EQUILIBRIUM
Quarterly Journal of Economics and Economic Policy
Volume 13 Issue 1 March 2018
p-ISSN 1689-765X, e-ISSN 2353-3293
www.economic-policy.pl

ORIGINAL PAPER

Citation: Wierzbicka, W. (2018). Information infrastructure as a pillar of the knowledge-based economy — an analysis of regional differentiation in Poland. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *13*(1), 123–139. doi: 10.24136/eq.2018.007

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Received: 18 May 2017; Revised: 14 December 2017; Accepted: 12 January 2018

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Information infrastructure as a pillar of the knowledge-based economy — an analysis of regional differentiation in Poland

JEL Classification: *O30; O33; R11*

Keywords: *information infrastructure; knowledge-based economy; regional differentiation; divergence; convergence*

Abstract
Research background: Information infrastructure is a very important pillar within a knowledge-based economy. The widespread use of information and communication technologies facilitates effective communication, dissemination and processing of information and knowledge. It also creates new opportunities for the effective use of knowledge and information in building competitive advantage. Information infrastructure is also a significant determinant in the development of territorial units, and therefore it affects the regional dimension of building the knowledge-based economy in Poland.
Purpose of the article: The purpose of the study was to evaluate regional differentiation of the level of information infrastructure in Poland, and changes which occurred in this respect between 2010 and 2015. An attempt was made to provide an answer to the following question: Are regional differences in the level of information infrastructure in Poland increasing or decreasing, i.e. is a regional divergence or a regional convergence process taking place in this respect?
Methods: Taxonomic methods were used, including linear ordering based on a synthetic variable and a method of grouping linearly-ordered objects.
Findings & Value added: The regional differentiation of the level of information infrastructure in Poland has slightly decreased, which means, that a slow convergence process has taken place in this respect. This fact is confirmed by the value of the variation coefficient, which fell from a level of 17.6% in 2010 to a level of 14.4% in 2015. Convergence

processes were observed in twelve provinces. In the case of seven of them, they had the nature of a catching-up effect, and in the case of the remaining five — a lagging-behind effect. Divergence processes were observed in four provinces. The Dolnośląskie and Mazowieckie Provinces distanced themselves from other areas of the country. In the Małopolskie and Opolskie Provinces a marginalisation effect was observed.

Introduction

The modern economy is known as a knowledge-based economy (KBE). A strategic factor for its economic growth is knowledge, and the capacity to create, absorb and use it. One of the pillars of the knowledge-based economy is a modern and adequate information infrastructure. It facilitates effective communication, dissemination and processing of information and knowledge. This implies the creation of new knowledge, and creates new possibilities for the effective use of knowledge and information in the management process. The widespread use of information and communication technologies contributes not only to the increased efficiency of individual economic entities, but also to the possibilities of enhancing the entire economy. Therefore, it is of vital importance for building a knowledge-based economy and forming the information society.

Information infrastructure is also a significant determinant in the development of territorial units, and therefore, it influences the regional dimension of building a KBE. As noted by Miszczak (2012, p. 109), the development of information and communication technologies increases the amount and the quality of information and facilitates access to it. The growing volume of circulating information implies the generation of new knowledge which — being one of the factors of regional development — determines the shaping of the new structure of an economic region. Therefore, regional differences in the level of information infrastructure may contribute to the aggravation of regional differences in the level of economic development, and may slow down the process of building a knowledge-based economy at the national level.

In light of the above, the purpose of this study was to evaluate regional differentiation of the level of information infrastructure in Poland, and changes that occurred in this respect between 2010 and 2015. An attempt was made to provide an answer to the following question: *Are regional differences in the level of information infrastructure in Poland increasing or decreasing, i.e. is a regional divergence or a regional convergence process taking place in this respect?* The proposal of an answer to the research question was formulated in the form of the following research hypothesis: *Regional differentiation of the level of information infrastructure in Poland*

is decreasing, i.e. a regional convergence process is taking place in this respect.

The study was performed at the regional NUTS II level. In the study, taxonomic methods were used, including linear ordering based on a synthetic variable and a method of grouping linearly-ordered objects.

