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LEVEL OF DEVELOPMENT OF NEW TECHNOLOGIES IN THE BSR COUNTRIES

The paper presents the level of development of new technologies in the BSR countries. The countries are classified by using the synthetic measure of development with respect to variables determining the development level. They are also be grouped by means of cluster analysis. The classification and grouping aim at finding the lead countries and showing the most important features determining their development. This could be used as a roadmap for less developed countries in order to let them catch up these developed ones.

Keywords: *BSR countries; classification; cluster analysis.*

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РІВЕНЬ РОЗВИТКУ НОВИХ ТЕХНОЛОГІЙ У КРАЇНАХ БАЛТІЙСЬКОГО РЕГІОНУ

У статті представлено рівень розвитку нових технологій у країнах Балтійського регіону. Країни класифіковано за синтетичним показником розвитку на основі ряду змінних і згруповано за результатами кластерного аналізу. Класифікація дозволила виявити країни-лідери, а також чинники, що визначають їх розвиток. Представлені дані можуть бути використані як "дорожня карта" для менш розвинених країн у їх наздоганяючому розвитку.

Ключові слова: *країни Балтійського регіону; класифікація; кластерний аналіз.*
Рис. 2. Табл. 7. Літ. 10.

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УРОВЕНЬ РАЗВИТИЯ НОВЫХ ТЕХНОЛОГИЙ В СТРАНАХ БАЛТИЙСКОГО РЕГИОНА

В статье представлен уровень развития новых технологий в странах Балтийского региона. Страны классифицированы по синтетическому показателю развития на основе ряда переменных и сгруппированы по результатам кластерного анализа. Классификация позволила выделить страны-лидеры, а также факторы, определяющие их развитие. Представленные данные могут быть использованы в качестве "дорожной карты" для менее развитых стран для догоняющего развития.

Ключевые слова: *страны Балтийского региона; классификация; кластерный анализ.*

Introduction

The functioning of today's world has changed dramatically since the beginning of the 21st century. Wide access to the Internet and mobile phone networks made the circulation of information much quicker than it used to be before. It means that the world today is hyperconnected. It is quite obvious that the level of use of modern technologies strongly influences the level of social and economic development. Therefore, there is a need to measure and analyse it. The main global report, where the information on the level of development of modern technologies can be easily found, is the Annual Global Information Technology Report (GITR).

Annual Global Information Technology Report, published by the World Economic Forum in cooperation with French Business School INSEAD, explores the impact of information and communication technologies (ICT) on productivity

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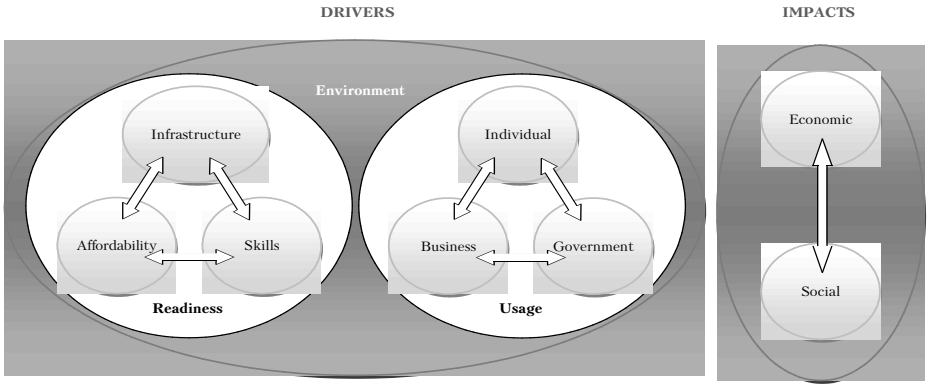
and development and also competitiveness. One of the main goal of the report is to help "policymakers and relevant stakeholders to track their economies' strengths and weaknesses as well as their progress over time. In addition, it has identified best practices in networked readiness and designed roadmaps and strategies for establishing optimal ICT diffusion to boost competiveness" (Dutta, Bilbao-Osorio, 2012).

