PwC [2016b], *Przemysł 4.0, czyli wyzwania współczesnej produkcji*, https://www.pwc.pl/pl/pdf/przemysl-4–0-raport.pdf

Schwab K. [2016], *The Fourth Industrial Revolution*, World Economic Forum, Cologny/Geneva.

Siemens [2016], *Smart Industry Polska 2016. Ocena aktualnego stanu polskiego przemysłu. Zastosowanie i znajomość technologii oraz metod zarządzania produkcją. Raport z badań,* https://publikacje.siemens-info.com/pdf/123/Raport%20Smart%20Industry%20Polska%202016.pdf

Chapter 15

Challenges and Instruments of Innovation Policy in Poland in the Context of Industry 4.0

Arkadiusz Michał Kowalski, Marta Mackiewicz

Introduction

The purpose of this chapter is to identify the challenges and present the existing instruments of innovation policy in Poland in the context of Industry 4.0, and to formulate recommendations in this area. The Industry 4.0 development strategy refers to the way the value stream is organized and controlled in the product life cycle. The cycle is based on customers' individualized needs and it covers both the idea, order, development, production and delivery to the end customer, as well as recycling and related services. The basic issue is the availability of all significant information in real time – by combining human labor and IT systems, it is possible to create dynamic, self-organizing, cross-organizational networks that can be optimized according to a number of criteria, such as costs, availability and consumption of resources [Bitkom, 2016].

Apart from Germany, which initiated the implementation of the Industry 4.0 development strategy, similar projects have been launched by many EU member states, including France, Sweden, the Netherlands, Italy, Spain, the Czech Republic, the United Kingdom [European Commission, 2017]. In Poland, the instruments of innovation policy aimed at the development of Industry 4.0 are still little visible, although it is one of the strategic areas of the Strategy for Responsible Development (SRD). This chapter analyzes various challenges for innovation policy in the context of Industry 4.0, in particular technological, social, business and investment challenges, and identifies risks related to the Fourth Industrial Revolution. Further on, instruments are presented, aimed at developing Industry 4.0 in the Polish economy – both a program already completed, INNOTECH, and measures and initiatives currently in progress, including the Robotization Act, the establishment of the Industry of the Future Platform Foundation in 2019, the establishment of Industry 4.0 Competence Centers at research institutions, or the setting up of the Industry 4.0 Leaders Incubator. An analysis of challenges in the context of development of Industry 4.0 and innovation policy instruments supporting digital transformation provides a basis for conclusions and recommendations for future instruments in this area.

15.1 Challenges for Innovation Policy in the Context of Industry 4.0

Technological Challenges

Transition to Industry 4.0 brings with it the challenge of implementing digital and physical systems in production and integrating processes that have been separate so far (e.g. production with IT systems that will directly transmit information gathered in the market so as to balance demand with supply). The widespread use of simulations and analytics will allow the design process to change so that the first prototype already meets the customer's expectations [McKinsey, 2015]. This will lead to the deployment of smart production systems which, apart from their inherent autonomy, will be characterized by the ability of self-configuration, self-control, or even self-repair. However, in order to achieve that state, it is necessary to perfectly synchronize multiple systems and elements of the production process. An example is Amazon's machine learning algorithm which allows demand for different products to be forecasted 18 months in advance. What poses a challenge related to the Fourth Industrial Revolution is the development of technologies owing to which the industrial cycle will be characterized by greater [Hitpass, Astudillo, 2019]:

- Autonomy in the value chain links management,
- Integration involving all the external agents that interact in the value chain,
- Integration with all the payment services and business transactions,
- Transparency from traceability and monitoring in production and logistic systems.

What poses a challenge for business entities in the context of shaping a new, digital economic reality, is the problem of ensuring security. Many existing manufacturing plants and lines are insufficiently prepared to operate in a digital world. Therefore, as new technological solutions are implemented, which allow for data flow and integration between different systems, it will be necessary to ensure security of their use. Concern about data security has been identified by 57% surveyed managers of Polish firms as one of the key challenges that the implementation of Industry 4.0 solutions involves [Boston Consulting Group, 2016, p. 33]. Therefore, with the development of Industry 4.0, it will be necessary to continuously develop cybersecurity technologies. To sum up, for the Industry 4.0 concept to be implemented successfully, a complete shift is necessary in the paradigm of thinking about the challenges facing entrepreneurs. In addition to the development of new technologies and ensuring cybersecurity, comprehensive remodeling is necessary of the organizational culture of business entities, or even the functioning of entire economies.

Social Challenges

Digitalization changes the economy as well as society. Owing to the fact that Industry 4.0 refers not only to technology, but it also required the involvement of human resources for the effective management of the creation of value added, the literature often refers to social issues [Dutton, 2014, Lorentz et. al., 2015, Schwab, 2016, Buhr, 2017, Wildeband, 2017, et al.). A wider analysis of the development of human resources in the context of challenges of Industry 4.0 and the digital economy in Poland is also provided in Chapter 11 by A.M. Dzienis.

As noted by Buhr [2017], Industry 4.0 should be viewed as interdependencies between technical and social innovations. While Industry 4.0 involves mainly technological solutions leading to changes and optimization of the value chain, it is people who play a leading role in the innovation process, being both co-creators and producers, and users and innovators.

Social challenges that emerge in connection with the new *modus operandi* include:

- changes in interaction between employees and the technologies used,
- changes in organizational structures,
- low public awareness of Industry 4.0,
- increased social inequalities.

The deployment of solutions related to Industry 4.0 requires a change in interaction between employees and the technologies used. It is assumed that smart systems with a multimodal, easy-to-use user interface may assist employees in their work and bring digital learning technologies directly to the workplace. New infrastructure and multimodal support systems require appropriate professional development. Changes will require not only professional development, but also the acquisition of new features, to be able to adjust to quick changes, related to the increasing role of artificial intelligence or life in smart cities, so as to fully utilize their potential.

The changes will have a significant impact on the nature of work and organizational structures. In order to adjust to different production systems, labor organization systems must be appropriately flexible, which may require, e.g. the organizational structure to be flattened, IT departments to be incorporated into other organizational units (or at least more integrated with other departments), and employees to adjust to different working hours or be constantly available with the use of mobile devices.

A flat organizational structure supports innovation – knowledge and new ideas can flow freely because expertise is integrated with a horizontal decision-making or information process [Wilkesmann, Wilkesmann, 2018].

Changes in organizational structures and changes in interactions between employees and technologies require acceptance by employees (both with regard to management and to new technological solutions deployed in production). For this reason, low awareness of Industry 4.0 issues, except key stakeholders, is a serious challenge. Research shows that large enterprises tend to have a positive attitude, but smaller firms voice many concerns [Smit et al., 2016]. They may relate to the market environment (keener competition, more dynamic value chains, more demanding customers) and internal processes (including the availability of suitable personnel).

One of major challenges related to the implementation of Industry 4.0 will also be to control information deluge (big data) and to deliver information required for a specific manufacturing process [Windelband, 2017].

Dissatisfaction may also result from the omnipresence of digital technologies and growing dynamics of information exchange, which are characteristic of social media. It is estimated that more than social media platforms are currently used by 30 percent of population for communication, learning and information sharing. Such interactions could become an opportunity for cross-cultural understanding, but they may also spread unrealistic expectations about what is seen as success for an individual or a group, and create opportunities for the dissemination of extreme ideologies [Schwab, 2017].

Another challenge will be to ensure duly qualified human resources. Substantial deficiencies of skills are already identified, which means difficulties, e.g. in adjusting to the European single digital market. The competences and skills required to adjust to the needs of Industry 4.0 are even higher. The reason is that new work methods are required, which have both a positive and negative impact on employees. Deficits of resources and competences which allow the needs of Industry 4.0 to be addressed are currently filled in part through immigration policy [Smit et al., 2016]. Due to uneven territorial distribution of competence and knowledge, there is a growing competition between the centers where they are concentrated.

Positive changes include greater flexibility of forms of employment and working time, which may help to ensure work-life balance. Combining easy-to-use technical assistance systems with new social practices, as well as better adjustment of various services, may facilitate social integration, fostering social inclusion and ensuring better compatibility of work with family and childcare, or address disability-related needs [Buhr, 2017].

Challenges for Business

The industrial sector in Poland employs more than 3 million people (according to GUS 2019, employment in that sector was 3,188,600 as at 31.12.2017), which means the country ranks third in Europe, after Germany and Italy. For this reason, and owing to the progressive reindustrialization of developed countries and marginalization of the significance of low labor costs, enabling entrepreneurs to adjust to the realities of the Fourth Industrial Revolution becomes a significant priority of innovation policy. The opposite strategy, which consists in building competitive advantage on low labor costs, may involve the marginalization spiral risk [Boston Consulting Group, 2016, p. 20]. This means the transfer of industrial production with the highest value added to countries in which digitalization will be effectively implemented, leaving the simplest elements of value chains in other locations. Years of delays in phasing in the third industrial revolution have become a challenge to the Polish innovation policy, as many enterprises are still at the stage of implementing the automation of production instead of building ecosystems of online-connected collaborative devices. At the same time, business opportunities related to the Fourth Industrial Revolution arise from the dynamic development of the information and communication technology (ICT) industry witnessed in Poland in recent years [Kowalski, 2016]. The development is strictly concentrated in the largest metropolitan centers, where ICT clusters have emerged [Kowalski, Marcinkowski, 2014].

Through the accumulation of a huge amount of data and its quick analysis, Industry 4.0 will facilitate a fundamental change in business processes. Instead of a mass product, customers will be offered an individual approach and tailored products, cheaper and quicker than ever before. The increase in productivity and value added may translate into reindustrialization of Western countries, which have, until now, been unattractive for manufacturing, due, e.g., to high labor costs. Thus, Industry 4.0 may lead to a lasting change in supply chains and value chains, with the transformation proceeding faster than in the case of horizontal value chains (i.e., in collaboration with counterparties, customers and other partners) than in the case of vertical chains, i.e., those involving internal processes of the enterprise [PwC 2017, p. 15). The “Internet of Services” enables internal and cross-organizational services to offered by different participants of the value chain [Stadnicka, Zielecki, Sęp, 2017].

Persistently low awareness of managerial staff regarding the significance of Industry 4.0 is a major challenge not only for business, but also for the state. Without relevant skills and knowledge, managers will be unable to take decisions to invest in digital transformation. What is more, the lack of competence of managerial staff may also result in incorrect implementation of certain solutions and wasting the potential of cooperation with other business partners.

It is pointed out that in the Fourth Industrial Revolution era the choice of partners with whom entrepreneurs wish to cooperate will be determined by the similarity and capability to mutually complement production [Götz, Gracel, 2017, p. 220]. The related challenge is how to ensure readiness of various stakeholders to cooperate. Such cooperation is usually possible in countries characterized by a high level of trust in other citizens and institutions. Owing to a low level of social trust in Poland, a significant business challenge that should be addressed in innovation policy is stimulate cooperation between businesses and the industrial and research sector. Such cooperation could help to make a more efficient use of the solutions of Industry 4.0 through mutual exchange of experience and sharing financial burdens related to R&D.

Investment Challenges

Transformation of the economy towards Industry 4.0 poses major challenges of a technological nature to entrepreneurs, which inevitably necessitates heavy investment outlays. It is expected that approx. EUR 40 billion annually will have to be invested in Germany alone (probably up to approx. EUR 140 billion annually in Europe). The investments may be particularly discouraging for small and medium-sized enterprises, which fear transition to digital technology [Davies, 2015]. According to studies by The Boston Consulting Group [2016, p. 31] as many as half of Polish managers believe that investments related to Industry 4.0 are characterized by a high degree of uncertainty of return.

Contrary to the third industrial revolution which involved the introduction of computers to industry and automation of manufacturing processes, the outlays should be lower, and the return on capital invested higher. Increasing revenue and reducing costs will be possible mainly owing to the possibility of reducing stocks. For example, exact matching of supply and demand owing to the use of data and algorithms will make it possible to maintain lower inventory levels than before, which will translate into lower maintenance costs. The use of robots or drones, in particular in countries with high labor costs, will have a similar effect. Thus, the Fourth Industrial Revolution leads to a more efficient use of resources and may contribute to reducing costs in future [Berger, 2016, p. 6].

Digital transformation of an enterprise requires the enterprise to integrate various processes and devices, and to develop automation originating in the previous industrial revolution. Systems are also introduced, based on the use of the cloud computing technology or 3D printing. Production planning and supervision processes are increasingly often performed by computers using data from integrated control systems. This is possible owing to the introduction of new, advanced algorithms, and the development of the industrial Internet of Things. Although expenditure on innovative equipment and technologies can be returned in future, e.g. through the reduction of operating expenses, one of major problems faced by entrepreneurs is access to capital which has to be invested at the start. In particular, small and medium-sized enterprises experience major problems with investment financing. For this reason, what poses a special challenge for innovation policy in the Fourth Industrial Revolution era is to ensure additional financing options that will enable also smaller enterprises to implement Industry 4.0.

Table 15.1 Challenges and positive changes related to the development of Industry 4.0

Challenges	Positive changes
Technological	
▪ Deployment of digital systems in production ▪ Widespread use of simulations and analytics with the use of big data ▪ Introduction of smart production systems ▪ Perfect synchronization of multiple systems and elements of the production process ▪ Development of uniform standards to enable integration of different types of systems and entities ▪ Ensuring cybersecurity	▪ Integration of technological processes that used to be separate ▪ Direct transmission of information gathered from the market, which will enable demand to be balanced with supply ▪ Self-configuration, self-control and self-repair capability of production systems
Social	
▪ Enhancing awareness and acceptance of the deployment of Industry 4.0 solutions ▪ Filling the competence gap ▪ Changes of management and organization structures ▪ Information deluge control ▪ Increased social inequalities	▪ Higher social integration owing to easier participation of excluded (e.g. mobility-impaired) persons ▪ Higher flexibility of forms of employment and working time ▪ Opportunity to cooperate within social networks ▪ New products, services and solutions that facilitate everyday life ▪ Personalization of products and services
Business	
▪ Increase in productivity and value added ▪ Lasting changes in supply chains and value chains ▪ Ensuring financial support for small and medium-sized firms ▪ Change of the employment structure, including the liquidation of many existing jobs and emergence of demand for many new employees with different skillsets ▪ Low awareness of managerial staff regarding the significance of Industry 4.0 ▪ Stimulating cooperation between businesses and the industrial and research sector	▪ Individual approach to customer needs ▪ Better utilization of resources ▪ Higher level of cooperation, exchange of experience and sharing financial burdens related to R&D ▪ Creating new jobs

cont. tab 15.1

Challenges	Positive changes
Investment	
▪ Providing enterprises with access to capital that has to be invested at the beginning in technological solutions related to Industry 4.0 ▪ Difficulties in financing investments necessary to implement Industry 4.0, in particular among small and medium-sized enterprises ▪ Investment risk related to Industry 4.0 solutions	▪ Increased revenue and reduced costs, e.g. owing to the possibility to reduce inventory by precisely matching supply and demand as a result of using big data and algorithms ▪ More efficient utilization of resources

Source: Own study

15.2 Risks Related to Industry 4.0

New opportunities opening up for some entities may pose a risk for others. Actors playing a key role in traditional industries may find themselves in the role of ordinary suppliers who can be replaced easily unless they are able to deliver “smart services” to consumers, tailored to their needs.

There are multiple concerns about Industry 4.0, as in the past major technological changes resulted in reductions in employment in a short term. Even if forecasts provide for a growth in employment in connection with the transformation of economies towards Industry 4.0 (approx. 6% in 2015–2025), this will certainly involve a change in the structure of employment, and less skilled workers may end up in a worse position in the labor market [Boston Consulting Group, 2015]. In the macroeconomic context, this may lead to growing structural unemployment. This poses a challenge for state policy, as it should cooperate with entrepreneurs in adjusting the curricula of schools and universities to future higher requirements. In the case of large structural mismatches between the skills offered by workforce and the skills sought by employers, business opportunities related to full utilization of the potential of Industry 4.0 will be limited.

Changes in the labor market will cause greater polarization between high-skilled and low-skilled workers, as the work performed by the latter may be partly replaced by automation of production processes. This gives rise to the risk of aggravating social inequalities. Demand for highly-skilled employees is growing, while demand for employees with lower education and lower skills is decreasing. The greatest beneficiaries of innovation are usually providers of intellectual and physical capital – innovators, shareholders and inventors [Schwab, 2016].

New jobs will require skills such as database processing, data preparation for analysis, conducting advanced analyses, and the application of the results of those analyses in production processes. Thus, such specialists must both understand the production process itself and use IT systems, be familiar with programming languages and statistical tools that allow big data to be analyzed. Skilled workers must cope with rising requirements in terms of interpretation of system data. It takes analytical skills and network thinking to cope with abstract information and get a quick overview of the production process.

