Nierówności Społeczne a Wzrost Gospodarczy, nr 53 (1/2018)
DOI: 10.15584/nsawg.2018.1.25 **ISSN 1898-5084**

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Application of the utility function to assess the diversity of voivodships in terms of degree of use of information technologies in Poland

Introduction

Information technologies (IT) play an increasingly important role in the modern world, penetrating almost every aspect of its activity. Mobile phones, the Internet, digital data transmission systems, bring together the once-distant worlds of radio and television media, constituting an integral part of the IT revolution, both at home, at school and also at work. Communication is no longer subject to any restrictions, with regard to time or geography.

The concept of information and communication technologies (in brief ICT), interchangeably referred to as information and telecommunications technologies, teleinformation technologies or information techniques, covers the family of technologies that process, collect and transfer information in electronic form [GUS report, p. 17]. In Polish language, this concept is a faithful representation of English term. According to A. Nowicki [2008, cit. p. 36], "information technology consists of all techniques, methods and tools that allow developing and implementing the information processes". Kolbusz et al. [2005, p. 56] define the information technologies as "a set of means enabling data processing in information systems. These measures include: equipment, software and data organization methods". A. Lenat [2005, cit. p. 12] defines information technology as a "set of hardware, software and organizational means enabling data processing". The essence of IT is generating, acquiring, collecting, storing and distributing information with the involvement of appropriate hardware and software.

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The level of access to ICT – mainly computers and the Internet is one of several partial indicators taken into account in the design of various synthetic indicators of the measurement of information society [Targowski 2005, p. 4; Luterek 2010, p. 33). However, it is worth noting that in the analysis of the level of development of information society, apart from the level of Internet access, one should take into account also those elements that are related to the method, scope and intensity of Internet use by households and enterprises [Goliński 2002, p. 107; Mroczek-Kwasiżur et al. 2005, p. 72; Szewczyk 2007, p. 14].

The analysis of information society, and, above all, determination of degree of its development, based on simple indicators, out of necessity is of an aspect nature. It does not give the possibility of coherent development of the question, which due to its comprehensiveness is described by many different indicators, and each of them may be additionally considered in relation to the cross-section of the population. Therefore, it seems necessary to create complex indicators, the formula of which will be based on a certain group of simple indicators [Luterek..., (http), p. 11]. The starting point of considerations about the information society is its development base, covering Internet access possibilities; infrastructure development, including permanent broadband connections; equipping households, enterprises and administration units with teleinformation technologies [Miciuła, 2011, p. 434].

The study is aimed at diagnosing the degree of use of information technologies in terms of territory in three key areas, regarding the use of IT in households, in enterprises and in public administration units. Such a diagnosis is possible after the analysis of reliable statistical information. To rearrange voivodships, the synthetic measure of a utility function nature was used. The analysis is aimed at answering the question, which voivodships are characterized by the highest, and which by the lowest level of access and use of IT, and whether there is any similarity in the classification of voivodships in the three areas under study.

SELECTION AND CHARACTERISTICS OF DIAGNOSTIC VARIABLES

The study of regional differentiation of the use of information technology is not an easy task. This results from small availability of indicators in the territorial cross-section. The basic source of information in this area is the „Information society" reporting run by the Statistical Office in Szczecin. Results of statistical surveys from the years 2011–2015, which present data in the layout of voivodships in Poland. The set of diagnostic variables selected on the basis of available information includes 24 features that illustrate the level of use of information technologies in the three areas under study.

The first area of the analysis of the use of information technology represented households. For the analysis of regional diversity, seven indicators were selected from a set of features regarding the scope of use of the Internet by citizens[2].