Information infrastructure as a pillar of the knowledge-based economy

The knowledge-based economy is a type of economy where knowledge is acquired, created, disseminated and used effectively by companies, organisations, natural persons and communities; contributing to the rapid development of the economy and society (Dahlman & Andersson, 2000, p. 32). This is an economy that utilises knowledge as the key engine of economic growth (Gorji & Alipourian, 2011, p. 44) and which is characterised by a high and growing intensity of ICT usage by well-educated workers (Bashir, 2013, p. 29). The knowledge-based economy is also defined as an economic system fuelled by innovation which, influencing all branches of the economy, accelerates enhanced productivity and the rate of economic growth (Piech, 2007, p. 27). Therefore, four pillars of knowledge are of vital importance for the development of the KBE: an economic incentive and institutional regime, educated and skilled workers, an effective innovation system, and a modern and adequate information infrastructure (Chen & Dahlman, 2006, p. 4).

The information infrastructure, also defined in the literature as *information and communication technologies (ICT),* creates the key infrastructure of the knowledge-based economy. Information and communication technologies are the backbone of this kind of economy and, as such, are imperative for its development. They also provide significant support for the development of the other three pillars of knowledge (Al-Busaidi, 2014, p. 16). For example, information and communication technologies are vital tools for knowledge workers, allowing them to take full advantage of technology's capacity to access, manipulate and process information. ICT are also an integral part of education, offering students access to information, as well as a range of information technology-based learning tools (Tocan, 2012, p. 210). Information and communication technologies are one of the key factors that connect technological progress and the globalisation process, which create the knowledge-based economy (Kałkowska, 2016, p. 363). The ICT sector is a key pillar of the knowledge-based economy, the development of which has become a priority challenge for many countries, including Poland (Strożek & Jewczak, 2016, p. 208). As noted by Balcer-

zak & Pietrzak (2017a, p. 8) the existence of digital economy infrastructure is the permitting condition, but it is not sufficient for macroeconomic gains. The benefits can be obtained, when there are effective complementarities between the tangible digital economy infrastructure and the intangible factors, such as quality of human capital and effective institutional order.

In line with the KBE concept, information infrastructure refers to the accessibility, reliability and efficiency of computers, phones, television and radio sets and the various networks that link them (Chen & Dahlman, 2006, p. 7). It encompasses hardware, software, networks and media for the collection, storage, processing transmission and presentation of information in the form of voice, data, text and images (World Bank, 2003, p. 2). Information infrastructure consists of a set of modern devices, extended databases, varied and competing services and specialist institutions whose aim is to ensure the effective communication and efficient processing, storage and distribution of useful information for a number of entities. This means that information infrastructure is made up of not only traditional media and advanced ICT, but also new areas of economic, social and public activity, such as e-trade, e-banking, e-learning and e-administration (Madrak-Grochowska, 2013, pp. 361–362).

Dynamic information infrastructure facilitates the efficient communication, distribution and processing of information and knowledge (Al-Busaidi, 2014, p. 16). It enables citizens and companies to have easy and cheap access to material information from all over the world (Tocan, 2012, p. 207). It allows for the relatively inexpensive and efficient distribution of information; therefore, it contributes to a decrease in uncertainty and transaction costs. Moreover, with the increased flow of information, technologies can be acquired and adapted more easily again, leading to increased innovation and productivity (Gorji & Alipourian, 2011, p. 53). Constructing a dynamic information infrastructure and a competitive and innovative information sector in the economy leads to the emergence of various efficient and competitive services in the area of information and communication, available to all parts of society (Kukliński (ed.), 2003, p. 15). The main beneficiaries of the knowledge-based economy and information and communication technology users are companies, public administrations, and citizens; all at the same time (Olszak & Ziemba, 2011, p. 197). ICT have become ubiquitous in the modern world — they are present in virtually all areas of economic and social life, noticeably changing how people behave and interact with each other, how companies run their businesses, and how governments provide public services (Arendt, 2015, p. 248). Information and communication technologies are tools that have been gener-

ating several ways of living and working together (Kamińska, 2009, p. 166).