By 2020, the European market is expected to face a shortage of up to 825,000 ICT specialists; this deficit may be even more evident in advanced manufacturing plants, in which big data analysts and cybersecurity experts are needed. While various initiatives are taken in order to encourage the acquisition of e-skills, young people are not necessarily interested in the digitization of jobs [Davies, 2015]. The question also arises whether people dealing with increasingly automated systems will still be able to acquire necessary knowledge to identify failures in critical situations and develop solutions [Windelband, 2017].

As studies show, what may be a remedy for staffing deficiencies is that the accumulation of technologies and skills in enterprises is conducive to personnel retention and preservation of jobs. Accumulation of specific human capital in more technologically-intensive firms is also conducive to innovation. [Silva, Lima, 2017].

Another significant risk is that of being excluded from global competition unless adjustments are made sufficiently quickly in enterprises. Acceleration of technological changes, automation and inclusion of enterprises in production networks should be enabled by an appropriately designed innovation policy.

15.3 Innovation Policy in Poland in the Area of Industry 4.0

One of the first instruments designed to support the digital transformation of the Polish industry is the INNOTECH program launched in 2011 by the National Center for Research and Development. The program supports the development of technological innovations in the economy, as a collaborative exercise between the industrial sector and the public R&D sector. Among its primary objectives, the INNOTECH program aims to:

- increase the number of technological innovations developed and implemented;
- increase corporate expenditure on research and development serving the economy,
- strengthen the cooperation between business and universities and public sector research units.

Calls for proposals under the program were open from 2011 to 2013, projects were co-financed between 2011 and 2018, and the monitoring of the implementation of project outcomes will continue until 2013. Small and medium-sized enterprises were eligible for participation in the program. They could choose one of two program paths:

1) In Tech, involving the implementation of innovative projects in various fields of science and industries,
2) Hi-Tech, which concerned the area of advanced technologies.

Funds from the program budget were allocated in the first place to entrepreneurs with capacity to apply in the economy research results obtained from research units. This way, the INNOTECH program contributed to encouraging entrepreneurs to invest in R&D and to strengthening cooperation between science and business.

Currently, there are several active instruments and initiatives supporting the implementation of Industry 4.0 in Poland. At the strategic level, this area is addressed in the Strategy for Responsible Development, which provides that "the development of the ICT industry and large-scale implementation of sensors and control systems based on information received from them, will contribute to the emergence of new management models, e.g., for traffic, transport, energy consumption, and it will contribute to the emergence of new manufacturing models in other industries. The anticipated outcomes include an increased innovation growth rate, reduction of marginal production costs, and the establishment of platforms that bring together various forms of activity in many sectors, and ultimately an increased scale of profits" [Ministry of Development, 2017].

Being aware of the problem posed by the need to incur significant costs on related investments, in 2017, the Ministry of Development and the Ministry of Finance proposed the adoption of the Act amending the Personal Income Tax Act of 26 July 1991 and the Corporate Income Tax Act of 15 February 1991, referred to as "Robotization Act" (Act of 7 July 2017) by making amendments providing for a depreciation allowance of up to PLN 100,000 annually. The allowance is available once a year to entrepreneurs purchase new equipment specifically listed in the Act (e.g., 3D printers, robots or industrial computers) for at least PLN 10,000. Given the relatively low amount of the allowance, the solution is supposedly intended to encourage mainly small and medium-sized enterprises to invest in new digital technologies.

One of the new initiatives towards the implementation of Industry 4.0 solutions is the Act of 17 January 2019 on the Industry of the Future Platform Foundation. According to the provisions of the Act, the objective of the Industry of the Future Platform Foundation is "seeking to improve the competitiveness of enterprises by supporting their digital transformation in processes, products and business models using the latest achievements in the field of automation, artificial intelligence, information and communication technologies, and machine-to-machine and man-to-machine communication, taking into account the appropriate level of security of those solutions". This objective is implemented through measures including:

- awareness building among entrepreneurs and promoting benefits arising from the digitalization of industry;
- improving the technological level of enterprises, including processing and logistic processes, and digital integration of these processes;
- supporting the use of smart management, manufacturing and distribution systems by enterprises, based on data acquisition, collection, transmission and analysis;
- providing industry digitalization information and training to entrepreneurs;
- presenting proposals to entrepreneurs for solutions related to digital transformation of industry;
- promoting integrated technological solutions among entrepreneurs to ensure interoperability, creating trusted data exchange systems, data sharing, and cybersecurity rules;
- working out mechanisms for collaboration, knowledge sharing and building trust in relations between entities involved in the digital transformation process;
- development of human and social capital, with a particular focus on the digitalization of industry;
- international cooperation for experience sharing, knowledge transfer, and development of a consistent approach to the processes of digital transformation of industry.

Another measure towards the implementation of the Fourth Industrial Revolution is the establishment of Industry 4.0 Competence Centers (CKP4.0) attached to research hubs, intended to form a national base of knowledge and skills as well as engineering and technological resources supporting the transition of industry to the Industry 4.0 level. CKP4.0 centers are designed to contribute mainly to knowledge transfer between entrepreneurs and the academy, the creation of catalogs of off-the-shelf solutions for the implementation and application of Industry 4.0 technologies, and to support the building of new business models based on Industry 4.0. Another measure is the establishment of the Industry 4.0 Leaders Incubator supporting the transformation of the domestic manufacturing industry. One of the main objectives is to train personnel proficient in the subject of Industry 4.0. Such staff will be able to provide advice on the application of new technologies in an enterprise, and to create a business model for the deployment of innovative technologies in enterprises. A person having undergone training in the Incubator should also act as an intermediary between entrepreneurs and the Industry 4.0 Competence Centers. Ultimately, persons trained in the Incubator will work for the Polish Platform of the Future or CKP4.0.

Conclusions and Recommendations

Industry 4.0 has emerged as an element of the German government's strategy which was a response to concerns about a loss of the competitive position of the German economy. The concerns arose from the fact that other countries had advanced faster in the computerization of manufacturing processes. The strategy of supporting Industry 4.0 should be treated on a par with other instruments that drive an upward shift in the value-added chain (as this is the principal objective of the Industry 4.0 development strategy). The selection of tools or technologies that will allow this to be achieved under the conditions of the Polish economy need not be identical with those in Germany, while key technologies spurring the development of Industry 4.0 are most likely to be similar, irrespective of economic conditions. What certainly needs consideration is what methods and what instruments can be deployed to move upwards in the value chain from the position of supplier of raw materials or simple components to an area situated closest to the final consumer.

As regards the Fourth Industrial Revolution, the involvement of the state seems to be a key factor enabling a full development of Industry 4.0 (the very fact that "Industry 4.0" tends to be called the best export product of Germany, and not a specific enterprise, shows the key role of the state in this case). It is increasingly often made clear that the government should eliminate the market failures faced in the 21st century, which halt the development of the full economic potential [Micklethwait, Wooldridge 2015]. What is more, the factor coming to the fore is the effectiveness and management capability of the government, so that reindustrialization and diversion of the economy towards Industry 4.0 proceed as efficiently as possible [Götz, Gracel, 2017, p. 223]. The establishment of a regulatory environment, financial instruments and other institutions encouraging investment in innovative solutions seems necessary to ensure that the entire economy, and its individual enterprises, can successfully embark on the Fourth Industrial Revolution. Therefore, it is so important to create an appropriate innovation policy supporting the development of Industry 4.0.

Irrespective of the choice of an optimum strategy, measures that can be taken will certainly involve ensuring the highest quality of education and building competence and skills of people who will be able to handle the challenges of the contemporary economy. Another direction is to provide access to financing for firms that want to modify their operating strategies and implement solutions allowing them to face up to international competition. The recommended innovation policy measures responding to identified risks are presented in Table 15.2.

Table 15.2 Risks involved in the development of Industry 4.0 and corresponding measures

Risks	Recommended innovation policy measures
Insufficient ICT skills	Financing education in fields in demand in connection with Industry 4.0 development
Polarization between high-skilled and low-skilled workers	Enhancing awareness of Industry 4.0 and the opportunities it brings
Technological and changes and automation too slow	Supporting research on digital manufacturing
No access to capital that has to be invested at the beginning in technological solutions related to Industry 4.0	Provision of funding and facilitating access to financing for SMEs to ensure their participation in the development of digital production and the Internet
Exclusion from global competition	Integration of SMEs with emerging value chains and production networks Supporting regional clusters, partnerships and chambers of industry.

Source: Own study

The ability to attract suitably qualified personnel is a key development component of Industry 4.0. The following ways of improving the availability of relevant competences are mentioned:

– increasing the participation of the part of the workforce which is not engaged currently,
– increasing of training and education,
– through immigration [Smit et al., 2016].

While the implementation of solutions related to Industry 4.0 requires efforts on the part of enterprises (including appropriate training of staff, change of the organizational model, and change of the personnel recruitment strategy), many activities can be undertaken within the framework of the government's new innovation policy. They can include the stimulation of peer-to-peer learning – inclusion of enterprises (also those with a low innovation level), scientists, social innovators in the process. Learning should also have an international dimension, e.g. international exchange of good practices, joint initiatives, etc.

Another issue is awareness-building among potential stakeholders. Forums and platforms may have a major role here, including chambers of commerce as well as organizations and associations of entrepreneurs. There is also room for cooperation between governmental institutions and industry, in particular in the form of joint work on designing educational programs with a view to improving competence and knowledge of the challenges of Industry 4.0. Entrepreneurs should actively participate in the process, starting with the identification of needs, through joint creation of educational programs (for different fields of study), to active participation in education, e.g., by providing practical knowledge to students and opportunities for internships in business. It is worth noting the need for coordination between key business stakeholders and universities. The coordinating role should consist not only in creating a platform for discussion on the directions of education as well as necessary skills and their continuous improvement, but also in setting out a long-term workforce development strategy for the purpose of Industry 4.0. Coordination activities might also include the preparation of descriptions of skills for different occupations, taking into account current needs and gaps in skills or competences. Another step is the launching of governmental programs addressing identified needs and filling gaps through education or professional improvement programs targeting small and medium-sized enterprises.

Innovation policy should support interdisciplinary projects by co-financing them, support direct orders and the development of secure infrastructure. It should also focus on making funds available to SMEs, to ensure their participation in the development of digital production and the Internet, and integration with the emerging value chains and production networks [Smit et al, 2016].

Policy aimed at supporting the implementation of the solutions of Industry 4.0 must be aligned with the conditions prevailing in the economy concerned – copying of solutions deployed in other countries will not work. For this reason, it is necessary to first diagnose the needs in areas related to digital production.

Bibliography

Berger, R. [2016], *The Industrie 4.0. transition quantified. How the fourth industrial revolution is reshuffling the economic, social and industrial model*, Munich: Roland Berger.

Boston Consulting Group [2015], *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries.*

Buhr, D. [2015], *Industry 4.0 – New Tasks for Innovation Policy*, Friedrich Ebert Stiftung.

Buhr, D. [2017], *Social Innovation Policy for Industry 4.0,* Division for Social and Economic Policies, Friedrich-Ebert-Stiftung.

Davies, R. [2015], *Industry 4.0. Digitalisation for productivity and growth.* European Parliamentary Research Service, Briefing.

Götz, M., Gracel, J. [2017], *Przemysł czwartej generacji (industry 4.0) – wyzwania dla badań w kontekście międzynarodowym*, "Kwartalnik Naukowy Uczelni Vistula", 1(51), pp. 217–235.

Hitpass, B., Astudillo, H. [2019], *Industry 4.0 Challenges for Business Process Management and Electronic-Commerce*, "Journal of Theoretical and Applied Electronic Commerce Research", 14(1), I–III.

Implementation Strategy Industrie 4.0, Report on the results of the Industrie 4.0 Platform, [2016], Bitkom e.V., VDMA e.V., ZVEI e.V.

European Commission, [2017]. *Key lessons from national industry 4.0 policy initiatives in Europe*, "Digital transformation Monitor", 2017.

Kowalski, A.M., Marcinkowski, A. [2014], *Clusters versus cluster initiatives, with focus on ICT sector in Poland*, "European Planning Studies", Vol. 22, No. 1, pp. 20–45.

Kowalski, A.M. [2016], *Poland, an emerging European ICT hub?*, "Baltic Rim Economies", Iss. 4.

Lorenz, M., Ruessmann, M., Strack, R., Lueth, K. L, Bolle, M., Boston Consulting Group [2015], *Man and Machine in Industry 4.0. How will technology transform the industrial workforce through 2025?*

McKinsey Digital [2015], *Industry 4.0. How to navigate digitization of the manufacturing sector*, McKinsey & Company.

Micklethwait, J., Wooldridge, A. [2015], *The Global Race to Reinvent the State*, Penguin Press, London.

Ministry of Development [2017], *Strategia na rzecz odpowiedzialnego Rozwoju do roku 2020 (z perspektywą do 2030)*, Warsaw 2017.

PWC (2017), *Przemysł 4.0 czyli wyzwania współczesnej produkcji,* www.pwc.pl/pl/pdf/przemysl-4–0-raport.pdf [accessed 12.01.2019].

Schwab, K. [2016], *The Fourth Industrial Revolution*, World Economic Forum, Cologny/Geneva.

Silva, H.C., Lima, F. [2017], *Technology, employment and skills: A look into job duration.* "Research Policy", Vol. 46, Issue 8, pp. 1519–1530.

Smit, J. Kreutzer, S. Moeller, C., Carlberg M. [2016], *Industry 4.0*, European Parliament's Committee on Industry, Research and Energy (ITRE) European Union, http://www.europarl.europa.eu/studies

Stadnicka, D., Zielecki, W., Sęp, J. [2017], *Koncepcja Przemysł 4.0 – ocena możliwości wdrożenia na przykładzie wybranego przedsiębiorstwa*, in: Knosala R. (ed.), *Innowacje w zarządzaniu i inżynierii produkcji*, Opole: Polskie Towarzystwo Zarządzania Produkcją, pp. 472–483.

Ustawa z dnia 17 stycznia 2019 r. o Fundacji Platforma Przemysłu Przyszłości, Dz.U.2019, item 229.

Ustawa z dnia 7 lipca 2017 r. zmianie ustawy o podatku dochodowym od osób fizycznych oraz ustawy o podatku dochodowym od osób prawnych, Dz. U. 2017, item 448.

Wilkesmann, M., Wilkesmann, U., [2018], *Industry 4.0 – organizing routines or innovations?*, "VINE Journal of Information and Knowledge Management Systems", Vol. 48, Issue: 2, pp. 238–254.

Windelband, L. [2017], *Work Requirements and Qualifications in Maintenance 4.0*, Springer-Verlag GmbH Germany.

Chapter 16

Digitalization of the Polish Economy and the Use of IT Innovations and Big Data by Polish Enterprises

Andżelika Kuźnar

Introduction

In the *International Encyclopedia of Communication Theory and Philosophy* [2016] J. Scott Brennen and Daniel Kreiss define two terms related to the digital economy. The first term, *digitization*, means the process of converting analog streams of information into digital bits. The latter term, *digitalization*, is used to describe the way in which the use of information and communication technologies (ICT) is adopted or increased by many countries, organizations and firms. In this approach, the conceptual scopes of the terms represent sets that have no element in common. This study examines the degree of adoption of digital technologies in the Polish economy, and therefore the latter term, digitalization, is relevant here.

The term Industrial Revolution 4.0 is also used in the study. It means the next stage of the world's economic development, which is related to disruptive changes, i.e., those in consequence of which one order eliminates another. The first such change, referred to as industrial revolution, took place at the end of the 18th century, and it was associated with the invention of the steam machine and the progressive mechanization of production. The characteristics of the second revolution, witnessed at the end of the 19th century, were mass production and the introduction of electricity. The third industrial revolution (or IT revolution) began in the mid-20th century and is associated with innovations in microelectronics, computerization and automation. The present, fourth industrial revolution, is driven primarily by the increase in the amount of available data and their analysis (big data), the use of mobile communications for data transmission from devices (Internet of Things, IoT), and automation of production processes (robotization).

The aim of the article is to determine the degree of digitalization of the Polish economy and the participation of enterprises that operate in Poland in Industrial Revolution 4.0.

16.1 Position of Poland in Rankings of Innovation and Technological Advancement

The *Europe 2020* [Europe 2020, 2010] strategy of social and economic development adopted in 2010 aims to enable the building of the EU's sustainable development foundations. Three priorities are to be the cornerstone of the development, relating to:
– smart growth, through the development of the economy based on knowledge and innovation;
– sustainable growth, based on a greener, more resource-efficient and more competitive economy;
– inclusive growth, ensuring a high level of employment, and social and territorial cohesion.