Table 1. Characteristics of IT use rates in households in Poland in 2015 (%)

Variable	Maximum	Minimum	Mean	Standard deviation	Coefficient of variation
x_1	Mazowieckie 82.9	Kujawsko–Pomorskie 66.2	77.7	4.2	5.5%
x_2	Zachodniopomorskie 72.5	Świętokrzyskie 54.9	64.7	5.4	8.3%
x_3	Mazowieckie 80.6	Łódzkie 65.8	75.6	4.2	5.5%
x_4	Zachodniopomorskie 74.0	Świętokrzyskie 55.2	64.8	5.5	8.6%
x_5	Podlaskie 44.7	Podkarpackie 28.3	36.2	4.7	13.1%
x_6	Mazowieckie 45.9	Świętokrzyskie 26.7	34.4	5.7	16.5%
x_7	Mazowieckie 33.1	Świętokrzyskie 15.6	25.0	4.1	16.4%

Source: own study based on [*Information society* ... 2015].

In 2015, 77.7% of households in Poland had at least one computer. The best situation in this respect took place in the Mazowieckie voivodship (82.9%), and the worst in Kujawsko-Pomorskie voivodship (66.2%). The share of people using computers on regular basis in the total number of people amounted to 64.7%. The highest percentage of regular computer users was observed in the Zachodniopomorskie voivodship (72.5%) and the lowest in the Świętokrzyskie voivodship (54.9%). The rate of households having access to the Internet at home was 75.6% and was lower than the average for the European Union by 7%. It should be emphasized that the disproportion both in fitting households with computers as well as an access to the Internet in individual regions is disappearing, as evidenced by the low value (5.5%) of the coefficient of variation. Greater diversity may be observed in the case of next three indicators concerning the ways of using the Internet in households. The percentage of people shopping online in 2015 amounted to 36.2% and compared to the previous year it represented an increase of 3%. The highest share of internet users shopping online was recorded in the Podlaskie voivodship (44.7%), while the lowest number of people making online purchases was in the Podkarpackie voivodship

[2] x_1 – percentage of households equipped with computers, x_2 – percentage of regular computer users, x_3 – percentage of households having Internet access at home, x_4 – percentage of people using the Internet regularly, x_5 – percentage of people ordering or buying goods or services for private use online, x_6 – percentage of people connecting to the Internet outside their home or place of work through mobile devices, x_7 – percentage of people benefiting from public administration services over the internet in the last 12 months.

(28.3%). Among all voivodships, the highest percentage of people using mobile devices to connect to the Internet was recorded in the Mazowieckie voivodship (45.9%), while the smallest popularity of these devices was recoded among Internet users from the Świętokrzyskie voivodship (26.7%).

Another environment in which the use of information technology was studied was the enterprise. The analysis covered nine indicators defining the size of the studied phenomenon[3].

Table 2. Characteristics of IT use rates in enterprises in Poland in 2015 (%)

Variable	Maximum	Minimum	Mean	Standard deviation	Coefficient of variation
x_1	Dolnośląskie 97.4	Zachodniopomorskie 89.3	93.7	1.9	2.0%
x_2	Dolnośląskie 95.7	Zachodniopomorskie 86.7	92.2	2.2	2.4%
x_3	Mazowieckie 58.0	Lubuskie 28.2	38.1	6.7	17.5%
x_4	Mazowieckie 53.6	Lubuskie 24.9	33.2	6.6	19.9%
x_5	Mazowieckie 27.1	Świętokrzyskie 12.8	18.6	3.3	17.8%
x_6	Mazowieckie 25.9	Lubuskie 14.1	19.5	2.9	15.0%
x_7	Mazowieckie 14.9	Świętokrzyskie 6.5	11.1	2.1	19.1%
x_8	Mazowieckie 71.9	Lubuskie 55.1	63.5	4.6	7.2%
x_9	Mazowieckie 75.2	Podlaskie 50.8	58.4	5.7	9.8%

Source: own study based on [*Information society*..., 2015].