Information and communication technologies are one of the most important factors for development and economic growth in the globalised economy (Maryska *et al*., 2012, p. 1060). ICT contribute to development in two ways: as an enabler for the delivery of public and commercial services, and as core technological competency for transforming all sectors of the economy. Furthermore, ICT as an industry is a new source of growth and a keystone sector of the knowledge economy in its own right (Hanna, 2010, p. 183). Being one of the major determinants of development and the engine for knowledge-based economies (cf. Żelazny & Pietrucha, 2017, pp. 43–62; Balcerzak & Pietrzak, 2016, pp. 66–81), ICT may play an important role in the convergence processes among countries or regions.

Research methodology

In line with the KAM[1] (*Knowledge Assessment Methodology*), designed by World Bank experts, the measurement of the knowledge-based economy takes place on the basis of numerous variables representing individual KBE pillars. Efficient communication, as well as data transfer processes that influence the distribution and processing of information and knowledge are measured as part of the pillar describing information infrastructure. To evaluate the level of information infrastructure, the following variables are used (Chen & Dahlman, 2006, pp. 37–38; Wasiak, 2008, pp. 83–84; Ujwary-Gil, 2013, p. 168; *Measuring Knowledge*... 2016, p. 3):

- telephones per 1,000 persons;
- computers per 1,000 persons;
- Internet users per 10,000 persons;
- television sets per 1,000 persons;
- expenditure on ICT as % of GDP;
- availability of e-administration.

Nevertheless, numerous studies pertaining to the information infrastructure have been performed on the basis of a modified set of variables as compared to the KAM (cf. Kukliński & Burzyński, 2004, pp. 2–41; Shapira *et al*., 2006, pp. 1522–1537; Central Statistical Office of Poland, 2017, pp. 11–177; Strożek & Jewczak, 2016, pp. 208–217; Balcerzak & Pietrzak,

[1] Many other indices have now been designed to measure the development of ICT and the information society, e.g. ICT Development Index — IDI or Networked Readiness Index - NRI (see Goliński, 2011, pp. 165–216).

2017b, pp. 21–28). When selecting a set of variables, the authors try to choose variables that correspond best to the adopted definition, and are adequate to the level of the performed analysis (not all variables proposed in the KAM are available at the regional level). They also take into account the availability of data for the adopted research period[2].

Being guided by the criteria above, the author selected variables with respect to substantive, formal and statistical aspects (taking into account their variability and the degree of correlation with other variables[3]). The final set of variables on the basis of which a synthetic index of information infrastructure was built included the following variables:

- X_1 – percentage of households with PCs with Internet access;
- X_2 – percentage of households with mobile phones;
- X_3 – percentage of households with satellite or cable television devices;
- X_4 – percentage of non-financial sector companies using computers;
- X_5 – percentage of non-financial sector companies with Internet access;
- X_6 – percentage of non-financial sector companies with their own websites;
- X_7 – percentage of non-financial sector companies receiving orders via computer networks;
- X_8 – percentage of non-financial sector companies filing orders via computer networks;
- X_9 – percentage of non-financial sector companies using the Internet in contacts with public administration bodies.

Synthetisation of variables was conducted with the use of non-pattern methods which consist in averaging the values of normalised variables. To ensure the comparability of provinces in a given year, as well as among years, diagnostic variables were treated as panel data. From a technical point of view, this means that in the formula according to which the unitarisation was performed, the minimum and the maximum values of each variable were designated from the entire panel of data, encompassing all years and provinces (cf. Bartkowiak-Bakun, 2017, pp. 417–432; Zygmunt, 2017, pp. 505–521; Balcerzak, 2015, pp. 190–210).

Normalisation of variables was performed with the use of the zeroed unitarisation procedure. Due to the fact that all variables were assigned

[2] In empirical research, the selection of variables should meet formal conditions, for example, the completeness of data for the largest number of objects accepted for research (see Kruk & Waśniewska, 2017, p. 343; Cheba & Szopik-Depczyńska, 2017, p. 492).