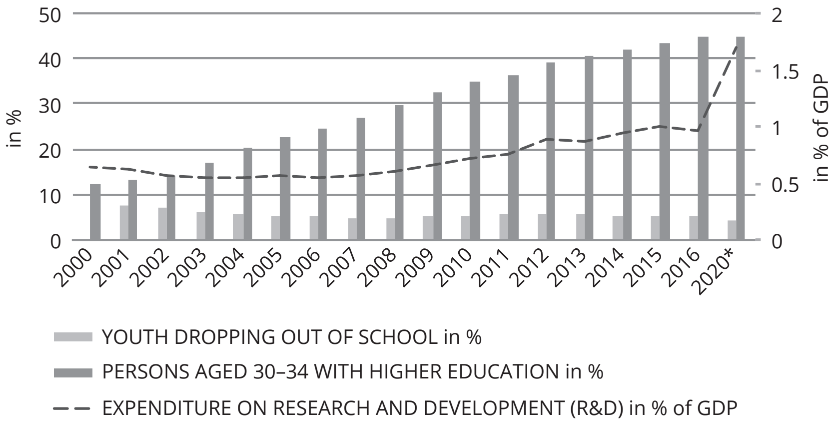
The fulfilment of these priorities is to be ensured by achieving up to 2020 five strategic targets, to which numerical values are assigned:
– achieving the employment rate of the population aged 20–64 of at least 75%;
– investing 3% of gross domestic product (GDP) in research and development (R&D);
– achieving the "20/20/20" climate and energy targets;
– reducing the school drop-out rate to less than 10% and increasing the proportion of tertiary degrees among 30–34 year olds to 40%;
– reducing the number of people threatened by poverty or social exclusion by 20 million.

The targets are interrelated and jointly contribute to the fulfilment of the priorities of the Strategy. The achievement of these priorities at the EU member state level is supported by seven flagship initiatives, i.e.: the Innovation Union, Youth on the Move, Digital Agenda for Europe, Resource-Efficient Europe, Industrial Policy for the Globalization Era, Agenda for New Skills and Jobs, and the European Platform against Poverty.

In Poland, actions are taken to implement the Strategy, set out in the National Reform Program Europe 2020 [Krajowy Program…, 2011]. The targets adopted by Poland differ from the average values adopted by the EU. For example, in the case of R&D expenditure, the target is 1.7% of GDP (i.e. below the EU average); as regards education-related targets, Poland intends to reduce school drop-out rate to 4.5% and to increase to 45% the percentage of population aged 30–34 with higher education (i.e. above the targets for the whole EU).

From the point of view of the study on the digitalization of the Polish economy, it is particularly important that the priorities of the Strategy include increasing the role of knowledge and innovation as drivers of smart growth. The degree of implementation of this priority can be measured, among other things, by the share of R&D expenditure in GDP, school drop-out rate and percentage of people with higher education, as well as progress in implementing the Digital Agenda for Europe. Reforms in this area can increase the capacity to absorb new technologies and innovations, and therefore, ultimately, contribute to increasing the level of digitalization of the Polish economy.

Figure 16.1 The degree of achievement by Poland of selected targets of the Europe 2020 strategy



Note: Data for 2020 represent the targets adopted by Poland

Source: Own study based on data from: GUS [2017].

The data shown in Figure 16.1 indicate that Poland is steadily approaching the targets assumed, but, in the case of R&D expenditure, the achievement of the 1.7% share of R&D in 2020 seems unrealistic. In 2016, R&D expenditure still accounted for less than 1% of GDP in Poland.

The development of an economy based on knowledge and innovation, which is one of the priorities of Strategy 2020, requires a high level of technical advancement, which in turn determines the level of competitiveness of the economy. It can be influenced by pursuing an innovation policy. For example, China historically relied on low labor costs to achieve international competitiveness, producing low-tech goods, but today is also successful in high-tech industries, building on innovative solutions. The shift was driven, among other factors, by an increase in governmental spending on R&D.

China now ranks second in world in R&D expenditure. In 2015, it amounted to USD 409 bn, which represented 2.07% of its GDP [Science & Engineering, 2018]. The Chinese authorities recognize that a skilled workforce is key to achieving the current objectives of economic policy which provides for modernization of the country.

States differ in the factors that determine their international competitiveness. In the *Global Entrepreneurship Monitor* (GEM), based on the classification used by the World Economic Forum (WEF), countries have been divided into those with factor-, efficiency- and innovation-driven economies. In the first group, competitiveness relies mainly on low labor costs or natural resources. The second group creates more-efficient production methods and raises the quality of goods and services. New and specialized products and innovative solutions are essential in the third group. Research and development play a major role.

According to this classification, Poland is ranked as an efficiency-driven economy in transition to the innovation-driven category [WEF, 2018a, pp. 319–320]. For this transition to be possible, with high wages and standards of living being maintained, enterprises must compete on the basis of new, innovative solutions. This can be fostered by a change in the role of the state in supporting entrepreneurship and economic growth[1]. While in an efficiency-oriented economy the state is supposed to create conditions for education towards adaptation of technology, in an innovation-oriented economy the role of the state is to assist in creating and commercializing knowledge [PARP, 2017, p. 19]. In particular, the state may reduce the risk of investing in the commercialization of research (by involving public funds), which is a major barrier to private investment. The weakness of Poland's performance in this regard is evidenced by the fact that business enterprise expenditure on R&D (BERD) as a percentage of GDP, usually closely related to commercialization and practical use of inventions, stood at a mere 0.67% in 2017[2] [Eurostat, 2019]. At the same time, there is a clear progress in this area, because as recently as 2010 the value of this ratio amounted to 0.19%[3].

More complicated measures used to determine and compare the innovation performance of countries are used in the *European Innovation Scoreboard* (EIS), the *Global Innovation Index* (GII), and the *Science, Technology and Industry Scoreboard*. Assessment of the innovation level in a country is also a component of the competitiveness index ranking published by WEF. i.e., *The Global Competitiveness Report*. Presented below is an assessment of Poland in terms of innovation performance in the context of its position in the above-mentioned international rankings.

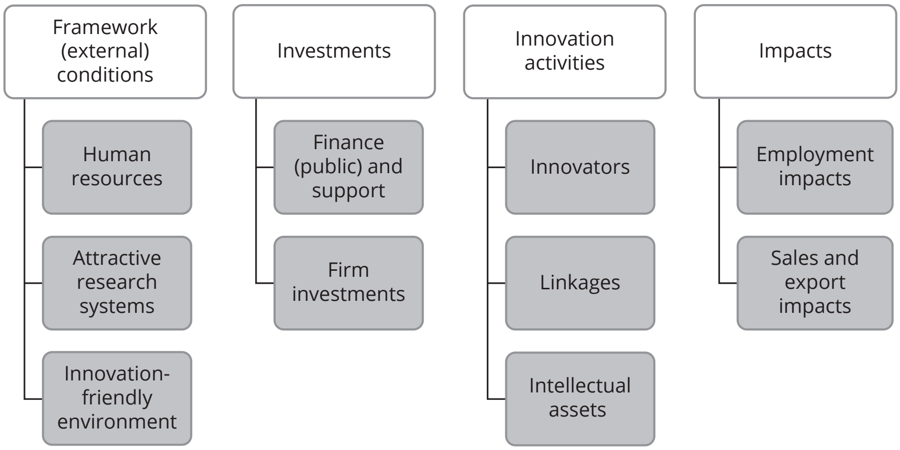
1 This role of the state is also indicated by the creators of the so-called new structural economy; see: Yifu Lin, Nowak [2017].

2 By comparison, in Hungary: 0.99%, in the Czech Republic: 1.13%.

3 For more on the diagnosis of the situation in Poland, see: Orłowski [2013].

The *European Innovation Scoreboard* provides a summary of core indicators of innovation performance for the European Union members states and is used to assess progress in implementing the *Europe 2020* strategy. The research methodology has been revised many times since the first edition of the EIS in 2001. The most recent major modifications were made in 2017. According to them, the summary innovation index comprises 27 partial indicators in four groups and ten dimensions (cf. Figure 16.2).

Figure 16.2 Components of the summary innovation index according to EIS 2017



Source: Own study based on EIS 2017, p. 8

Poland is characterized by relatively low innovation indicators, although their growth rate is favorable in certain groups (e.g. with regard to innovation-friendly environment). In the 2018 report, as in the previous years, Poland was ranked among moderate innovators. Poland ranked fourth from the bottom, ahead only of Romania, Bulgaria and Croatia, with a score of 53.6% of the EU average. Poland showed the best performance, above the EU average, in employment impacts (especially in fast-growing enterprises), innovation-friendly environment and firms' investments in innovation. In contrast, the greatest weaknesses existed in the Attractive research systems and Innovators dimensions. In the latter case, Poland's performance represents 3.4% of the EU average. It is attributable to low (and deteriorating in recent years) achievements of small and medium-sized enterprises (SMEs) in terms of product and process innovations, marketing and organizational innovations, and in-house innovations.

The *Global Innovation Index* ranking consists of two sub-indices: Innovation Input and Innovation Output. The first one is based on five areas: institutions, human capital and research, infrastructure, market sophistication, and business sophistication, whereas the other one consists of knowledge and technology achievements and creative outputs

[Baranowski, 2017]. The areas are subdivided into 80 indicators [GII, 2018]. In the 2018 report, Poland was ranked 39th overall among 126 countries. Poland performed the worst in innovation linkages, mainly in university/industry research collaboration (86th) and strategic alliances and joint ventures (89th). Poland scored much better, while still low, in the ICT area. Poland ranked 36th in terms of access to ICT, 58th in ICT use, 45th in e-government, and 14th in e-participation.

The *OECD Science, Technology and Industry Scoreboard 2017* was dedicated to the digital transformation of economies, owing to which the data collected can be used directly to determine Poland's position measured by selected digitalization indicators. However, the OECD publication does not contain any composite indicator, nor does it rank countries. Its objective is to provide policy makers and analysts with the means to compare economies with others of a similar size or with a similar structure and to monitor progress towards desired goals.

For example, machine-to-machine (M2M) communication[4], which is key to enabling the Internet of Things, has been developing relatively fast in our country, as the number of subscriptions per 100 inhabitants increased from 4 in 2012 to 10 in 2017, but this score is still much below the OECD average (15), and below China's (16.6) [STI, 2017].

In 2005–2015, Poland recorded the highest growth among 37 analyzed countries in the share of researchers working in business (i.e., universities, government administration, NGOs), but with a score of 35% in 2015 Poland came in at a distant 29 place. Israel, South Korea, the US and Japan are in the lead, with shares of such researchers exceeding 70%. In China, the score was 63%. The low R&D expenditure in Poland, mentioned previously, is also reflected in relatively low employment in the R&D sector. In 2015, there were 5 researchers per 1000 employees (32nd among 42 countries ranked). The EU-28 average was 8 persons.

Poland performs well in comparison to OECD countries in terms of the number of new doctorate graduates of natural sciences, engineering and IT. In 2015, they represented 22.3 of all graduates, with the OECD average of 23.4%. 17 countries scored worse than Poland, including Japan, the US, and the Netherlands. At the same time, 44% of graduates of these courses were women, which earned Poland the first place (ahead of India – 42% and Estonia – 41%, with the OECD average of 31%). A high level of education in these areas is particularly desirable in the processes of transition to digital economies.

Another indicator related to the Fourth Industrial Revolution concerns the use of robots in the economy. In Poland, there was 1 robot per 1000 workers in industry,

[4] The M2M SIM card enabled online data transmission between at least two devices. Such a card can be installed, e.g., in a car for remote diagnostics, can be used for inventory management, in medicine, etc.

compared with the OECD average of 6.2. From the point of view of the labor market, the low level of robotization in Poland may mean, on the one hand, a lower risk of job loss in occupations involving repeatable tasks, whereas, on the other hand, the deployment of robots to perform work is a source of production efficiency, improvement of product quality and output growth in the face of the declining population of working age. Therefore it is unreasonable to expect that firms operating in Poland will not be willing to take advantage in future of the capabilities offered by robotization. Workers willing to find a job in the changing labor market will have to adjust their competences, especially in ITC, necessary for working with robots. What may provide an incentive to such a change is the fact that work that requires high ITC competences usually involves non-routine tasks, and therefore less prone to replacement by robots. Compared with other OECD member states, the ICT intensity index in Poland remains at a low level.

Against those indicators, Poland performs a little better in terms of the number of Internet users. This is important in that digital economy requires, among other things, communication between users and devices. In Poland, 73% of persons aged 16–74 were Internet users in 2016 (compared with only 40% in 2006). Virtually all (98%) persons aged 16–24 used the Internet. However, Poland had the lowest share of businesses using cloud computing among OECD countries (8.2%) [STI, 2017, p. 174].

Achievements of individual countries, including Poland, in terms of innovation level, are also examined by the World Economic Forum (WEF). The latest report, published in 2018, introduces a new research methodology which takes into account various aspects of digital economy in the definition of competitiveness. The new *Global Competitiveness Index* emphasizes the role of human capital, innovation ecosystems, resilience (resistance to crises and external shocks), and agility in influencing the country's economic success, as drivers and defining features of economic success in the digital revolution [WEF, 2018b]. Competitiveness of the economy is assessed on the basis of 12 pillars with equal weights assigned to them, grouped into four categories (Enabling Environment, Markets, Human Capital and Innovation Ecosystem). The objective is to obtain 100 points, both in each pillar and overall. In 2018, Poland scored 68.2 points, which earned us the 37th place among the 140 countries surveyed (the US scored the highest – 85.6 and Chad the lowest – 35.5). Poland, like 30 other countries, earned 100 points for macroeconomic stability. The lowest score (49) were awarded to Poland for innovation potential, where the rating of the number of international co-inventions, R&D expenditure and multi-stakeholder collaboration was particularly low. In addition, firms in Poland are characterized by a low ability to absorb disruptive ideas (36 points), low susceptibility to business risk (47 points), lack or workforce diversity (39 points), poor availability of venture capital (29 points), which adds up to a reduced capability to commercialize innovative ideas.

Poland also recorded a weak result in ICT adoption, scoring 54 points. What has a negative effect on this result is a relatively low share of subscribers with fixed-broadband Internet access, but it is improved by the score for the number of mobile cellular telephone subscriptions.

Employee skills are key factor driving productivity, and thus competitiveness of a country. Their high level supports the ability to manage change instead of passive submission to it. Therefore, Poland's relatively high score of 73 points in the skills pillar is a positive signal. What requires a definite improvement, however, is the style of teaching, so that future workers have the ability of critical thinking. Better performance is also needed in vocational education and skills of graduates useful in professional work.

Another ranking, *The IMD World Digital Competitiveness Ranking*, prepared by the International Institute for Management Development IMD) in Lausanne focuses exclusively on the digital competitiveness of countries, defined as "the capacity of an economy to introduce and explore digital technologies leading to the transformation in public administration practices, business models and society in general" [after: Talar, 2017, p. 229]. It is measured by the Digital Competitiveness Index (DCI). It is composed of factors grouped into three categories: knowledge (necessary to discover, understand and create new technologies), technology (factors enabling the development of digital technologies), future readiness (to exploit digital transformation). Each of them is subdivided into three sub-factors. As a result, analysis is carried out within 9 sub-indices, covering 50 criteria in total, 31 of which are shared with the previous IMD World Digital Competitiveness Ranking, and 19 criteria are new. 63 countries were analyzed in 2018. In this ranking, Poland earned the 36th place, the best from 2014. Over that time, performance improved also in the technology and future readiness categories, while worse results (albeit still highest) were achieved in the area of knowledge. This is affected by a particularly low degree of internationalization of highly skilled workers and small international experience of management staff.

Having regard to the aim of this study, the area of future readiness, which represents the level of preparedness of an economy to assume its digital transformation, has been analyzed more extensively. It comprises three components: adaptive attitudes, business agility, and IT integration. Digital competitiveness means that society is capable of absorbing digital technologies. To this end, society must have a specific level of adaptive attitudes, including the willingness to participate in digital-related processes, participation in online communication with public administration, Internet retailing, tablet and smartphone possession or attitude toward globalization. Future readiness also requires business agility in absorbing new technologies and taking advantage of new opportunities. The level of that readiness is affected by innovations created in the private sector, decisions taken by firms on the basis of big data, as well as knowledge transfer between universities and the private sector. Finally, future readiness requires IT integration, which determines to what extent individual actors (natural persons, enterprises, governments) apply IT practices and processes. The following are assessed: provision of e-government services, public-private partnership, cyber security, and software piracy (IMD, 2018). Results for Poland in this area are shown in Table 16.1.

Table 16.1 Future readiness for the digital transformation – Poland's position measured by the Digital Competitiveness Index (DCI), 2018

Component	Poland's position
FUTURE READINESS	**37**
Adaptive attitudes	**33**
e-participation	14
Internet retailing	32
tablet possession	35
smartphone possession	46
attitudes toward globalization	56
Business agility	**40**
opportunities and threats	12
innovative firms	32
agility of companies	23
use of big data and analytics	37
knowledge transfer	49
IT integration	**40**
e-government	31
public-private partnerships	57
cyber security	48
software piracy	37

Source: Own study based on data from IMD [2018].

A summary of data on Poland's position in the rankings listed above is provided in Table 16.2.

In summary, Poland's place in the global and regional rankings of innovation and technological advancement is in the middle of the tables. However, in many areas it is so low that without strong improvement in the coming years Poland will not be able to take advantage of the opportunities which are the source of Industrial Revolution 4.0.