The situation of Polish enterprises in terms of the analysed features presented itself much more favourable as compared with households. In 2015, 93.7% of enterprises used computers. The value of this indicator places Poland at a slightly lower level than the average for the European Union (95%). Among all voivodships, the Dolnośląskie voivodship is clearly distinguished, and is characterized by the highest share of enterprises using computers (97.4%) and those having an access to the Internet (95.7%). The lowest values of this indicator were observed in the Zachodniopomorskie voivodship, 89.3% and 86.7%, respectively. The dispersion of this indicator in individual provinces is very small (2.0-2.4% coefficient of variation). Significant territorial differentiation may be observed in relation to an indicator illustrating the percentage of employees using a computer, including this with an access to the Internet. The highest

[3] x_1 – percentage of enterprises using computers, x_2 – percentage of enterprises having an access to the Internet, x_3 – percentage of employees using computers in enterprises, x_4 – percentage of employees using computers with an Internet access, x_5 – percentage of enterprises using social networks, x_6 – percentage of enterprises placing orders via computer networks, x_7 – percentage of enterprises receiving orders via computer networks, x_8 – percentage of enterprises holding their own website, x_9 – percentage of enterprises equipping their employees with mobile devices.

values of this measure were recorded in the Mazowieckie voivodship (58% and 53.6%), while the smallest values were observed in Lubuskie (28.2% and 24.9%). Over half of companies (58.4%) equipped their employees with equipment enabling mobile Internet access.

In recent years, the popularity of social media has significantly increased, and they are willingly used by enterprises in the field of business, as a new communication channel to promote their products and brands. Despite the increase in popularity of this form of communication in the classification of European Union states in terms of use of social media, Poland in 2015 was placed as 25th with an average of 18.6%. Taking into account the territorial division of the country, a large diversity is visible; the highest percentage of enterprises using at least one of the social media (social networking services) took place in the Mazowieckie voivodship (21.1%), and the smallest – Świętokrzyskie (12.8%). The success of modern companies is correlated with having a company/Internet website/portal. Each year more and more enterprises perceive their website as a marketing tool. In 2015, 63.5% of enterprises had their own website. The leader in this respect was the Mazowieckie voivodship (71.9%), the Podlaskie voivodship was ranked as last (55.1%).

An important form of using information technology in enterprises is placing and receiving orders via computer networks. Based on the available data from 2014, the highest percentage of companies placing orders via computer networks (25.9%) took place in the Mazowieckie voivodship. The least frequent purchases by computer networks were made by enterprises from the Lubuskie voivodship (14.1%).

The third area in which the use of ICT was analysed is the public administration units. In 2015, the Central Statistical Office (GUS) conducted an additional study[4] regarding the degree of computerization in public administration units, which covered all commune offices, county offices and municipal, marshal and voivodship offices. The results concerned the year 2014. eight indicators in terms of territory were subject to analysis[5].

[4] According to the Central Statistical Office, the study was conducted as part of the project entitled "The support for the system of monitoring cohesion policy in the 2007–2013 financial perspective and programming and monitoring cohesion policy in the 2014–2020 financial perspective" co-financed by the European Regional Development Fund

[5] x_1 – percentage of offices with their own website, adapted to be used by mobile phones and other mobile devices, x_2 – percentage of offices with the Intranet, x_3 – percentage of offices equipping their employees with mobile devices, x_4 – percentage of offices providing training to improve employees' skills in the field of ICT for specialists, x_5 – percentage of offices providing training to improve ICT skills for other employees, x_6 – percentage of offices promoting the use of public administration services in electronic form, x_7 – percentage of offices using an electronic document management system, x_8 – percentage of offices with dedicated personnel dealing with IT support.