[3] The threshold value of the coefficient of variation was set at 5%, while the threshold value of the correlation coefficient was set at 0.8 (it was conditioned by substantive aspects).

with the character of stimulators[4], the procedure was performed in line with the formula below (Panek & Zwierzchowski, 2013, p. 37):

$$z_{ij} = \frac{x_{ij} - \min\limits_{i}\{x_{ij}\}}{\max\limits_{i}\{x_{ij}\} - \min\limits_{i}\{x_{ij}\}} \qquad i = 1, 2, \dots, n; j = 1, 2, \dots, m, \quad (1)$$

where:
z_{ij} – normalised value of the j^{th} variable in the i^{th} object;
x_{ij} – value of the j^{th} variable in the i^{th} object;
$\min\limits_{i}\{x_{ij}\}$, $\max\limits_{i}\{x_{ij}\}$ – min and max values of the j^{th} variable in the set of objects.

Normalised variables were subject to the synthetisation procedure in line with the aggregating formula (Panek & Zwierzchowski, 2013, p. 63):

$$s_i = \frac{1}{m}\sum_{j=1}^{m} z_{ij} \qquad i = 1, 2, \dots, n; j = 1, 2, \dots, m, \quad (2)$$

where:
s_i – value of synthetic variable in the i^{th} object;
z_{ij} – normalised value of j^{th} variable in the i^{th} object;
m – number of variables.

The synthetic index of the information infrastructure (ICT index) adopted values within the range of [0, 1]. A higher value of the index implies a more favourable position of the province with respect to the examined characteristics.

Regional differentiation of the level of information infrastructure in Poland

Regional differentiation of the level of information infrastructure in Poland was evaluated on the basis of the values of the synthetic ICT index in provinces between 2010 and 2015, which are presented in Table 1. Values higher than the average in a given year are appropriately marked.

Between 2010 and 2015, the level of information infrastructure in Poland clearly improved, which is confirmed by an increase in the average

[4] Verification of the adopted character of variables was performed *ex post* by checking the correlation of individual variables with the synthetic variable.

value of the synthetic ICT index for Poland by 27%. The dynamics of changes occurring in this respect in individual provinces was diversified. The highest growth was recorded in the Świętokrzyskie Province — 1.59 and the Lubelskie Province — 1.54; the lowest was in the Kujawsko-Pomorskie Province and the Małopolskie Province — 1.13 in each. A 1% drop in the level of information infrastructure when compared to 2010 was recorded in only one province — the Zachodniopomorskie Province.

Regional differentiation of the level of information infrastructure in Poland is at an average level, whereas the scale of this differentiation has slightly decreased[5]. This may be confirmed by the value of the variation coefficient, which fell from a level of 17.6% in 2010 to a level of 14.4% in 2015, as well as the fact that the relation between the maximum and the minimum values of the synthetic ICT index in provinces in individual years fell. In 2010, it amounted to 2.1; in 2015 it was at the level of 1.7.

Attention should be drawn to the fact that regional convergence with respect to the level of information infrastructure in Poland was accompanied by the convergence and divergence of individual provinces. The nature of processes occurring in provinces was identified on the basis of values of the synthetic ICT index in 2010 and its changes between 2010 and 2015 in comparison to the average value for Poland. The results of the grouping are presented in Table 2.

Convergence processes were identified in 12 provinces. In the case of seven of them, they had the nature of a catching-up effect, and in the case of the remaining five there was a lagging-behind effect. The following provinces were characterised by catching-up convergence: Lubelskie, Lubuskie, Łódzkie, Podkarpackie, Podlaskie, Świętokrzyskie and Warmińsko-Mazurskie. At the beginning of the examined period, the level of the synthetic index of information infrastructure in these provinces was much lower than the national average; however, on account of higher than average growth dynamics in this respect, their situation improved in comparison to the average situation for the country. The second type of convergence occurred in the following provinces: Kujawsko-Pomorskie, Pomorskie, Śląskie, Wielkopolskie and Zachodniopomorskie. As a result of the lagging-behind that was observed, the situation of these provinces was aggravated in comparison to the average situation in the country. What is more, the position of these provinces in rankings with respect to the ICT level also dropped. In the case of Pomorskie, Śląskie and Wielkopolskie, there was

[5] In the case of the KBE pillar pertaining to human capital, regional divergence is slightly higher, yet the scale of divergence is growing (cf. Wierzbicka, 2017, pp. 329–343). In the case of the pillar describing the innovation system, regional divergence is much higher, yet it displays a decreasing tendency (cf. Wierzbicka, 2016, pp. 343–357).

only a one-position drop, yet in the case of Zachodniopomorskie the result worsened by eight positions (cf. Table 3).