Table 16.2 Position of Poland in rankings of innovation and technological advancement

Ranking	Poland's position	Notes
Global Entrepreneurship Monitor 2018	Efficiency-driven economy in the transition phase to the innovation-driven category.	Summary based the World Economic Forum classification, factor-, efficiency- and innovation-driven economies
European Innovation Scoreboard 2018	Moderate innovator; 24th among EU-28 economies; 53.6% of EU average; deterioration of indicator compared to 2010	27 indicators in four groups (framework conditions, investments, innovation activities, impacts) and ten dimensions
Global Innovation Index 2018	39th among 126 countries	80 indicators in the areas: Innovation Input (institutions, human capital and research, infrastructure, market sophistication, and business sophistication; and Innovation Output (knowledge and technology achievements and creative outputs)
OECD Science, Technology and Industry Scoreboard 2017 – The Digital Transformation	In 2015: – 29th among 37 countries in terms of share of researchers working in business; – 32nd among 42 in terms of share of employees in R&D per 1,000 employees; – 1st in terms of share of female doctorate graduates in sciences; – 22 among 28 in terms of share of robots per 1000 workers; – 33 rd among 33 in terms of share of businesses using cloud computing.	No formal ranking and one composite indicator; five areas of analysis: knowledge, talent and skills; research excellence and R&D collaboration; SMEs innovating in-house; leadership and competitiveness; digital society and transformation
Global Competitiveness Index 2018 (WEF)	37th among 140 countries	12 pillars in four categories: enabling environment, markets, human capital, innovation ecosystem
The IMD World Digital Competitiveness Ranking 2018	36th among 63 countries; 37th in the category "readiness of an economy to adopt its digital transformation"	*Digital Competitiveness Index;* 9 sub-indices covering 50 criteria, 31 of which are shared with the IMD World Digital Competitiveness Ranking

Source: own study

16.2 Assessment of the level of digitalization of the Polish economy

Digital economy is an intangible economy based on knowledge or intellectual capital [Kuźniar, 2017, p. 47]. The components of such capital are knowledge, experience, organizational technology, customer relations, and professional skills [Edvinson, Malone, 2001]. Contemporary economies are increasingly composed of large data sets (big data), software, algorithms, intellectual property (copyrights, patents, etc.), human capital, organizational culture, business models and processes, network of technological linkages, and customer relations. Thus, digitalization of the economy is a significant, albeit not only, characteristic of modern economies, which translates into competitive advantage in the market.

The degree of digitalization of the economy can be studied on the basis of various data sets, depending on the definition of digitalization adopted. The simplest indicator is the share of ICT in the economy, measured by the share of ICT in GDP and employment, expenditure on R&D in ICT, R&D staff in ICT, etc. Relevant data are provided by sources including Eurostat. They are also used to create more complex indices of innovation performance or competitiveness of countries, as presented in the first part of the study. The ICT Development Index (IDI) published since 2009 by the International Telecommunication Union (ITU), is also used to compare countries' performance in information and communication technologies. It is calculated on the basis of countries' achievements in 11 areas, divided into three groups: ICT access, ICT adoption, and ICT skills. The IDI takes values between 0 and 10. In 2017, Poland ranked 49th in the world (overall, the analysis included 176 countries), with an aggregate score of 6.89. It was the 9th lowest score in in Europe, where the average score was 7.5 points (Poland being trailed by Bulgaria, Serbia, Romania, Montenegro, Turkey, Macedonia, Bosnia and Herzegovina, and Albania). However, Poland's global position improved by one place compared to 2016. For ICT access, Poland was ranked 40th in 2017 (with 7.58 points), whereas in terms of ICT adoption it was 64th (with a score of 5.47). The best scores were awarded for ICT skills, a category in which Poland ranked globally 25th with 8.35 points [ITU, 2017]. The results show that while Poland has human capital capable of facing the challenges posed by modern economies[5], it lacks infrastructure that would enable it to fully utilize the capability.

Assessments of the economy and society digitalization level can also be made using more complex indicators. One of them is the Digital Economy and Society Index (DESI) prepared by the European Commission. It aggregates a set of 30 indicators grouped into the following categories: connectivity, i.e., the development level of communication infrastructure and access to it, digital skills of human capital, the intensity of Internet use by society, the extent of integration of digital technology by business, and the level of digital public services. The maximum value of the index is 100. In 2017, Poland scored 45 points. While the result was much better than in the previous years (cf. Figure 16.3), Poland was ranked at a distant 24th place among 28 EU member states[6].

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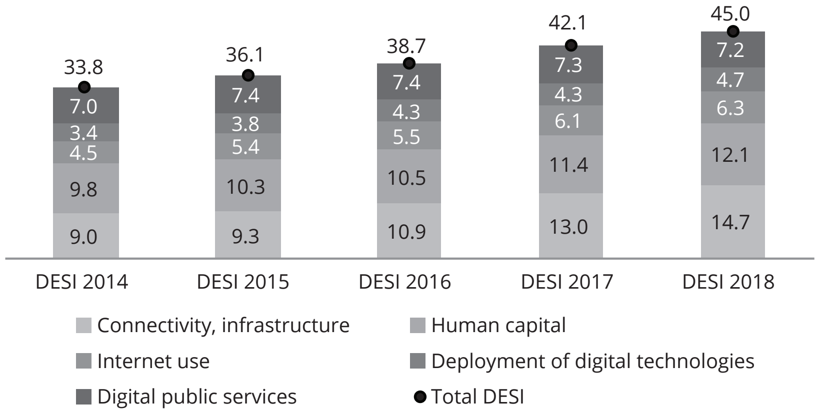
[5] Which is confirmed also by other data, such as, e.g., the popularity of computer science as a field of study, and the number of graduates of STEM programs (science, technology, engineering, mathematics) exceeds the EU average [*Indeks gospodarki cyfrowej…, 2018*].

[6] The following countries ranked lower than Poland: Italy, Bulgaria, Greece and Romania.

Figure 16.3 Digital Economy and Society Index (DESI) for Poland, 2014–2018



Source: Own study based on https://digital-agenda-data.eu/datasets/desi/

In 2014–2018, a particularly significant progress was witnessed in Poland in connectivity and infrastructure (especially in the development of mobile broadband services, where Poland performs better than the EU average) and the deployment of digital technologies (mainly due to improvements in electronic information exchange, use of cloud services and e-invoicing).

Within the individual components, Poland is ranked best (though still low) for human capital (20th[7]) and worst for deployment of digital technologies (27th). The Polish economy is characterized by both a lower level of digitalization of enterprises (e.g., only 6.6% of SMEs use cloud services, 10% use social media), as well as e-commerce. In 2017, only 9.5% of SMEs were involved in online sales and 3.9% in cross-border online sales. The e-commerce turnover recorded by those enterprises is also low compared with the EU average. It represents only 6.6%, compared with 10.3% for the EU. According to the authors of the European Commission's report, the main challenges in the digitalization of businesses in Poland are the lack of knowledge of the opportunities available, limited availability of workers with digital skills, lack of financing, and insufficient investment in improving workers' ICT skills [Indeks gospodarki cyfrowej…, 2018].

More variables than in the European Commission's study were used to build the Country Digitalization Index, with the Economy Digitalization Index as its important component [Arak, Bobiński, 2016]. The latter is composed of three pillars: Digital

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[7] In previous years, Poland performed best in the digital public services component. In 2018, two additional indicators were included here: digital public services for businesses and e-health services.

Resources (IT hardware, systems and network access); E-business (dissemination of new media and IT systems in relations between firms); E-commerce (dissemination of ICT in relations between firms and customers), examined by means of 95 indicators. Adding two more pillars – Business Environment (government openness, regulatory friendliness, social trust regarding personal data protection) and digital competence (advanced Internet and computer use skills) allows the level of country digitalization to be determined.

According to data available for 2014, Poland scored 33 points in the Economy Digitalization Index, ranking fourth from the bottom in Europe (with the European average of 47.2 points). Certain other countries of the Central and Eastern European region performed worse than Poland, i.e., Hungary, Bulgaria and Romania. In contrast, the Czech Republic's score was half again as good as Poland's. Poland performed even worse against European countries in the Country Digitalization Index, ranking 28th +among the 30 countries under study, falling into the so-called digitalization laggards group (along with Italy, Croatia, Hungary, Cyprus, Greece, Bulgaria and Romania). However, Poland is among the countries which are catching up on digitalization the fastest. It was ranked fourth for growth of the Economy Digitalization Index (up by 74% in the years 2008–2014) and seventh for growth of the Country Digitalization Index (up by 62% in the years 2008–2014). The popularity of the use of computer hardware in firms has been on the rise; they have been increasingly using Customer Relationship Management Systems (CRM) and other IT systems, and enhancing their Internet purchase offer; the government has been increasingly making data available online; the digital competence of consumers and employees has been improving [Arak, Bobiński, 2016].

Nevertheless, the overall picture of digitalization in Poland is not very optimistic. Polish firms are still unable to take advantage of the opportunities that ICT provides to them in business management, Poles are doing poorly in terms of advanced computer skills, and the government is slow in building e-administration, making little data and services available to citizens online. At the same time, Poles trust private firms processing their personal data, but do not trust medical firms and government institutions in this respect [Arak, Bobiński, 2016]. This is major obstacle to putting into practice the idea of big data, as its starting point is access to data, including data made available by citizens.

Digitalization of Enterprises in Poland

The sources of information on the digitalization of enterprises in Poland are reports drawn up by or for consulting firms, industrial technology providers, as well public institutions, usually presenting results of questionnaire surveys. They are not comparable to each other owing to different sets of respondents, but they are useful in drawing conclusions and getting a wider view of Industrial Revolution 4.0.

Big data is one of the foundations of the Fourth Industrial Revolution. However, it becomes valuable only when analyzed. These analytics are based on the automatic collection and processing of data sourced from devices or directly from people. The information obtained ensures better management of corporate resources, production planning, product life cycle management, fostering relations with suppliers, and better responding to customer needs [PwC, 2017].

The results of a survey carried out by PWC among 2000 persons from 26 countries (including 50 respondents from Poland) show that only 18% of the respondents declare they are able to analyze data in an advanced manner. More than half note that their organizations have major deficiencies in this area. 9% have no analytical capabilities within their organization [PWC, 2017]. A survey conducted for Siemens in 2017 on a national sample of 241 industrial SMEs in Poland shows that big data is not of particular interest to Polish industrial enterprises. Only 11.6% of the respondents stated big data was used in their firms. As many as 61% noted that implementation of big data analytics was not even planned in their firms [Smart Industry…, 2017]. Even if production data is collected, methods that require human involvement prevail in Poland, which means both smaller data sets and the need to digitize them. In 2015, automatic data retrieval from machines was declared by 36% Polish firms, while 16% responded they collected data on paper, and 59% entered data manually [Astor, 2016].

Another pillar of Industrial Revolution 4.0 is the Internet of Things. It encompasses different technologies that allow devices to be connected to the Internet, as well as remote access to them. They include both household appliances and articles of everyday use, such as watches and smartphones, or machines and equipment in industrial plants [Astor, 2016]. IoT can be applied in any industry, from motoring to medicine to mining. With this technology, it will be possible to predict a hardware failure and prevent it. It will be possible to analyze the consumption of energy and other resources, and to optimize them. Research shows that the idea of the IoT is still little known and understood by managers in enterprises, but the knowledge has been growing rapidly. The authors of the Industry 4.0 report refer to the 2015 survey results, according to which as many as 44% respondents did not understand the idea of using IoT, whereas in 2016 the proportion dropped to 19% [Astor, 2016]. The use of the Internet of Things is declared by 13.1% of SMEs, while 65% do not expect to use this technology in their firms in future [Smart Industry…, 2017].

The Fourth Industrial Revolution is also the automation of manufacturing and the related widespread deployment of robots. More and more manufacturing processes will be performed in future by machines, without human involvement. Nearly 49%

of the SMEs surveyed in Poland use automation of manufacturing with the use of standalone machines, 27% of firms automate production using integrated machines, and comprehensive robotization of a production line has been implemented by only 14.3% of firms. Almost 62% of the respondents have no plans for such comprehensive robotization [Smart Industry…, 2017]. Such results show that Polish firms are still the stage of the third industrial revolution, which is characterized by simple automation of production.

Having regard to the types of work performed on production lines and the extent to which robots are involved to perform such tasks, it can be concluded that the robotization level in Poland is of small significance to production. In more than half of firms, operations are performed which require the use of considerable force, while robots are engaged to carry out such tasks in less than 5% of firms. Precision tasks are performed in more than 60% of firms, but only 7% use robots for such tasks. 49% declare that hazardous tasks are performed in their firms. Only 4.4% employ robots in such a case. More, 11% of the firms surveyed, use robots to perform repeatable operations [Smart Industry…, 2017]. At the same time, the labor automation potential is high in Poland, as shown by a McKinsey [2018] report. It is estimated that 49% of working time in Poland may be automated by 2030 (i.e., approx. 7.3 m FTEs) with the use of technologies available today (such as artificial intelligence).

The results presented above are in contrast with the outcomes of the PWC [2017] survey in terms of perception of the Industry 4.0 idea by Polish firms. It turns out that the respondents highly appreciate the advancement of digitalization in their firms and were optimistic about the opportunities of Industrial Revolution 4.0. The results may be indicative of a lack of full knowledge on the latest solutions in this field in the world, as well as a distorted perception of the firm's situation in the context of the leap forward that has taken place in modernization of manufacturing processes in recent years.

Summary

Poland's long-term development is largely dependent on identifying and consolidating competitive advantages based on knowledge and innovation instead of low labor costs, as has been the case so far. For this reason, it is extremely important to develop innovation activities of Polish enterprises and enhance their awareness of the opportunities for building knowledge-based competitive advantages.

Poland's performance thus far is not optimistic. Enterprises in Poland have been taking advantage of the opportunities of Industrial Revolution 4.0 to a very small extent. What is more, many of them have no solid foundations on which to base the automation and digitalization of production, meaning that it has not even fully adopted the Industrial Revolution 3.0 stage. Unless determined efforts are made towards boosting the role of enterprises not only in consuming but mainly in building digital solutions, firms in Poland will lose their competitive advantage. The world is changing – it is developing at a very fast pace without waiting for laggards.

Bibliography

Arak, P., Bobiński, A., [2016], *Czas na przyspieszenie. Cyfryzacja gospodarki Polski*, Polityka Insight, Warsaw.

Astor [2016], *Przemysł 4.0. Rewolucja już tu jest. Co o niej wiesz?*, Astor Whitepaper, https://www.astor.com.pl/images/Industry_4-0_Przemysl_4-0/ASTOR_przemysl4_whitepaper.pdf (20.01.2019).

Baranowski, M. (ed.), [2017], *Badania – rozwój – innowacje. Wybrane zagadnienia*, NCBiR, Warsaw.

Edvinsson, L., Malone, M.S., [2001], *Kapitał intelektualny*, PWN, Warsaw.

EIS, [2017], *European Innovation Scoreboard 2017*, European Commission, https://ec.europa.eu/docsroom/documents/24829 (20.01.2019).

EIS, [2018], *European Innovation Scoreboard 2018*, European Commission, https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_pl (20.01.2019).

Europa 2020. Strategia na rzecz inteligentnego i zrównoważonego rozwoju sprzyjającego włączeniu społecznemu, [2010], Brussels, 3.3.2010, KOM (2010), https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=celex:52010DC2020 (10.01.2019).

Eurostat, [2019], *Business expenditure on R&D (BERD) by NACE Rev. 2 activity*, https://ec.europa.eu/eurostat/data/database (10.01.2019).

GEM, [2018], *Global Entrepreneurship Monitor 2017/2018*, https://www.gemconsortium.org/report/50012 (10.01.2019).

GII, [2018], *Global Innovation Index 2018. Energizing the World with Innovation*, Cornell University, INSEAD, WIPO, https://www.globalinnovationindex.org/userfiles/file/reportpdf/gii_2018-report-new.pdf (10.01.2019).

GUS, [2017] http://stat.gov.pl/statystyka-miedzynarodowa/porownania-miedzynarodowe/tablice-o-krajach-wedlug-tematow/wskazniki-monitorujace-europa-2020/ (10.01.2019).

IMD, [2018], *IMD World Digital Competitiveness Ranking 2018*, https://www.imd.org/globalassets/wcc/docs/imd_world_digital_competitiveness_ranking_2018.pdf (10.01.2019).

Indeks gospodarki cyfrowej i społeczeństwa cyfrowego (DESI) 2018, Sprawozdanie krajowe dotyczące Polski, [2018], ec.europa.eu/newsroom/dae/document.cfm?doc_id=52340 (20.01.2019).

International Encyclopedia of Communication Theory and Philosophy, [2016], John Wiley & Sons, Inc.

ITU, [2017], *Measuring the Information Society Report 2017*, Volume 1, Geneva.

Krajowy Program Reform Europa 2020, [April 2011], Warsaw, http://www.mg.gov.pl (20.01.2019).