Table 3. Characteristics of IT use rates in public administration units in Poland in 2014 (%)

Variable	Maximum	Minimum	Mean	Standard deviation	Coefficient of variation
x_1	Opolskie 41.2	Lubuskie 26.1	34.1	4.0	11.8%
x_2	Zachodniopomorskie 54.7	Opolskie 32.4	42.2	5.7	13.6%
x_3	Dolnośląskie 70.0	Lubelskie 42.9	57.7	8.3	14.4%
x_4	Wielkopolskie 44.1	Opolskie 20.6	32.5	6.7	20.7%
x_5	Podlaskie 48.3	Dolnośląskie 25.7	37.3	7.3	19.5%
x_6	Śląskie 65.8	Lubuskie 38.7	46.9	6.5	13.9%
x_7	Śląskie 74.1	Warmińsko-Mazurskie 13.6	40.9	17.7	43.3%
x_8	Małopolskie 81.8	Podlaskie 52.5	68.2	8.4	12.3%

Source: own study based on [*Information society* ... 2015].

From among the offices that submitted the report, all had in 2014 their own website [Information society..., p. 35]. Only in case of 34.1% of the surveyed offices, their websites were adapted to be operated by mobile phones and other mobile devices. Over 42% of offices had an access to the internal Internet network – Intranet. The largest number of such offices was recorded in the Zachodniopomorskie voivodship (54.7%), and the lowest in the Opolskie voivodship (32.4%). Nearly 60% of offices in Poland in 2014 equipped their employees with portable devices enabling mobile Internet access for business purposes.

The largest number of such offices was located in the Dolnośląskie voivodship (70.0%), and the smallest – in the Lubelskie voivodship (42.9%) [Information society..., p. 37]. Trainings improving the ICT skills for both specialists and other employees were conducted in 32.5% and 37.3% of offices respectively. Most of this type of training was conducted in the Wielkopolskie and Podlaskie voivodships, while the lowest in Opolskie and Dolnośląskie. The feature with the highest variation (43.3%) was the percentage of offices using the electronic document management system. Most offices using the electronic document management system were recorded in the Śląskie voivodship (74.1%), and the least – in the Warmińsko-Mazurskie voivodship (13.6%).

RANKING OF VOIVODSHIPS

On the basis of selected variables, the voivodships were rearranged due to the degree of use of information technologies in three different areas. The basic tool was a synthetic development measure, which, by means of a single aggregate variable, characterizes the objects (voivodships) described by many characteristics. Based on the X observation matrix composed of $m = 16$ rows (objects) and $n = 24$

columns (diagnostic features of a stimulant character), two hypothetical voivodships were created, determined by means of the least and the most beneficial set of feature values. Hypothetical objects were represented by x_0 and x_{m+1} vectors with n components each [Binderman, 2008, p. 35]. Since the feature values had different orders of magnitudes, the diagnostic variables were normalized using the method of zero unitarization in accordance with the formula [Kukuła, 2000]:

$$z_{ij} = \frac{x_{ij} - x_{0j}}{x_{m+1\,j} - x_{0j}}, \quad 0 \leq i \leq m+1, \quad 1 \leq j \leq n$$

Using the normalized utility function U(z), synthetic meters were calculated. The concept of design of a spatial synthetic measure of development based on the utility function was presented and described by A. Binderman in the works [Binderman, 2008, p. 29; 2006, p. 7]. The meter calculation formula is as follows:

$$U(z_i) = \frac{d(z_0, z_i) + d(z_0, z_{m+1}) - d(z_i, z_{m+1})}{2d(z_0, z_{m+1})}$$

where d(x,y) means the Minkowski's metric [Zeliaś 2000, p83]:

$$d(x,y) = \left(\sum_{k=1}^{n} (x_k - y_k)^p \right)^{1/p}$$

The utility function takes values from the [0,1] interval, whereby, $U(x_0)=0$, $U(x_{m+1})=1$.

The results of calculations and the ranking of voivodships for the three main environments using IT technologies are presented in Table 4.