Only four provinces were characterised by divergence processes. As in the case of convergence processes, they were of a dual character. In the Małopolskie and Opolskie Provinces a marginalisation divergence was observed. These provinces were characterised by a low level of information infrastructure even at the beginning of the examined period. Additionally, their growth dynamics in this respect were much lower than average, which worsened their position in comparison to the average situation in the country. For example, in 2010 the synthetic ICT index in the Małopolskie Province was lower than the average value for Poland by 5.8%, whereas in 2015 it was lower by 15.9%. A reverse situation was observed in the case of the Dolnośląskie and Mazowieckie Provinces. At the beginning of the examined period these provinces were already characterised by a level of information infrastructure that was higher than the national average. Furthermore, they recorded higher than average growth dynamics in this respect, and therefore they distanced themselves from other areas of the country. For example, in 2010 the synthetic ICT index in the Mazowieckie Province was higher than the average value for Poland by 17.9%, and in 2015 by as much as 24.1%.

In consequence of such processes, the position of individual provinces with respect to others has changed quite significantly. This is confirmed by the results of rankings prepared on the basis of the value of the synthetic ICT index presented in Table 3 (worse positions of provinces are marked with darker shades of grey).

Starting from 2011, Mazowieckie Province has been the leader with respect to the level of information infrastructure. The advantage of this province is that it has the highest national percentage of households with PCs with Internet access, and non-financial sector companies receiving and filing orders via computer networks and having their own websites. The Pomorskie Province has a strong and relatively stable situation with respect to the level of information infrastructure; in 2015, it held second position in the country. The advantages of this province include the highest national percentage of non-financial sector companies using the Internet in contacts with public administration bodies, and the highest percentage of households equipped with satellite and cable television devices, as well as a high percentage of households with PCs with Internet access. Dolnośląskie Province held the third highest position in the ranking in 2015; it is characterised by the highest national percentage of non-financial sector companies making use of computers and having Internet access.

The Świętokrzyskie Province occupied the lowest position in the ranking over the entire analysed period. This province's weakness is that it has the lowest national percentage of households with PCs with Internet access, and non-financial sector companies receiving orders via computer networks. This province is also characterised by a very low percentage of non-financial sector companies using computers and having Internet access. The Warmińsko-Mazurskie Province also holds a low position in the rankings along with the Zachodniopomorskie Province since 2012, which dropped to 15th position in 2015 from 7th position in 2010. Such a significant aggravation of the situation in the province has been caused by the highest national decrease in the percentage of non-financial sector companies using computers and having Internet access; the result was the lowest position in the country in these two aspects. As a consequence of these changes, the Zachodniopomorskie Province was classified in the group of provinces with a very low ICT level in 2015 (Fig. 1).

The classification of provinces was performed with the use of the standard deviation method. The borders of divisions were set out on the basis of the arithmetic mean values of the synthetic ICT index for all provinces ($\bar{s}$) and the level of standard deviation of this index $S(s)$ in the examined year (Panek & Zwierzchowski, 2013, pp. 118-119). The collection of examined objects was divided into four groups:

1. Group with very high ICT level, encompassing objects with the values of the synthetic index within the range of $s_i \geq \bar{s} + S(s)$, therefore $s_i \geq 0.744$;
2. Group with high ICT level, encompassing objects with values of the synthetic index within the range of $\bar{s} + S(s) > s_i \geq \bar{s}$, therefore $0.744 > s_i \geq 0.643$;
3. Group with low ICT level, encompassing objects with values of the synthetic index within the range of $\bar{s} > s_i \geq \bar{s} - S(s)$, therefore $0.643 > s_i \geq 0.542$;
4. Group with very low ICT level, encompassing objects with values of the synthetic index within the range of $\boldsymbol{s_i} < \bar{s} - S(s)$, therefore $\boldsymbol{s_i} < 0.542$.

Apart from the above-mentioned Zachodniopomorskie Province, the group of provinces with a very low level of information infrastructure included the Lubelskie and Świętokrzyskie Provinces. Three provinces, i.e. Dolnośląskie, Mazowieckie and Pomorskie, were classified in the group of provinces with a very high ICT level. The group of provinces with a high ICT level includeed Kujawsko-Pomorskie, Lubuskie, Podkarpackie, Śląskie and Wielkopolskie.