Kuźnar, A., (2017), *Międzynarodowy handel produktami wiedzy*, SGH Publishing House, Warsaw,

McKinsey [2018], *Ramię w ramię z robotem. Jak wykorzystać potencjał automatyzacji w Polsce*, https://mckinsey.pl/wp-content/uploads/2018/05/Rami%C4%99-w-rami%C4%99-z--robotem_Raport-McKinsey.pdf (20.01.2019).

Orłowski, W., [2013], *Komercjalizacja badan naukowych w Polsce. Bariery i możliwości ich przełamania*, PWC, Warsaw.

PARP, [2017], *Raport z badania Global Entrepreneurship Monitor – Polska*, https://www.parp.gov.pl/storage/publications/pdf/raport%20z%20badania%20global%20entrepreneurship%20monitor_2017_2018.pdf (20.01.2019).

PWC, [2017], *Przemysł 4.0 czyli wyzwania współczesnej produkcji*, https://www.pwc.pl/pl/pdf/przemysl-4–0-raport.pdf (25.01.2019).

Science & Engineering Indicators 2018, [2018], National Science Foundation, https://www.nsf.gov/statistics/2018/nsb20181/report/sections/research-and-development-u-s-trends-and-international-comparisons/cross-national-comparisons-of-r-d-performance (25.11.2018).

Smart Industry Polska 2017, [2017], *Adaptacja innowacji w działalności mikro oraz małych i średnich przedsiębiorstw produkcyjnych w Polsce. Raport z badań*, Ministry of Development / Siemens Sp. z o.o. Warsaw, https://publikacje.siemens-info.com/webreader/00131––000758-raport-smart-industry-polska-2017/index.html (25.01.2019).

STI, [2017], *The OECD Science, Technology and Industry Scoreboard 2017: The Digital Transformation*, http://www.oecd.org/sti/scoreboard.htm (25.01.2019).

Talar, S., [2017], *Wskaźniki syntetyczne konkurencyjności cyfrowej*, https://www.researchgate.net/publication/322250900_Wskazniki_syntetyczne_konkurencyjnosci_cyfrowej (27.01.2019).

WEF, [2018a], *The Global Competitiveness Report 2017–2018*, https://www.weforum.org/reports/the-global-competitiveness-report-2017–2018 (27.01.2019).

WEF, [2018b], *The Global Competitiveness Report 2018*, https://www.weforum.org/reports/the-global-competitveness-report-2018 (27.01.2019).

Yifu Lin, J., Nowak, A.Z. (eds.), [2017], *Nowa ekonomia strukturalna wobec krajów mniej zaawansowanych*, Dom Wydawniczy Elipsa, Warsaw.

Chapter 17

Poland's Competitive Position in the Use of Digital Technology

Andreas Bielig

Introduction

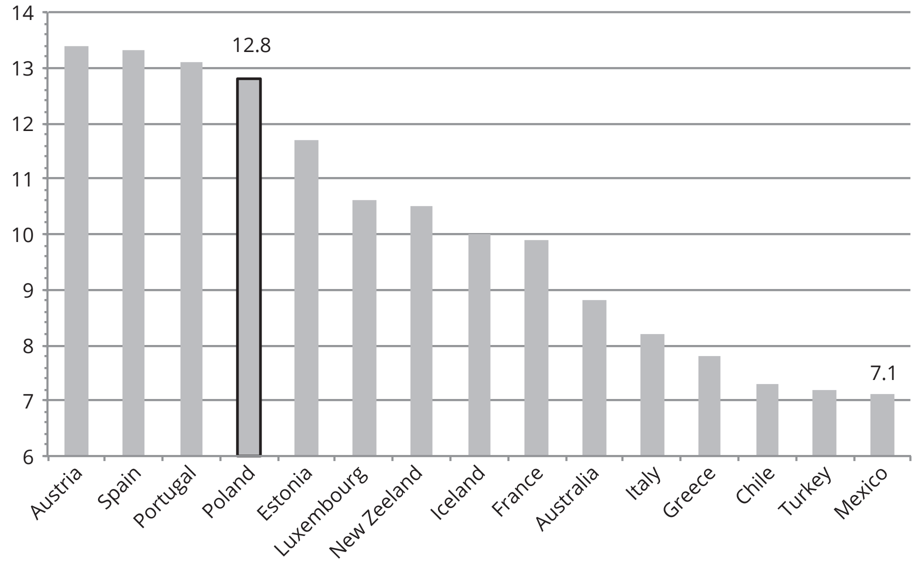
Poland has made a huge progress in the digital transformation of economy and society in the recent years. However, in many areas competitiveness in international perspective is below the OECD average. This concerns, for instance, the dissemination of digital infrastructure as well as the economic and social diffusion of digital services. The article analyzes the Polish position in digital technology usage in an international comparison of key empirical indicators provided by the OECD for digitalization, and derives conclusions for political advice to support digitalization strategy.

17.1 Analysis of Poland's International Position in the Use of Digital Technology

Black-and-white contrasting seems an unsuitable approach to depicting empirical reality in Poland's digitalization position. To draw a realistic picture here a set of 10 indicators has been developed, which are outlined below. In an international comparison of *average speeds of internet access*, measured by the so called Akamai index (see Figure 17.1), Poland failed in the first quarter 2016 with 12.8 Mb/s not only to reach the OECD average but also belonged to the lowest- ranked countries in the international comparison [OECD, 2017a]. The leading position was held by Korea with an internet speed of 29.0 Mb/s, well ahead of to the next-ranked countries, Norway and Sweden, with 21.3 and 20.6 Mb/s, respectively. The OECD average of the analyzed set of 35 countries was only 14.1 Mb/s. The economies with slow average internet provider speeds include European countries, such as Austria, Spain and Portugal (from 13.4 to 13.1 Mb/s) but also Estonia (11.7), which is currently heralded as pioneer in digitalization, or France and Italy (9.9 and 8.2, respectively).

The bottom positions were taken by Mexico, Turkey, Chile and Greece with internet speeds of a mere 7.1 to 7.8 Mb/s.

Figure 17.1 Last ranked-countries in internet speed in selected OECD economies in 2016, average speed [Mb/s]

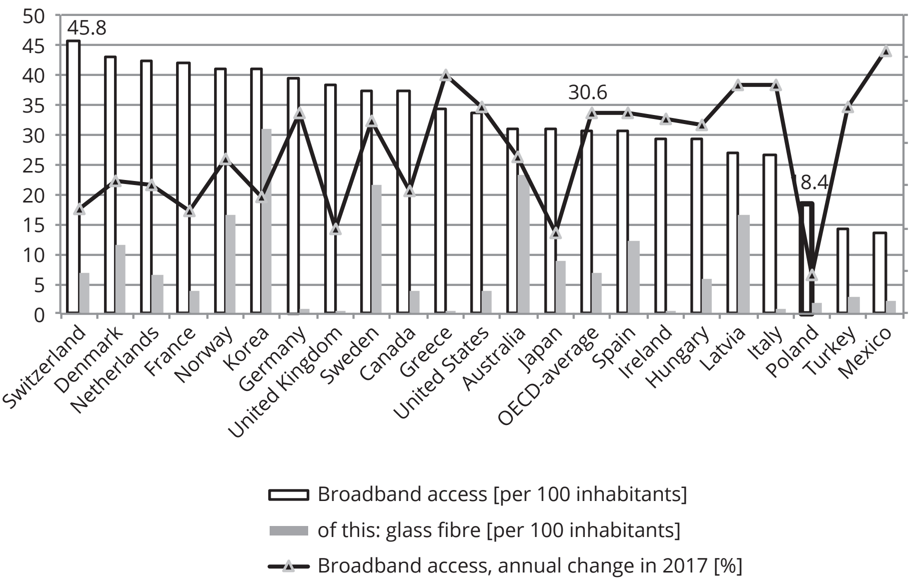


Source: Own study based on OECD data (2017a).

Concerning the *dissemination of broadband access,* including glass fibre cables, among the population, in 2017 Poland, with 18.4 internet access points per 100 inhabitants, held only the third lowest place in the international comparison (Destatis, 2018). The leading position was held by Switzerland with broadband coverage of 45.8% (see Figure 17.2, left scale). The international average of broadband coverage was 30.6%. All countries of the leading group revealed, with exception of Switzerland, a homogeneous density of coverage between 42.9 to 40.9% of broadband supply, whereas the following economies had significantly smaller coverage ratios. Beside Poland, the last-ranked group in broadband supply was formed by Mexico, Turkey, Italy and Latvia, with coverage rates between 13.5 and 26.8%. If temporal dynamics is considered, another picture can be drawn: Mexico, Greece, Italy and Latvia, with annual changes of 6.3 to 4.7%, showed the largest growth rates in broadband supply. In contrast to this, Poland, Japan and France recorded even relative degradations in supply, with negative growth rates of –4.2 to –2.0%. But also the leading economy Switzerland, with a small negative growth of –1.1%, revealed %a slight reduction in broad band supply.

In contrast to this, if the supply of *broadband glass fibre access* is also taken into account, Poland, with 1.7 accesses per 100 inhabitants, had only the sixth lowest rank, before Italy (0.9%), Germany (0.8%), United Kingdom and Ireland (both 0.4%) and Greece (0.1%) (see Figure 17.2, right scale). The leading countries in the provision of high-speed glass fibre infrastructure were Korea with 30.9 accesses per 100 inhabitants, Australia (23.4%) and Sweden (21.7%), with an outstanding coverage position of Korea in this area. The latter is illustrated by a comparison with the international average coverage of 6.8%. Switzerland as the leading country in broadband access, reached only an average level in glass fibre, but also France and Canada fell behind the leading group. Poland was slightly better in glass fibre access provision than in overall broadband supply, but was nevertheless placed in the last group.

Figure 17.2 Dissemination of broadband access in selected OECD economies in 2017, of which: glass fibre (left axis) and annual change of broad band access (right axis)

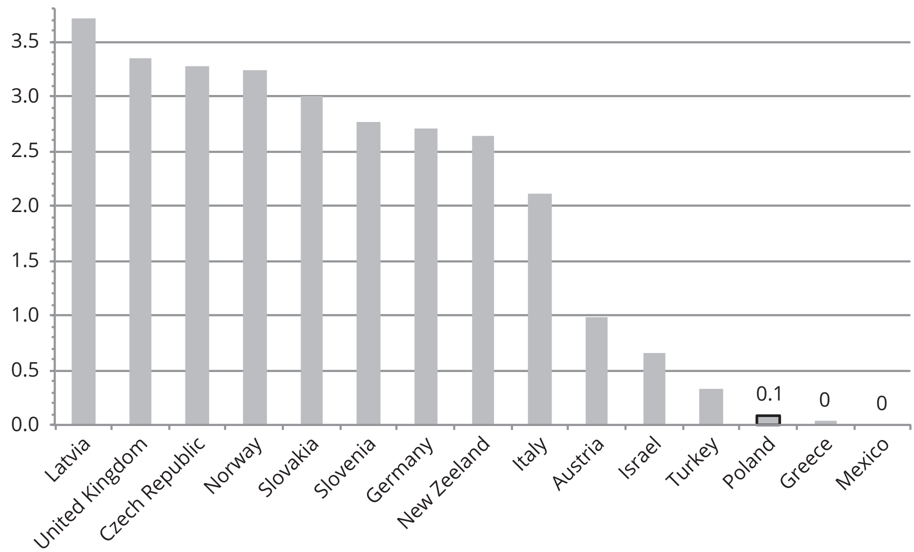


Source: Own study and calculations based on Destatis data (2018).

For future innovative internet services, especially high speed broad band access is regarded as an essential precondition, both for enterprises and for private households. If we focus on *fixed high speed broadband access,* Poland in 2016 ranked only the third lowest in international comparison [OECD, 2017b]. Only Greece and Mexico reached smaller shares of population of a near-zero level (see Figure 17.3). The group of lowest-ranked countries also included large European economies, such as United

Kingdom (3.4%), Germany (2.7%) or Italy (2.1%). The leading country, Korea, revealed a coverage of 30.7 accesses per 100 inhabitants, with a large lead of 48.9% and 66.2%, respectively, over the next-placed countries, Japan (20.6% coverage) and Switzerland (18.5% coverage). Korea had an outstanding position in the provision of high speed broadband, as illustrated by the lead of 110% over fifth-ranked Hungary or 310% over 10th ranked Finland. Compared to this leading group, Poland has an enormous need to catch up (with a gap of 36,283% to the leader Korea). Thus, strong efforts are necessary to face up to future challenges of digitalization in economy and society.

Figure 17.3 Lowest-ranked countries in fixed high speed broadband subscriptions (above 100 Mb/s) in selected OECD economies in December 2016, share of population [%]

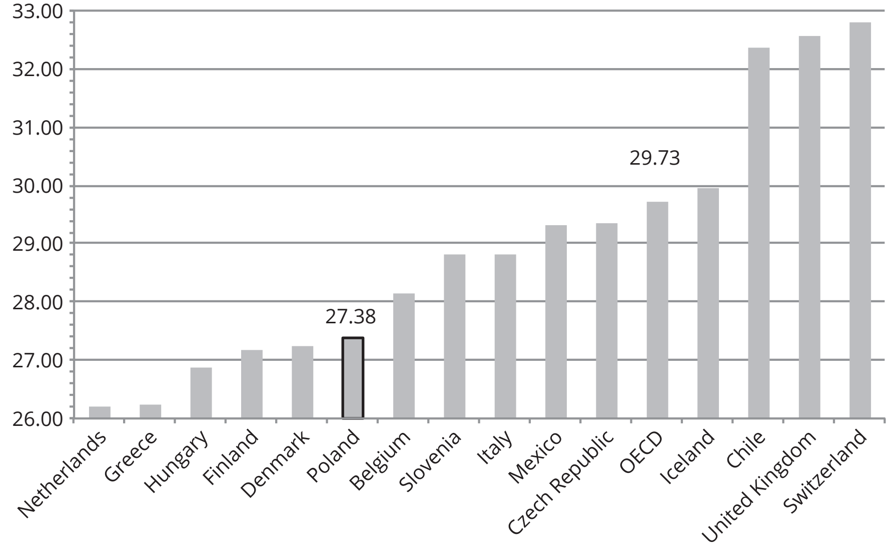


Source: Own study based on OECD data (2017b).

Competitiveness in the provision of digital infrastructure is, beside quantitative and qualitative aspects, also determined by the existing price levels of service usage. As Figure 17.4 shows, the *set prices* of *fixed broadband access usage* in 2017 for Polish *small clients* amounted to a medium level in the international comparison at USD 27.38 per month (rank 16),. The lowest prices for broadband access were paid by users in Latvia at USD 15.11 and in Korea at USD 15.96 [OECD, 2017c]. The highest prices had to be paid by users in Spain at USD 52.13 for a comparable set of services. Very large prices for small clients were also reported by Ireland, Norway, United States and Luxembourg (from USD 44.08 to 46.5). The OECD average for fixed broadband access was USD 29.73. Consequently, Polish users paid set prices slightly below average.

However, due to the considerable international dispersion of recorded prices, the possibility of arriving at a reliable quantitative indication of average value is limited.

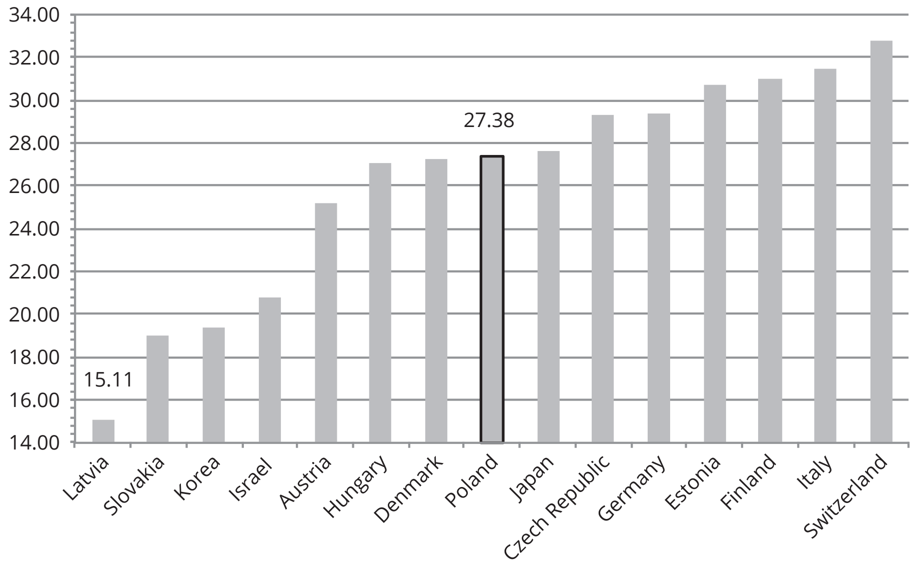
Figure 17.4 Medium-ranked countries in prices for fixed broadband for small clients in selected OECD-economies in June 2017, set prices (20 GB/month, data transfer above 0.25 Mb/s) [USD (PPP)]



Source: Own study based on OECD data (2017c).