Table 4. Values of a synthetic measure for three environments using information technologies

Voivodships	Synthetic measure of the use of information technology U(z) in					
	households	position	enterprises	position	public admin--istration units	position
1	*2*	*3*	*4*	*5*	*6*	*7*
Dolnośląskie	0.695	3	0.649	2	0.507	6
Kujawsko-Pomorskie	0.133	16	0.433	9	0.499	7
Lubelskie	0.516	11	0.389	11	0.440	11
Lubuskie	0.601	7	0.292	14	0.303	16
Łódzkie	0.270	15	0.447	8	0.318	15
Małopolskie	0.538	9	0.469	6	0.667	2
Mazowieckie	0.918	1	0.896	1	0.387	13

1	*2*	*3*	*4*	*5*	*6*	*7*
Opolskie	0.648	5	0.506	5	0.456	10
Podkarpackie	0.406	13	0.382	12	0.477	9
Podlaskie	0.629	6	0.420	10	0.418	12
Pomorskie	0.698	2	0.616	3	0.606	3
Śląskie	0.575	8	0.561	4	0.747	1
Świętokrzyskie	0.332	14	0.217	16	0.342	14
Warmińsko-Mazurskie	0.512	12	0.267	15	0.485	8
Wielkopolskie	0.533	10	0.462	7	0.565	5
Zachodniopomorskie	0.683	4	0. 298	13	0.603	4

Source: own study.

When arranging voivodships according to the value of the determined measure, it should be stated that in respect to the first two areas of information technologies, i.e. households and enterprises, the Mazowieckie voivodship was ranked first with a value of meter amounting to 0.918 and 0.896 respectively. By far the lower value of meter in a group of households had the Pomorskie voivodship (0.698) and Dolnośląskie voivodship (0.695), thus positioning themselves on two consecutive positions in the ranking. In the area of enterprises the same voivodships were ranked second and third, but their position in the ranking was reversed. The worst situation in terms of using information technology in households took place in the Świętokrzyskie (0.332), Łódzkie (0.270) and Kujawsko-Pomorskie (0.133) voivodships. Last positions in the ranking in terms of using information technology in enterprises were taken by Lubuskie (0.292), Warmińsko-Mazurskie (0.267) and Świętokrzyskie voivodships (0.217), respectively. In the analysis of level of use of information technologies by citizens and enterprises, it is worth noting the low position of the Świętokrzyskie and Warmińsko-Mazurskie voivodships, which are characterized by a relatively low level of socio-economic development.

Improvements in communication as well as document and resource management are the main advantages that Intranet can bring. Another area was diagnosing the state of computerization and determining its impact on improvement of work of public offices in Poland in 2014. In this area, the ranking of voivodships was slightly different. Leaders in the ranking were Śląskie (0.747), Małopolskie (0.667) and Pomorskie (0.606) voivodships. The last positions were occupied by the following voivodships: Świętokrzyskie (0.342), Łódzkie (0.318) and Lubuskie (0.303).

In order to compare the value of a synthetic measure in these three areas of IT use, basic descriptive characteristics were presented in the table below.

Table 5. Descriptive characteristics for synthetic meters of voivodships in Poland

Descriptive characteristics	Areas of the use of information technology		
	households	enterprises	public administration units
Mean	0.543	0.467	0.489
Interval	0.785	0.679	0.444
Standard deviation	0.189	0.169	0.125
Coefficient of variation	34.88	36.94	25.63
Coefficient of asymmetry	-0.408	0.976	0.402

Source: own study.

The mean value of meter was highest in the area of IT use in households. The analysis of coefficient variability shows that in Poland, in terms of the degree of use of information technologies, a large regional diversity still exists. The largest disproportions may be observed in the area of households and the smallest in public administration units. Such a large difference between the maximum and minimum value of meter in relation to households was caused by the very high value of the synthetic measure for the Mazowieckie voivodship. The biggest differences in the values of descriptive statistics of the synthetic measure may be noticed by analysing the calculated asymmetry coefficient. Positive direction and highest value of asymmetry close to 1 were observed in the area of enterprises. This means that most of voivodships have obtained values of this measure lower than the average. Lower positive asymmetry took place in the area of it IT use in public administration units. The desired negative direction of asymmetry took place in the area of households, which means that voivodships with values of the meter higher than the average dominated.