Conclusions

The development of information infrastructure is an essential condition for the growth of an information society and for building a knowledge-based economy, including at the regional level. Having a modern information infrastructure facilitates effective communication, as well as the dissemination and processing of information and knowledge, which is one of the factors of regional development. Therefore, a significant improvement in the level of information infrastructure in Poland is of vital importance. The highest growth of the synthetic index of information infrastructure was recorded in the Świętokrzyskie and Lubelskie Provinces, i.e. in provinces which were characterised by the lowest level of this index at the beginning of the examined period. The lowest growth was recorded in the Kujawsko-Pomorskie and Małopolskie Provinces. In one province, i.e. Zachodniopomorskie, a drop in the synthetic ICT index was recorded.

As a consequence of the diverse dynamic changes and a diverse level of information infrastructure at the beginning of the examined period, parallel convergence and divergence processes were observed within the group of provinces. Convergence processes were observed in twelve provinces. In the case of seven provinces there was a catching-up effect. This was observed in the: Lubelskie, Lubuskie, Łódzkie, Podkarpackie, Podlaskie, Świętokrzyskie and Warmińsko-Mazurskie provinces. Whereas in the remaining five provinces, there was a lagging-behind effect. These were the Kujawsko-Pomorskie, Pomorskie, Śląskie, Wielkopolskie and Zachodniopomorskie provinces. Divergence processes were observed in four provinces. It is important to note that in the case of two of them, i.e. Małopolskie and Opolskie, these processes had a marginalisation effect. The situation of these provinces in comparison to the average situation in the country has been aggravated, and the distance separating these provinces from others has increased. In 2015, it was greater than at the beginning of the examined period.

As a result of the parallel convergence and divergence processes, the structure of the group of provinces with respect to the level of information infrastructure has become more homogeneous. This fact is confirmed by the value of the variation coefficient, which fell from the level of 17.6% in 2010 to the level of 14.4% in 2015. The decreasing regional differentiation of the level of information infrastructure in Poland means that a slow convergence process has taken place in this respect. Therefore, the research hypothesis has been positively verified.

Summing up, changes occurring in the area of the level of information infrastructure in Poland have a positive character. Improvement in the level

of information infrastructure stimulates the process of building a knowledge-based economy and the developing an information society. This may also contribute to an increase in the total productivity of production factors and overall economic development.

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Annex

Table 1. Synthetic index of the information infrastructure in provinces between 2010 and 2015

Province	Value of the the synthetic ICT index						Dynamics of changes in 2010-2015
	2010	2011	2012	2013	2014	2015	
Dolnośląskie	0.559	0.564	0.605	0.552	0.670	0.757	1.35
Kujawsko-Pomorskie	0.582	0.592	0.598	0.506	0.558	0.655	1.13
Lubelskie	0.346	0.436	0.528	0.597	0.503	0.533	1.54
Lubuskie	0.533	0.537	0.514	0.560	0.550	0.698	1.31
Łódzkie	0.467	0.456	0.537	0.530	0.527	0.625	1.34
Małopolskie	0.504	0.491	0.469	0.528	0.534	0.571	1.13
Mazowieckie	0.631	0.678	0.703	0.712	0.741	0.842	1.34
Opolskie	0.515	0.462	0.576	0.587	0.604	0.632	1.23
Podkarpackie	0.447	0.418	0.429	0.470	0.577	0.648	1.45
Podlaskie	0.407	0.470	0.430	0.482	0.451	0.584	1.44
Pomorskie	0.656	0.647	0.617	0.657	0.711	0.803	1.22
Śląskie	0.584	0.599	0.682	0.664	0.640	0.713	1.22
Świętokrzyskie	0.307	0.200	0.347	0.360	0.404	0.488	1.59
Warmińsko-Mazurskie	0.397	0.384	0.380	0.442	0.503	0.552	1.39
Wielkopolskie	0.558	0.524	0.565	0.617	0.655	0.651	1.17
Zachodniopomorskie	0.535	0.526	0.490	0.487	0.481	0.530	0.99
Average for Poland	**0.535**	**0.538**	**0.568**	**0.584**	**0.609**	**0.679**	**1.27**
Variation coefficient	**17.6%**	**20.6%**	**17.4%**	**15.1%**	**15.1%**	**14.4%**	

Source: own calculations based on Local Data Bank (2017).