For the usage of *fixed broadband accesses* by *large clients,* Polish users paid relatively small *prices* in international comparison (rank 8), as Figure 17.5 shows. At With a set price of USD 27.38, providers charged, for a significantly more comprehensive services set, the same average price as for small clients, which means in Poland was no price differentiation at the average level recorded [OECD, 2017d]. A comparable configuration was found in the leading countries Latvia and Slovakia, which revealed also identical prices of USD 15.11 and USD 19.02, respectively, for both small and large clients. Relatively small prices were also found in Korea at USD 19.35. Here, a price differential of market segmentation of 21.2% was recorded. The OECD average price level was USD 37.38, so large clients had to pay for their (more comprehensive) service sets (only) 25.7% more than small clients. The highest prices were paid by large clients in Mexico, the United States and Spain at USD 64.26, 61.07 and 55.91, respectively, which equaled mark-ups of 119.2%, 31.6% and 7.2%. Compared with the leading country Latvia, large clients had to pay in Poland 81.2% higher prices, which applies also to small clients due to the lacking price differentiation at the average level in both countries. However, large Polish clients paid 26.8% less than the OECD average price.

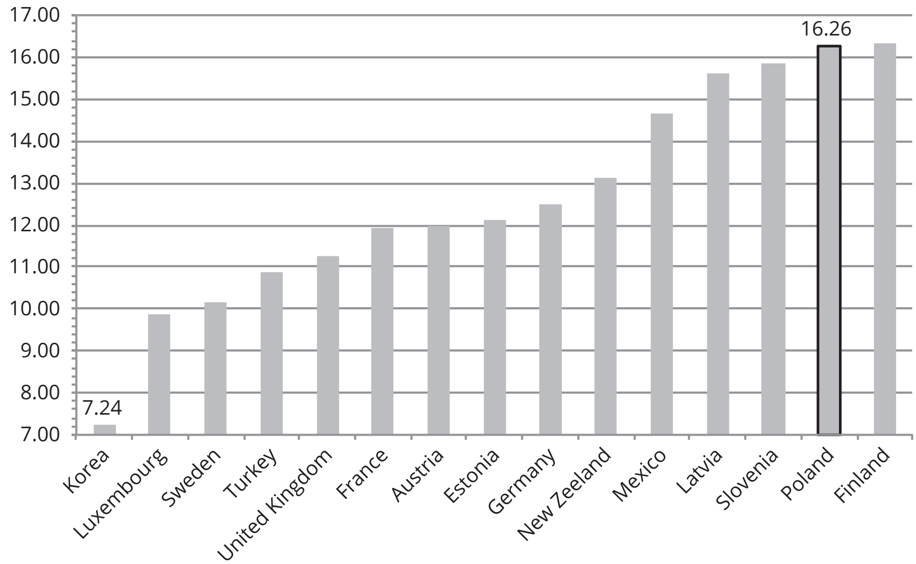
Figure 17.5 First-ranked countries in terms of prices for fixed broadband for large clients in selected OECD economies in June 2017, set prices (200 GB/month, data transfer above 25 Mb/s) [USD (PPP)]



Source: Own study based on OECD data (2017d).

Also in *prices* for the use of *mobile broadband services for small clients* Poland had a relatively moderate position in the international comparison (see Figure 17.6). Small customers had to pay in 2017 for a fixed set of call minutes and data transfer USD 16.26 (rank 14) [OECD, 2017 e]. With a huge lead, the lowest average prices were paid by clients in Korea at USD 7.24, so the Polish price mark-up on the leading position was 124.6%. But also in Luxembourg, Sweden and Turkey prices for small clients were relatively low, ranging between USD 9.85 and 10.89. The OECD average level was USD 22.46. In contrast to this, prices in Japan, the Czech Republic and the United States for mobile internet were extraordinarily large. Especially Japanese customers had to pay a national average price of USD 67.16, meaning a markup of 199% on the international average price. With USD 49.79 and 46.21, respectively, also prices in the Czech Republic and the United States were more than twice the international average. Remarkably, a strong discrepancy between prices for fixed internet access and mobile services was recorded in Slovakia. The country belonged to the leaders in fixed internet access but in mobile services in fell into the bottom group in terms of its price competitiveness of the services provided (USD 36.73).

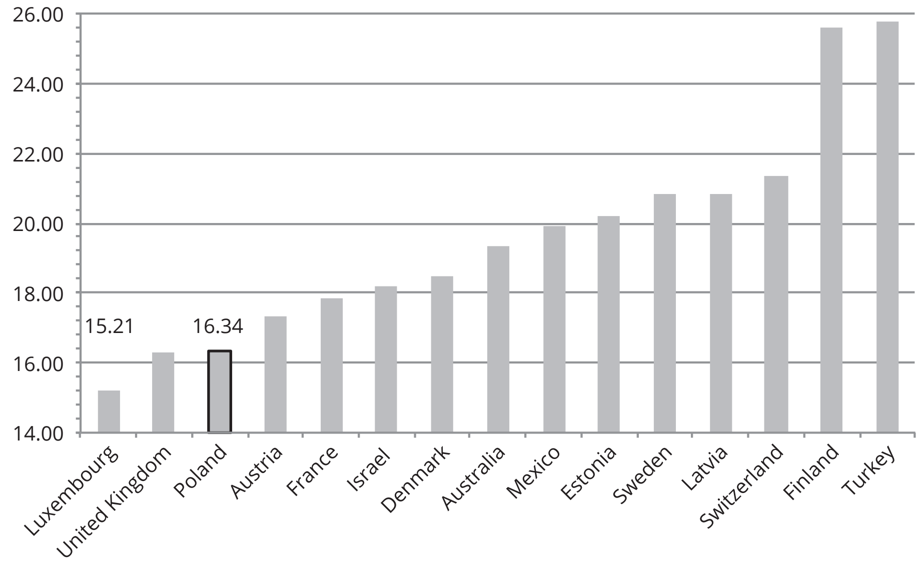
Figure 17.6 First-ranked countries in terms of prices for mobile broadband for small clients in selected OECD economies in May 2017, set prices (incl. 100 call minutes and data transfer 500 MB) [$ (PPP)]



Source: Own study based on OECD data (2017e).

The moderate position of Poland in *prices of mobile Internet access services* improved in the market segment of *large clients* (see Figure 17.7). For a set of mobile services, large customers paid USD 16.34 in 2017, so Poland belonged to the most competitive countries in this respect (3rd place) [OECD, 2017f]. The OECD average was USD 36.77. Lower prices were paid only by large clients in Luxembourg at USD 15.21 and the United Kingdom (USD 16.29). The recorded price differential between Polish large and small clients was only marginal 0.49% of the small clients' level. The international level of markup in OECD was 63.7% in 2017. The highest prices were paid by large clients in Greece at an extraordinary level of USD 120.95. Hungary and Japan followed far behind, with the respective prices of USD 86.87 and 73.47 for comparable sets of services. It is noteworthy that the international price range was very large in mobile services for large clients (USD 105.74, meaning a markup of 695.2% on the leading position). Initially, it was assumed that a high intensity of competition in this market segment of business clients existed, leading to lower prices and marginalization of price differences. However, the existing competition is not only recordable at the price level and in many countries it is first visible in the large segment of small clients, reflecting the drive to reach network effects fast.

Figure 17.7 First-ranked countries in prices for mobile broadband for large clients in selected OECD economies in May 2017, set prices (incl. 900 call minutes and data transfer 9 GB) [$ (PPP)]



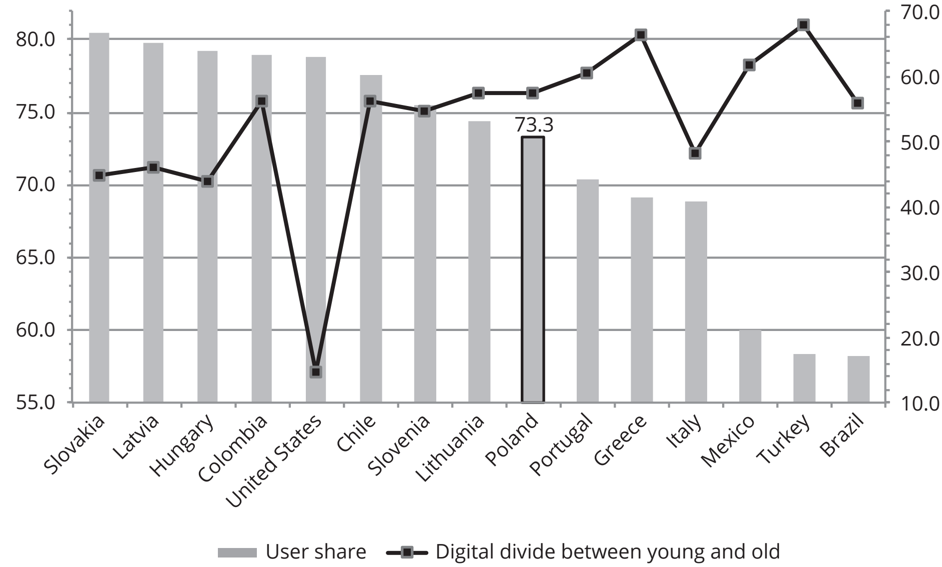
Source: Own study based on OECD data (2017f).

Apart from the required technological infrastructure, the most important element in digitalization processes of society is the human capital of population. Therefore, an evaluation of the social status quo in Poland is outlined in terms of two aspects: *age of population* participating in digitalization and attained *formal education*. Both social characteristics are selected due to their potential effects on social discrimination and focus on social problems accompanying digitalization transformation processes in Poland but also at the international level.

In *social dissemination of internet usage* among its population, Poland has a weak position in the international comparison, as Figure 17.8 shows on the left axis. In 2016, only 73.3% of entire population used internet services. Compared with the OECD average of 83.8%, this is significantly below international standard level [OECD, 2017g], so Poland belongs to those countries ranked lowest in international comparisons (7th lowest place), before Portugal (70.4%), Greece (69.1%) and Italy (68.9%). The largest active population shares were shown by Iceland (98.2%), Japan (98.0%) and Luxembourg (97.5%), whereas Brazil (58.2%), Turkey (58.3%) and Mexico (60.0%) had the smallest observed coverage ratios. However, not all age groups of entire population participated equally in digitalization processes. In the Polish age group between 16 and 24 years, the coverage ratio was 98.0%, whereas in the oldest measured group of 55 to 74 years of age only 40.7% of the population used internet services.

If the observed gap between both age cohorts is used as an indicator of a *digital divide in the society*, the existing social differences can be measured by the *share differences between young and old members of the population*. With an indicator value of 57.3%pp, the digital divide in Poland was extraordinary large in international perspective (see Figure 17.8, right axis). The OECD average indicator value was 33.7%pp of the participation gap between young and old, so Poland was ranked the 6th lowest, before Lithuania (57.4 pp), Portugal (60.6%pp), Mexico (61.7%pp), Greece (66.3%pp) and Turkey (67.7%pp). But also benchmarking against the OECD average in the evaluation of Poland position is misleading to some degree here, because it fails to consider the competition field in detail: the leading country Sweden recorded only a marginal digital divide in its society in terms of age at 1.7%pp, underlined by a very high average internet participation level of entire population at 93.3%. Iceland, the leading country in overall internet participation share of population, also revealed, together with the 3rd ranked Luxembourg, very small indicator values of digital divide at 6.3 and 7.1%pp. The countries ranked next were Denmark, Norway and the Netherlands with 8.0, 8.5 and 9.2 pppp. It is observable that countries of the leading group in internet coverage of entire population by tendency also reached an equal dissemination of digital technology and services across all age groups. Hence, here digitalization is not restricted as an issue to younger segments of population. Japan constituted the only exception from this trend,. Although Japan revealed very large internet coverage of entire population of 98.0% (rank 2), it recorded a large indicator value of digital divide of 22.5%pp. While 99.1% of younger Japanese population used internet services, only 76.6% of older population was active in internet issues. The dimension of digital divide in Japan is evidently smaller than the OECD average but as an effect of the large coverage of the entire Japanese population in contrast to this, the small participation rate of older persons is revealing a larger gap in the society. Even if or just because the average coverage value is rated as good, observable discrimination of older population is more clearly visible, especially in comparison to countries with small overall internet participation. Structural characteristics contrary to Japan's were shown by the United States, where only 85.2% of the younger population in 2016 used internet services (2nd lowest rank before Turkey) and only 70.5% of the older population were active in the internet. So the average internet usage coverage of the entire population was only 78.8% (28th place after Colombia). Finally, the small internet activity of young Americans, seen from international perspective, had (statistically) a positive impact on the indicator of digital divide in American society, which, at 14.7%pp, together with an overall small internet activity level of the American population, was even below the OECD average value. Thus, the American society is an example of leveling out of the existing inner society differences on the basis of low activity level, which is a social behavior opposite to that of the technology-oriented Japanese society. Very large digital social divides in the sample were revealed those countries above the 33.7%-point OECD-average. Among them were also countries which are recognized as leaders in other areas of digitalization, e.g., Korea (35.6%pp), the smaller Baltic states Estonia (34.2%pp), Latvia (46.0%pp), Lithuania (57.4%pp) but also older EU members, such as Austria, Italy, Spain, Portugal or Greece (from 35.7 to 66.3%pp) as well as the Central Eastern European countries Czech Republic, Hungary, Slovakia, Slovenia and, finally, Poland (from 39.0 to 57.3%pp). Poland's weak overall position in dissemination of digitalization is attributable mainly to the extraordinarily small participation of the older age cohort (40.7%), so the resulting social challenge is obvious. Digitalization does not allow waiting until existing problems are solved automatically by demographic processes. Otherwise social problems are expected to arise.

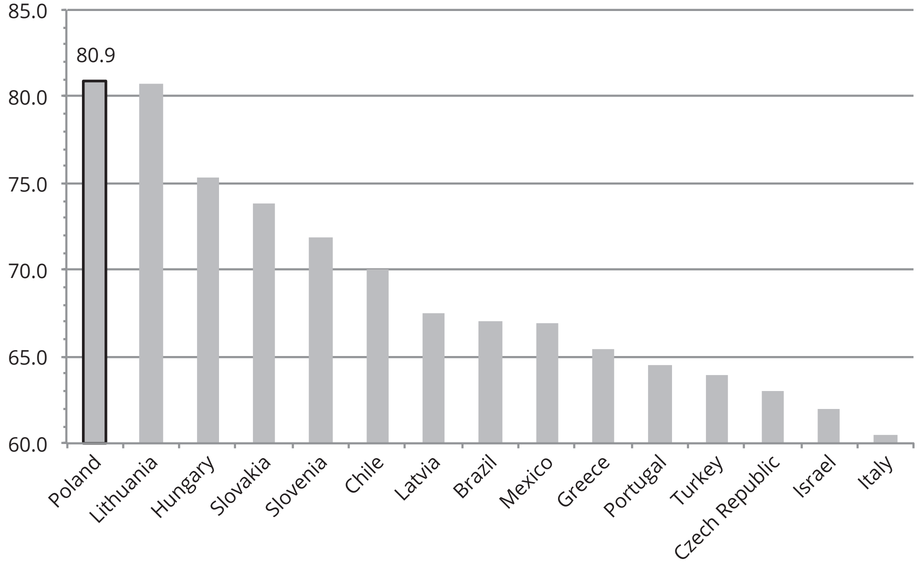
Figure 17.8 Last-ranked countries in internet user shares in total population [%] (left axis) and digital divide (share difference between young and old) [pp] (right axis) in selected OECD economies in 2016



Source: Own study and calculations based on OECD data (2017g).