In order to compare the consistency of obtained rankings based on the calculated synthetic measures in three researched areas, the Spearman rank correlation coefficients were calculated. The rank correlation always takes values from the [-1, + 1] interval. The value of this coefficient amounting to 0.61, indicates a moderate consistency of results (ranking) in the area of using information technologies in households and enterprises. Differences in the obtained rankings were observed in relation to classification of voivodships in the area of using information technologies in households and public administration units as well as enterprises and public administration units, which is confirmed by the low value of Spearman rank correlation coefficient amounting to 0.22 and 0.36, respectively.

Summary

In Poland, the level of access to the Internet and the degree of using information technologies in households, enterprises as well as public administration units still shows regional diversification.

The analysis conducted using the utility function to calculate the synthetic measure showed that citizens and enterprises in such voivodships as Mazowieckie, Pomorskie and Dolnośląskie are characterized by both relatively high possibilities of Internet access and skilfully make use of these possibilities. These voivodships are characterized by both a high share of households and enterprises having a computer and access to the Internet, and a relatively high share of households and entrepreneurs using the Internet to realize various types of services. At the other extreme there are voivodships, such as Lubuskie, Warmińsko-Mazurskie and Świętokrzyskie, which have relatively the smallest possibility of access and use of the Internet.

Diagnosing the state of computerization of public offices made it possible to make other ranking of voivodships. In this area of IT use, the Śląskie, Małopolskie and Pomorskie voivodships were ranked first.

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Abstract

The aim of the study is to diagnose the degree of use of information technology depending on the province in three key areas, namely, households, enterprises and public administration. On the basis of selected diagnostic features and using a utility function the synthetic measures were selected, which allowed to rank provinces separately in each of the areas.

The analysis of synthetic measure shows that in Poland, in terms of the use of information technology, there is still a large regional diversity. The largest disproportions can be observed in the area of households and the smallest in the public administration. With regard to the use of IT in households and enterprises in the first positions of the ranking were the following provinces: Mazowieckie, Pomorskie and Dolnośląskie. A completely different ranking of provinces was obtained on the basis of the assessment of the level of computerization of offices. In this area of the use of IT in the first positions were the following provinces: Śląskie, Małopolskie and Pomorskie.

Keywords: information society, utility functions, synthetic measure

Zastosowanie funkcji użyteczności do oceny zróżnicowania województw w zakresie stopnia wykorzystania technologii informacyjnych w Polsce

Streszczenie

Celem opracowania jest diagnoza stopnia wykorzystania technologii informacyjnych w ujęciu terytorialnym w trzech kluczowych obszarach, w gospodarstwach domowych, w przedsiębiorstwach i w jednostkach administracji publicznej. Na podstawie wybranych cech diagnostycznych wykorzystując funkcję użyteczności wyznaczono mierniki syntetyczne, które pozwoliły na porządkowanie województw odrębnie dla każdego z obszarów.

Analiza miary syntetycznej wskazuje, że w Polsce pod względem stopnia wykorzystania technologii informacyjnych nadal występuje duże zróżnicowanie regionalne. Największe dysproporcje można zaobserwować w obszarze gospodarstw domowych zaś najmniejsze w jednostkach administracji publicznej. W odniesieniu do stopnia wykorzystania IT w gospodarstwach domowych i w przedsiębiorstwach na pierwszych pozycjach w rankingu znalazły się województwa mazowieckie, pomorskie i dolnośląskie. Ocena stanu informatyzacji urzędów pozwoliła na dokonanie zupełnie innego rankingu województw. W tym obszarze wykorzystania IT na pierwszych pozycjach znalazły się województwa śląskie, małopolskie i pomorskie.

Słowa kluczowe: społeczeństwo informacyjne, funkcja użyteczności, syntetyczny miernik

JEL: C38, M15, R29