Table 2. Character of processes occurring in provinces with respect to the information infrastructure between 2010 and 2015

		Synthetic ICT index in 2010 in comparison to the average value for Poland	
		Lower than average	Higher than average
Dynamics of changes in the synthetic ICT index between 2010 and 2015 in comparison to the average dynamics for Poland	Lower than average	**Divergence (marginalisation effect)**	**Convergence (lagging-behind effect)**
		Małopolskie Opolskie	Kujawsko-Pomorskie Pomorskie Śląskie Wielkopolskie Zachodniopomorskie
	Higher than average	**Convergence (catching-up effect)**	**Divergence (distance effect)**
		Lubelskie Lubuskie Łódzkie Podkarpackie Podlaskie Świętokrzyskie Warmińsko-Mazurskie	Dolnośląskie Mazowieckie

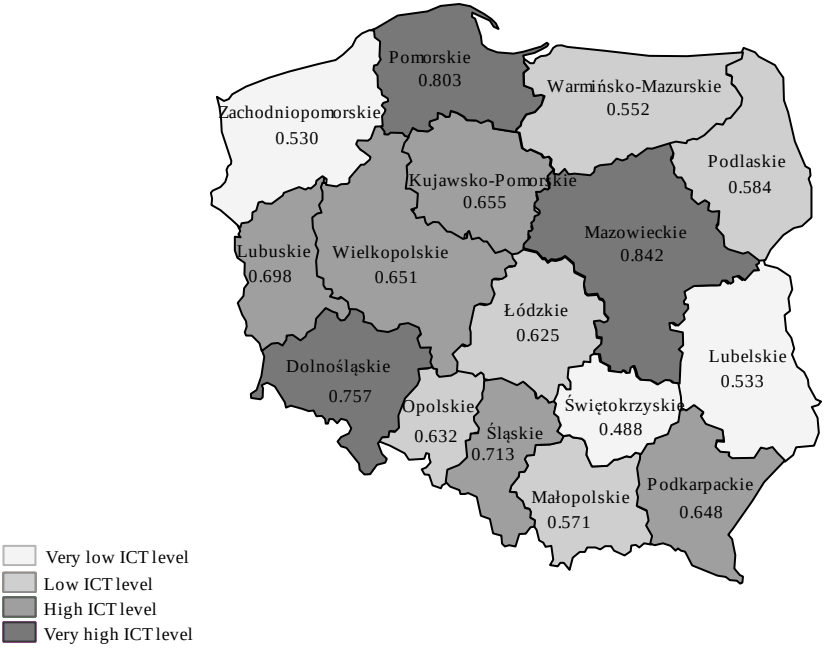
Source: author's own study on the basis of Table 1.

Table 3. Ranking of provinces according to the synthetic ICT index between 2010 and 2015

Province	**Position in ranking**						**Change of position in 2010–2015**
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	
Dolnośląskie	5	5	4	8	3	3	+2
Kujawsko-Pomorskie	4	4	5	11	8	6	-2
Lubelskie	15	13	9	5	12	14	+1
Lubuskie	8	6	10	7	9	5	+3
Łódzkie	11	12	8	9	11	10	+1
Małopolskie	10	9	12	10	10	12	-2
Mazowieckie	2	1	1	1	1	1	+1
Opolskie	9	11	6	6	6	9	0
Podkarpackie	12	14	14	14	7	8	+4
Podlaskie	13	10	13	13	15	11	+2
Pomorskie	1	2	3	3	2	2	-1
Śląskie	3	3	2	2	5	4	-1
Świętokrzyskie	16	16	16	16	16	16	0
Warmińsko-Mazurskie	14	15	15	15	13	13	+1
Wielkopolskie	6	8	7	4	4	7	-1
Zachodniopomorskie	7	7	11	12	14	15	-8

Source: author's own study on the basis of Table 1.

Figure 1. Results of the grouping of provinces according to the level of information infrastructure in 2015



Source: author's own study on the basis of Table 1.