Other forms of digital divide in society are linked to the individual education status, measured by the highest formal education level attained by persons, which has an impact on the dissemination of digital competences and the usage of internet services in the population. The resulting effects of observable divide phenomena largely depend on the age group and affect especially older population segments, what is consistent with the findings outlined before. As regards countries with the largest *digital divide between shares of internet users with higher and lower formal education* in the older population, Figure 17.9 shows the current situation. Poland was ranked last in 2016 in the international comparison. Here, the largest digital divide of 80.9%pp between different education standards in the older population cohort was recorded, before Lithuania (80.7%pp) and Hungary (75.3%pp) [own calculations on the basis of OECD data, 2017h]. While 88.5% of Poles with higher formal education used internet services, only 7.5% of persons with lower education were active in the internet. Only Lithuania revealed, at 5.0%, a lower indicator value of internet-active persons with lower attained education in this age group. Consequently, Lithuania also recorded one of the largest digital divides of society in terms of education standards. The average value of internet activity in the older Polish population was 40.7%, for all education levels, before the last-ranked countries Portugal (38.6%), Greece (30.5%), Brazil (30.5%), Mexico (19.9%) and Turkey (16.5%). In contrast to this, in the leading country Iceland 100% of older persons with higher education used internet services, whereas 89.7% of members of the same age cohort with lower formal education were active internet users. On average, not only 93.7% of the older population were active users (rank 1). In addition, the digital divide between segments of higher and lower formal education was also at a low level of 10.3%pp (1st rank). Other countries showing relatively small indicator values of digital divide were Denmark (13.7%pp), Sweden (16.9%pp), Luxembourg (17.6%pp) and Norway (19.1%pp). As regards the analysis results in Poland, as well as in many other countries, persons in the lower formal education segment bear an increased statistical risk of being negatively affected by the existing digital divide of society. Exceptional configurations are found, e.g., in the case of the population in Iceland, where this risk is only marginal, which implies that the measured digital divides in countries result from specific society developments rather than being a quasi "natural" consequence of existing differences in formal education standards. They are obviously "homemade". As a result, age and education are in this combination risk factors for the participation in positive effects of digitalization in the Polish society. If we widen the perspective to European level, the same problem occurs: the EU-28 average indicator value of the digital divide was at a high level of 55.1 p.p.pp, which illustrates the existing social problem behind the scene. In the European Union, older persons with lower formal education have large chances of failing to keep up with digital development. In 2016, only five countries (of 34) revealed indicator values of digital divide below 20%pp, only seven below 30%pp and eleven below 40%pp. There is a large probability that social problems and conflicts deriving from the digital divide increase with its dimensions. But we find also positive outcomes in the analyzed context: the problem of *digital divide* is less obvious for the *younger population between 16 and 24 years of age*. The digital divide between persons with higher and lower formal attained education is significantly smaller than in older age cohorts. In 2016, five countries had indicator values of zero%pp; these were Iceland, Luxembourg, Norway, Finland and Estonia, 21 countries of had less than 5%pp and only four countries revealed values larger than 20%pp (Turkey 21.3, Mexico 28.8, Brazil 29.4 and Israel 30.1). The EU-28 average value was only 3.8%pp, in Poland it was 2.1 (higher education 100% of cohort vs. 97.9% with lower education). This implies that internet usage is a feature of general nature for the segment of younger population, therefore no sign of digital divide is visible in terms of pure media usage.

Figure 17.9 Last-ranked countries in digital divide between internet users with higher and lower formal education aged between 55 and 74 in selected OECD -economies in 2016, difference of shares [pp]



Source: Own study and calculations based on OECD data (2017h).

Summary and Implications

If Poland's international position in digitalization aspects were to be described by (only) one word, "negative" would be a consequent answer. But in practice more differentiation allows not only a more detailed but also more adequate picture of digital reality to be drawn. In the analysis, 10 indicators were used for the international comparison of Poland within a group of 34 OECD countries, with digitalization data provided by the OECD database. With the selected indicator set, Poland's position in terms of technology dissemination, market prices and social dispersion was analyzed and evaluated (see Table 1).

Table 17.1 Synopsis of Poland's international position in digital technology usage

Criteria	Measurement by indicator	Result
Internet speed	Average speed by akamai's indicator [Mb/s]	Last group (negative)
Dissemination of broad band	Broad band access per 100 inhabitants [%]	Last group (negative)
Access to high speed broad band	Fixed high speed broadband subscriptions (above 100 Mb/s) per 100 inhabitants [%]	Last group (negative)
Prices for fixed broad band for small clients	Set prices (20 GB/month, data transfer above 0.25 Mb/s) [$ (PPP)]	Medium group (neutral)
Prices for fixed broad band for large clients	Set prices (200 GB/month, data transfer above 25 Mb/s) [$ (PPP)]	First group (positive)
Prices for mobile broad band for small clients	Set prices (incl. 100 call minutes and data transfer 500 MB) [$ (PPP)]	First group (positive)
Prices for mobile broadband for large clients	Set prices (incl. 900 call minutes and data transfer 9 GB) [$ (PPP)]	First group (positive)
Internet usage	Internet user shares on entire population [%]	Last group (negative)
Digital divide according user age	Population share difference between young and old) [pp]	Last group (negative)
Digital divide according education	Population share difference between internet users with higher and lower formal education in age from 55 to 74 years [pp]	Last group (negative)

Source: Own study.

Three indicators showed a positive position of Poland in the group of leading countries (they concern, without exception, prices for internet services), one indicator showed a neutral position (also concerning prices for internet access) and six indicators showed a negative position (concerning technology characteristics, dissemination of the internet and social divide in digitalization). Poland (still) belongs to the countries with the smallest share of internet users in entire population in international perspective. Further serious problems include, e.g., an insufficient technological infrastructure for high-speed internet and a low scale of its dissemination among t Polish society. Here, substantial public efforts are required to close the existing gap in terms of the provision of adequate technological, legal and economic framework conditions to build competitive infrastructures in Poland but also to support incentives for people to take up the individual challenges of digitalization. In this matter Poland bears a twofold burden in international competition in the era of digitalization: the economy still lacks innovativeness to catch up with the competition also in more traditional industrial product segments. Simultaneously, it is necessary to set the course for digitalization of the economy. Producing (only) physical products of high quality will increasingly prove in the near future to be an inadequate strategy in international competition, both at the macro but also at the micro level, if these products tend to be increasingly regarded as platforms for digital services. But also social problems of digitalization are evident: concerning the two factors, age and formal education of population, Poland reveals one of the largest digital divides in the worldwide comparison. Especially this area constitutes a touchstone of whether Poland will be able to cope with challenges of digitalization in the future successfully.

Bibliography

Destatis [2018], Japan und Korea treiben Digitalisierung mit Glasfaser voran, Deutschland surft mit DSL und Kabel, in: https://www.destatis.de/DE/ZahlenFakten/LaenderRegionen/Internationales/Thema/WissenschaftForschungTechnologie/Breitbandanschluesse.html

OECD [2017a], Akamai's average speed, Q1 2016, OECD Digital Economy Outlook 2017, OECD, in: https://www.oecd-ilibrary.org/science-and-technology/oecd-digital-economy-outlook-2017_9789264276284-en

OECD [2017b], Fixed broadband subscriptions per 100 inhabitants, per speed tiers, December 2016, OECD Digital Economy Outlook 2017, OECD, in: https://www.oecd-ilibrary.org/science-and-technology/oecd-digital-economy-outlook-2017_9789264276284-en

OECD [2017c], OECD Fixed Broadband basket, Low user, including 20 GB / month. 0.250 Mbps and above, June 2017, OECD Broadband statistics, OECD, in: http://www.oecd.org/sti/broadband/broadband-statistics/

OECD [2017d], OECD Fixed Broadband basket, High user, including 200 GB / month, 25 Mbps and above, June 2017, OECD Broadband statistics, OECD, in: http://www.oecd.org/sti/broadband/broadband-statistics/

OECD [2017e], OECD Mobile broadband basket, Low user, including 100 calls + 500 MB, May 2017, VAT included, OECD Broadband statistics, OECD, in: http://www.oecd.org/sti/broadband/broadband-statistics/

OECD [2017f], OECD Mobile broadband basket, High user, including 900 calls + 2 GB, May 2017, VAT included, OECD Broadband statistics, OECD, in: http://www.oecd.org/sti/broadband/broadband-statistics/

OECD [2017 g], Internet users by age, 2016, OECD Broadband statistics, OECD, in: http://www.oecd.org/sti/broadband/broadband-statistics/

OECD [2017h], Internet users by age and educational attainment, 2016, OECD Broadband statistics, OECD, in: http://www.oecd.org/sti/broadband/broadband-statistics/

Final Conclusions

Competitive Position of the Polish Economy in the Context of Digital Economy Development

Marzenna Anna Weresa, Arkadiusz Michał Kowalski

The Fourth Industrial Revolution currently unfolding in the global economy involves the development of information and communication technologies (ICT) and integration of digital systems with economic processes. The use of new technologies allows an interactive network of products, machines and workforce to emerge, enhances linkages within the value chain, and affects the conditions of competition. Initially, the changes were labelled Industry 4.0 [Kagermann et al., 2013], but taking into account the fact that the development of the digital economy covers all sectors, the term "Economy 4.0" has now been coined. Digital transformation is not only the development of the Internet of Things, artificial intelligence, use of big data in business, or augmented reality, but also new business models, changes in the functioning of the public sector, social and cultural transformations leading to the rise of digital society. All those changes translate into the competitiveness of economies and regions [Porter, Heppelmann, 2014]. Schwab, 2016].

Digital transformation also has implications for the theoretical approach to competitiveness, expanding it to include a new dimension related to digitalization. Moreover, the need arises to seek new ways of measuring the competitive ability and position.

The analyses in this monograph refer both to theoretical issues concerning the competitiveness of economies in the context of the Fourth Industrial Revolution, and to empirical ones, which consist in determining the competitive position of the Polish economy in 2018 compared with other EU member states, taking into consideration the level of advancement of Industry 4.0.

The objective of theoretical considerations is to develop a new approach to the concept of competitiveness by identifying its new dimensions, such as technological, digital and sustainable competitiveness. They complement the traditional dimensions of competitiveness (competitiveness in international trade, income competitiveness, investment competitiveness, etc.) adding new elements related to the Fourth Industrial Revolution.

The empirical layer of the monograph seeks to answer the following questions: How does the international competitive position of Poland in the era of the digital economy compare with that of other EU member states? What factors have driven its changes in the last five years? How does the Fourth Industrial Revolution affect Polish enterprises? What are the barriers to the development of Industry 4.0 in Poland? What are the implications of the Fourth Industrial Revolution for the competitiveness of the Polish economy?

With regard to the theory considered in the context of the Fourth Industrial Revolution, it is worth giving some thought to whether and how the ongoing digitalization process is reflected in the concept of international competitiveness. In doing so, it should be noted that considerations of a conceptual nature are focused mainly on issues of macro competitiveness, i.e. considered at country level. As shown by the extensive literature, the concept of competitiveness is a multi-dimensional phenomenon; there are different definitions of this term, but so far there is no comprehensive theory of international competitiveness [cf., *inter alia*, Bossak, 1984; Hatzichronoglou 1996; Porter, 2008; Bieńkowski, Weresa, Radło, eds., 2010; Misala, 2011 and 2014; Aiginger, Vogel, 2015].

Traditionally defined competitiveness of countries is focused on the level and dynamics of unit labor costs or unit labor productivity. A competitive economy is one with continuously growing profitability which translates into improved living standards for citizens [Porter, 2008, p. 176]. GDP per capita at purchasing power parity (PPP) is one of the most commonly used measures of living standards. Yet many authors argue that viewing competition through the lens of per capita income has many weaknesses [Aiginger, Vogel, 2015]. In this context, many different approaches have emerged in the literature, such as competitiveness in international trade, investment competitiveness (related to climate for investors), or sustainable competitiveness encompassing social and ecological elements[1]. The Fourth Industrial Revolution is linked to digital competitiveness. Its definition and characteristics are based on technological competitiveness, which, in essence, means comparing the development of different types of technology in a country with the level of technology in the world. Digital competitiveness refers to the development of information and communication technologies (ICT), which are used today in manufacturing processes and contribute to value creation. Digital innovations and skills necessary for their implementation and use affect the productivity of inputs and thus become an important element of competitiveness. What is more, digitalization also impacts traditional dimensions

1 For more on this subject, see Chapter 1 of this monograph.

of competitiveness, e.g. it contributes to changes in GDP per capita, influences competitive advantages in international trade, or investment climate.

The institutional setup is another important area of impact of the Fourth Industrial Revolution and its main driver, digitalization. The considerations pursued in Chapter 2 of this monograph lead to the conclusion that the institutional environment may foster the efficiency of the socio-economic system or, conversely, reduce that efficiency. Qualitative improvement of institutions translates into a reduction in transaction costs of doing business. As a consequence, this can increase the productivity of inputs, i.e. improve competitiveness. In contrast, poor quality of institutions works in the opposite direction. It should be noted that the competitiveness of countries is influenced by both national and international institutions stemming from the global regulatory framework and international agreements and treaties. Nevertheless, the question arises: how these processes proceed in the era of the Fourth Industrial Revolution?

Digitalization and development of Industry 4.0 have a two-fold impact on competitiveness. Firstly, existing institutions are subject to change and adapt to digital disruption. Robotization, use of big data and artificial intelligence in manufacturing processes, augmented reality or the Internet of Things require the modification of broadly understood institutions, that is, established legal political and social principles that govern the fundamentals of production and exchange, including international exchange (e.g. regulations underpinning new business models, the scope and principles of intellectual property protection, etc.). In addition, there is a need to create completely new, previously unknown institutions such as, for example, regulations on personal data protection, network security, confidentiality protection or the use of open source solutions.

Many new regulations cannot be limited to a single country, as they have a worldwide impact, which is why the importance of global cooperation in this area is increasing.

To sum up, the new aspects of competitiveness related to the Fourth Industrial Revolution, identified in this monograph, concern an extension of the definition of competitiveness, with new factors being pinpointed which contribute to digital competitiveness, such as digital innovation consisting in the implementation of a new or substantially improved ICT product, process enhancements, marketing or organizational innovations, which emerge from the use of information and communication technologies. Digital knowledge and skills are also crucial to enable both manufacturers and users of digital solutions to derive additional benefits from these innovations. Furthermore, by impacting GDP, investment and foreign trade advantages, digitalization also means changing the traditional dimensions of competitiveness, such as income, investment or international competitiveness. Institutions are also modified, and the need arises to create completely new regulations, both at national and international level. The

Fourth Industrial Revolution is spreading rapidly in the global economy, gaining importance for global governance in the area of digital technologies. The development of Economy 4.0 also has implications for ways of measuring the competitiveness of countries, regions and businesses. There is a need to develop new metrics to characterize digital competitiveness.

The context of theoretical findings, outlined above, is a starting point for seeking an answer to the empirical questions posed in the monograph.

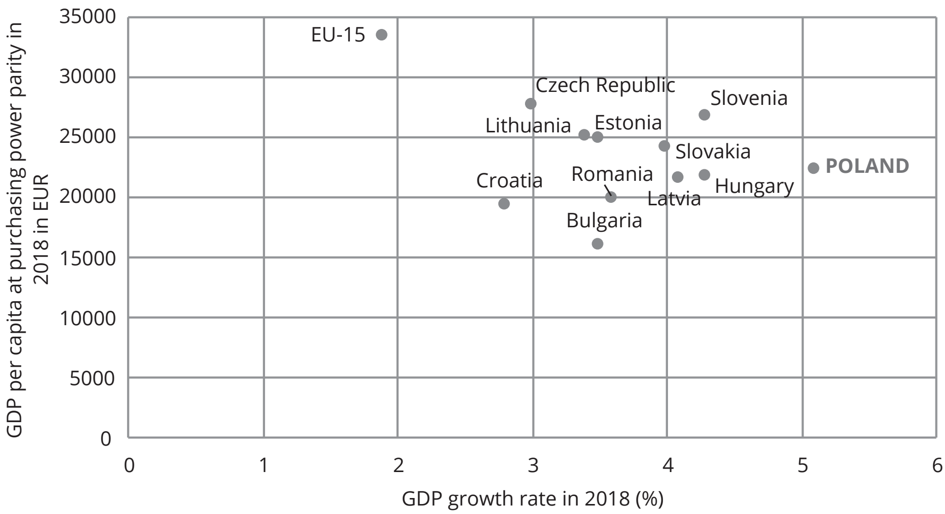
The first question refers to the identification of Poland's competitive position compared with other European Union member states in the era of digital economy. Preliminary conclusions on the change in the importance of Poland's economy in the European Union can be derived from the country's share of GDP across the EU-28. Taken at purchasing power parity, this indicator shows that Poland's share increased from 4.7% in 2010 to 5.4% in 2018. This resulted, among other things, from a higher rate of GDP growth compared to the EU-15 countries. Following Poland's accession to the EU, GDP was growing at an average of approx. 4.2% per year, and 2018 saw an acceleration of this dynamic to 5.2%. The developmental divide between Poland and the EU-15 countries has been gradually decreasing, and in 2018 alone the gap in the level of economic development was bridged by 2 percentage points. In 2018, GDP per capita in Poland (at PPP) represented 67% of the average for the EU-15, while in 2010 it was 57% (cf. Chapter 4 of this monograph).

Taken jointly, the values of the above two indicators for 2018, i.e. GDP per capita and real GDP growth rates allow Poland's position to be benchmarked against that of other EU countries from Central and Eastern Europe (Figure 18.1). It turns out that in 2018 year Poland performed the best in the CEE region in terms of real GDP growth rate, but much worse compared with other countries of the region in terms of prosperity level, lagging behind the Czech Republic, Slovenia, Lithuania, Estonia and Slovakia (Figure 18.1).

It is reasonable to complement the macroeconomic development indicators with the social dimension, one of its metrics being the level of income inequality of households measured by the Gini coefficient. The level of the income disparities and poverty risk has been gradually diminishing in Poland – the Gini coefficient stood at 29.2 in 2017 vs. 34.2 in 2010. Against the backdrop of the EU as a whole, Poland performs relatively well in terms of poverty reduction. The period 2010–2017 saw a significant reduction of the risk of poverty, both overall and among young people. The analysis carried out in Chapter 6 of this monograph shows that benefits under the Family 500+ program have contributed to narrowing income inequality.

A measure of social progress wider than the Gini coefficient is the Social Progress Index (SPI). It covers not only social aspects but also countries' achievements in environmental protection. The index comprises three components describing the following issues: basic human needs, foundations of well-being, and opportunity [Porter et al., 2017, pp. 16–18]. The SPI does not cover economic aspects of development, focusing exclusively on social and environmental factors. An analysis of the level of the index and its changes over time (i.e., since 2015, when the concept was created, and the values of the index were calculated for the first time for different countries) is therefore an excellent addition to measures of prosperity based on national income per capita.

Figure 18.1 GDP growth and development level measured by purchasing power parity standard (PPS) in 2018: Poland vs. Central and Eastern European EU countries



Source: Own study based on Eurostat data.

In terms of the value of the Social Progress Index, in 2018 Poland ranked 32nd among 146 analyzed countries. In the same group of countries, Poland came in lower, ranking 36th in terms of GDP per capita [SPI, 2018]. This means that Poland is relatively more advanced when social aspects of development are considered than if only economic aspects are taken into account. When it comes to social progress measured by the SPI, the leader among the Central and Eastern European EU countries in 2018 was Slovenia, followed by the Czech Republic and Estonia, and then Poland. In 2018, Poland managed to overtake Slovakia and move one place up in the EU, climbing from the 21st to the 20th position.

The SPI components which are relevant to the development of Industry 4.0 form a group categorized as “Access to Information and Communication”. An analysis of those components shows Poland as a very good performer in the development of mobile telephone access measured by the number of subscriptions per 100 people (5th in the

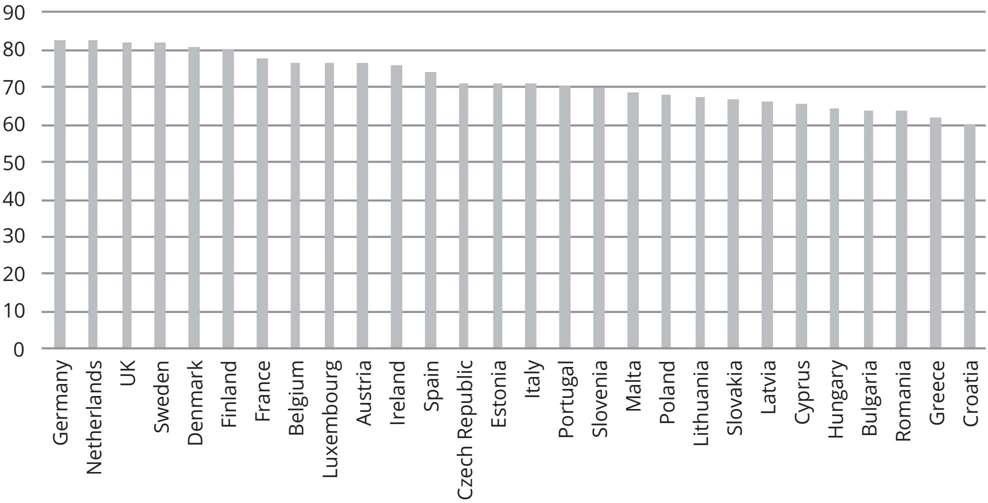
EU). Another indicator for which Poland is ranked among the leaders is the use of the Internet for citizens' participation in society and the economy (8th in the EU). The evaluation measure used here is the availability of e-participation tools on a national governmental portal for the provision of information on the Internet, organizing online public consultations, and engaging citizens directly in decision-making processes. The above-average Polish results regarding these two sub-indices enabled the country to rank 11th in the EU for "Access to Information and Communication", which may testify to some extent that the development of digital society is gaining ground. However, it is only one of few harbingers of the process, since another component of the SPI, defined as "Access to Communication and Information", reflecting the proportion of citizens with Internet access is rather low in Poland (22nd in the EU).

The analyses of the competitiveness of the Polish economy set out in this monograph can be summarized by means of the Global Competitiveness Index (GCI). In 2018, the index was expanded for the first time to include elements describing the advancement of the Fourth Industrial Revolution in individual economies. In designing the Global Competitiveness Index 4.0 (GCI 4.0), the World Economic Forum took into account more detailed information on factors that will be gaining in significance as economies move towards the Fourth Industrial Revolution. They are: human capital, innovation, resilience to external shocks, and agility. The factors are represented by new components of the GCI 4.0, both "soft" (e.g., entrepreneurial culture, multistakeholder collaboration, critical thinking, social trust) and "hard" ones (e.g., physical infrastructure, ICT development) [WEF, 2018, p. 2].

In 2018, Poland ranked 19th in the EU in terms of the GCI 4.0 (Figure 18.2). It is worth noting that the 2017 GCI, which did not include the aspects of the Fourth Industrial Revolution, placed Poland 17th among the EU member states [Weresa, Kowalski, 2018, p. 294].

Analyzing institutional factors and their significance in shaping competitive advantages in the era of the Fourth Industrial Revolution, the assessment of the key directions of economic policy in Poland in Chapter 9 has made it possible to diagnose key challenges for economic policy. One of them is the lack of vision of the target model of capitalism that would best suit the conditions prevailing in Poland and the country's development aspirations. This is reflected in an inconsistent institutional architecture whose individual elements show a low degree of complementariness. Another developmental challenge is the risk of perpetuating the peripheral position of the Polish economy in the European Union as that of a producer of low and medium-low-tech products and subcontractor for goods with a relatively low value added in global networks of transnational corporations. Another problem is related to the state's failure in providing conditions conducive to long-term economic development, which is reflected in low R&D expenditure, development of human capital and ICT technologies, which are of key significance in the context of the Fourth Industrial Revolution. What also poses a challenge is a high share of public expenditure in GDP (over 40%) and the structure of public expenditure itself, which is characterized by a high share of redistributive expenses at the cost of developmental expenses.

Figure 18.2 Poland's position among other EU member states in competitiveness ranking taking into account the advancement of the digital economy according to the World Economic Forum in 2018 (GCI 4.0 values)



Source: Own study based on WEF data, 2018, p. XI.

Competitiveness and innovation of the economy, also in the context of the development of Industry 4.0, is threatened by a low stock of social capital, manifesting itself, among other things, in a low level of social trust, prevalence of individualistic behavior over pro-social attitudes, an insufficient cooperation between actors in different sectors, the inability to take advantage of the potential of public institutions, an institutional environment unfavorable to the development of creative industries, and disparities in access to education, including civic and digital education. In particular, a historically conditioned pattern of distrust among Poles for the institutions of the state is augmented by numerous bureaucratic barriers imposed by the administration, which contributes to growing distrust in relations between the state and private business. Unfavorable demographic trends should also be noted, in particular a lasting decline in the dependency ratio showing the number of people in the labor force per retiree.

The development of Industry 4.0 brings with it the challenge of raising finance for projects related to the digitalization of the economy and participation of Polish enterprises in Industrial Revolution 4.0. These sources are similar to those drawn upon in financing traditional projects and include internal financing (retained profit or sale of assets), borrowing, leasing, factoring, forfaiting, issuing debt or equity instruments in the capital market, venture capital funds, and business angels. Particular difficulties in financing investments related to Industry 4.0 are experienced by small and medium-sized enterprises, which compare unfavorably with large entities in terms of financial, physical and human resources or professional strategies and management systems. Large firms usually operate in more demanding markets, where they compete with strong transnational corporations, which is a significant incentive driving innovations, including Industry 4.0 solutions. Small and medium-sized enterprises, which have a narrower scope of business, based on a smaller number of products, have relatively less room for innovation.

The factors behind the competitiveness of the economy include the amount of capital expenditure, which determine the rate of transformation of the product structure and the economic model. The analysis of investment outlays carried out in Chapter 11 shows that domestic funds prevail as the biggest source of investment financing in Poland, in addition to a steadily decreasing, albeit still significant, inflow of capital from abroad. At the same time, the volume of investment outlays increased continuously over the 2013–2018 period (except 2016), which stimulated the increase of competitiveness of the Polish economy. In particular, the growth in investment outlays in 2018 was caused mainly by endogenous factors, including increased public investments related to the political business cycle and local government elections, low unemployment rate, and negative real interest rates. In addition, a fast growth of investment in machines and equipment was recorded, which makes it reasonable to expect that this may lead to gradual upgrading of the machinery fleet and increasing the degree of its mechanization and robotization, creating positive conditions for the implementation of Industry 4.0 solutions.

The Fourth Industrial Revolution leads to profound changes in the development of human capital and functioning of the labor market. Demand for routine labor that requires low skills is declining, which translates into growing inequalities between low-skilled and high-skilled workforce. It should also be noted that even industries that require high skills, such as medical, legal or financial services, are subject to progressive automation. This opens up new opportunities for the development of flexible forms of labor, which can result in an increase in the number of self-employed persons. In view of the need for continuous improvement of skills in order to meet the challenges of Industry 4.0, lifelong learning (LLL), has been gaining in significance. Compared with other EU countries, Poland has one of the lowest rates of adult participation in lifelong learning – according to the results of the Continuing Vocational Training Survey

[European Commission 2018], in 2017, the participation of adults in lifelong learning was 4% in Poland compared to the EU average of 10.9%, while in 2015 44.7% of Polish enterprises provided vocational training to their employees (the EU average was 72.6%).

The significance of institutions and tangible and intangible resources, in particular technological progress, to shaping Poland's competitiveness in the years 2009–2018 can be determined by analyzing changes in total factor productivity (TFP). The research conducted in Chapter 13 shows that Poland performed the best among 11 Central and Eastern European EU member states in terms of the average TFP growth (1.5%). While the variables driving total factor productivity include Industry 4.0, it is not possible to precisely estimate their impact by means of the available statistical data.

Industry 4.0 is driven by innovations implemented in new technological areas related to digitalization. An assessment of the state of digitalization of the economy in Poland is enabled by an analysis of the Digital Economy and Society Index (DESI), according to which Poland, which ranks 24th in the European Union, was classified among countries lagging behind in terms of digital competitiveness. Such a position means the risk of marginalization of the Polish economy in the context of the progressive re-industrialization of developed countries, which consists in transferring industrial production with the highest value added to digitally advanced countries, where the development of Industry 4.0 will boost productivity and value added.

The development of Industry 4.0 involves various challenges to the economy. What poses a technological challenge is the implementation of smart manufacturing systems and integration and synchronization of their elements. Implementation of digital systems brings the advantage of greater autonomy in the management of interlinked elements of the value chain and the capability to monitor manufacturing and logistic systems. It should be noted, however, that years of delays in phasing in the third industrial revolution have become a challenge to the Polish economy, as many enterprises are still at the stage of implementing the automation of production instead of building ecosystems of online-connected collaborative devices. Inherent in functioning in a digital economic reality is the problem of ensuring cyber-security. Industry 4.0 relates not only to technological aspects, but it also requires the development of necessary competences and skills. In this context, challenges appear, related to the formation of human capital and ensuring workforce with relevant skills. In addition, Poland faces the problem of low competence and awareness of executives about the significance of Industry 4.0. This has a negative impact on the implementation of new digital technologies, all the more so as Polish firms, in particular small and medium-sized enterprises, experience difficulties in access to capital that has to be invested at the start in innovative equipment and technologies, before returns are generated in future, e.g. through reduced operating costs.

The development of Industry 4.0 creates new challenges for innovation policy, which should support the digitalization of the economy. The EU policy directions are currently set by the Europe 2020 strategy of social and economic development [Europe 2020, 2010] and the flagship initiatives, in particular the Innovation Union and the Digital Agenda for Europe. In individual member states, EU strategic guidelines are implemented through measures including operational programs. In Poland, the Digital Poland Operational Program for 2014–2020 (DPOP 2014–2020) is of key significance in this area. In diagnosing public support in the field of digitalization, it should be borne in mind, however, that at the time the Europe 20200 strategy or DPOP 2014–2020 was adopted, digital development was at a different stage than it is today and did not cover many areas related to Industry 4.0. The Fourth Industrial Revolution is characterized by its rapid progress and continuous implementation of new technological solutions. This poses challenges to innovation policy, which should respond in a flexible manner to changing technological challenges and trends.

The research results presented in this monograph provide a basis for recommendations for a competitiveness support policy, in particular in the context of the Fourth Industrial Revolution. Due to the complexity and comprehensiveness of innovation processes related to digitalization, it is necessary to introduce a holistic set of mutually complementary policy instruments that support the development and implementation of Industry 4.0 solutions. Given the fact that the majority of Polish business entities, especially small and medium-sized enterprises, are still at the initial stage of automation, innovation policy should be aimed at public co-financing of industrial or development research in the field of digital technologies, automation, and technological process robotics. Intervention would address the problem of limited capability to finance digital investments and it would reduce the risk involved in creating and implementing solutions that fall in line with the Fourth Industrial Revolution. This would contribute to raising the level of digitalization among Polish enterprises and increasing the number of new digital technologies and products implemented in business.

In order to increase investment of Polish enterprises to strengthen the infrastructural base for the development of Industry 4.0, it is worth considering the introduction of subsidies or financial instruments (loans or bank guarantees) for the purchase of hardware or software necessary to deploy digital technologies, and to automate industrial processes and use Robotic Process Automation (RPA) solutions, meaning the automation of service mechanisms through the use of IT applications, that is, robots [Aguirre, Rodriguez 2017; Van der Aalst, Bichler, Heinzl 2018]. Such instruments would impact the professionalization of business processes and enterprise management (e.g., through cloud computing or big data analytics), reducing the engagement of human resources in performing routine, repeatable operations.

The implementation of Industry 4.0 is conditional on the development of skills necessary to drive digitalization, and on improved awareness of the existing technological and business opportunities, as well as available support programs in this field. This gives rise to the need to include relevant digital skills in educational programs, and to develop relevant teaching methods for specific target groups, covering, e.g., children, entrepreneurs, elderly persons, etc. It is also important to work towards an optimal allocation of skills, e.g. by ensuring appropriate flexibility of the labor market, which is characterized by the capability to quickly reallocate workers and talent between industries and enterprises. This requires efforts to be taken, aimed at increasing the participation of adults in continuous education and applying innovative methods in pilot programs and experiments in this area.

Bibliography

Aguirre S., Rodriguez A. [2017], *Automation of a Business Process Using Robotic Process Automation (RPA): A Case Study*, in: Figueroa-García J., López-Santana E., Villa-Ramírez J., Ferro-Escobar R. (eds.), *Applied Computer Sciences in Engineering*, “Communications in Computer and Information Science” book series (CCIS, Vol. 742), Springer, Cham.

Aiginger, K., Vogel, J. [2015]. *Competitiveness: from a misleading concept to a strategy supporting Beyond GDP goals*, “Competitiveness Review”, 25(5), pp. 497–523.

Bieńkowski W., Weresa M.A., Radło M.J. (eds.) [2010], *Konkurencyjność Polski na tle zmian gospodarczych w krajach OECD. Ewolucja znaczenia czynników konkurencyjności*, SGH Publishing House, Warsaw.

Bossak J.W. [1984], *Społeczno-ekonomiczne uwarunkowania międzynarodowej zdolności konkurencyjnej gospodarki Japonii*, “Monografie i Opracowania”, No. 153, SGPiS, Warsaw.

Kagermann, H., Helbig, J., Hellinger, A., Wahlster, W., [2013], *Recommendations for Implementing the strategic initiative INDUSTRIE 4.0: securing the future of German manufacturing industry*; final report of the Industrie 4.0 working group, Forschungsunion.

European Commission [2018], *Education and Training Monitor 2018. Poland*, Publications Office of the European Union, Luxembourg.

Misala J. [2011], *Międzynarodowa konkurencyjność gospodarki narodowej*, PWE, Warsaw 2011

Misala J. [2014], *Theoretical Grounds of the Development of Long-Term Competitive Advantages in International Trade*, in: M.A. Weresa (ed) [2014], *Innovation, Human Capital and Trade Competitiveness. How Are They Connected and Why Do They Matter?*, Springer, Cham Heidelberg, New York, Dordrecht, London, pp. 3–51.

Porter M., Stern S., Green M. [2017], *Social Progress Index 2017*. Social Progress Imperative, Washington, https://www.socialprogressindex.com/assets/downloads/resources/en/English-2017-Social-Progress-Index-Findings-Report_embargo-d-until-June-21–2017.pdf, accessed 20.03.2018.

Porter M.E., Heppelmann J.E. [2014], *How Smart, Connected Products Are Transforming Competition*, "Harvard Business Review" 92, No. 11 (November 2014), pp. 64–88.

Schwab K. [2016], *The Fourth Industrial Revolution*, World Economic Forum, Cologny/Geneva.

SPI (2018), https://www.socialprogress.org/assets/downloads/scorecards/2018/en/POL-Scorecard.pdf, accessed 31.05.2019.

Weresa M.A., Kowalski M.A. [2018], *The Competitive Position of the Polish Economy in 2010–2017 with Focus on City Competitiveness*, in: *Poland. Competitiveness Report 2018. The Role of Cities in Creating Competitive Advantages*, SGH Publishing House, Warsaw, pp. 291–302.

Van der Aalst W.M., Bichler M., Heinzl A. [2018], *Robotic process automation*, "Business & Information Systems Engineering", Vol. 60, Iss. 4, pp. 269–272.

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