The report's research methodology has been stable, aside from some minor adjustments, since 2002. It has allowed for comparisons across time and created a valuable database of technology metrics (Kuczera, 2009). The research is based on Network Readiness Index (NRI) covering wide spectrum of factors grouped, up to last issue, into 3 pillars. However, this year authors decided to put some changes into the process of building the rank of economies based on the aggregated NRI framework. Dramatic change in ICT had been noticed so the modification was made in order to ensure that NRI framework remains aligned with the latest changes in the ICT industry and responds better to policy needs. Raising ICT field can be characterized by such numbers as: according to Gartner sales of mobile devices reached 440.5 mln units alone in the third quarter of 2011, Ericsson estimates the number of connected devices in the world by 2020 as over 50 bln, International Data Corporation says that the amount of data transmitted worldwide surprised one zettabyte for the first time in 2010, the digital universe is now expected to double every 2 years (Dutta, Bilbao-Osorio, 2012).

New patterns of using ICT by individuals has been also recognized, e.g. there are more than 800 mln active users on Facebook, Google Plus surpassed 40 mln users in less than 6 months (Dutta, Bilbao-Osorio, 2012). New ways of delivering public services as well as redefined mechanisms of governance and social engagement have appeared.

Taking into account trends mentioned above, the evolved Networked Readiness Index framework was introduced this year issue of the Report as shown in Figure 1.



Source: The Global Information Technology Report 2012 Living in a Hyperconnected World, edited by Dutta S., Bilbao-Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf, p. 5.

Figure 1. **The evolved Networked Readiness Index framework**

The modified framework was inspired by 5 underlying principles (Dutta, Bilbao-Osorio, 2012):

1. Measuring the economic and social impacts of ICT is crucial.

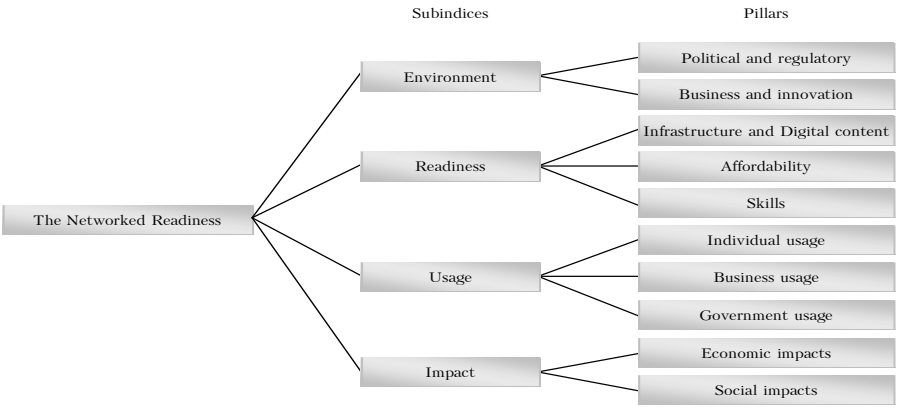
2. An enabling environment determines the capacity of an economy and society to benefit from the use of ICT.

3. ICT readiness and usage remain the key drivers and preconditions for obtaining any impacts.

4. All factors interact and co-evolve within an ICT ecosystem.

5. The framework should provide clear policy orientations and identify public-private partnership opportunities.

Environment performed by readiness of the society to use ICT and the actual usage of all main stakeholders as well as impact are 4 of the subindices of the networked readiness index. Each of them covers pillars (10) which contain variables (53). The main change shown in the NRI is introducing the impact subindex as an effect of regrouping ICT impact-related variables. The authors attempt to emphasize the importance of impact by putting the fourth subindex measuring the impacts of ICT on both economy and society. They hope that in near future, when richer datasets are available, wider impact will be covered in such areas as environment, energy, and health. So in the next editions some alignments could be expected. Structure of the evolved networked readiness index is shown in Figure 2.



Source: The Global Information Technology Report 2012 Living in a Hyperconnected World,edited by Dutta S., Bilbao-Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf, p. 6.

Figure 2. **The evolved networked readiness index structure**

The Report includes 142 economies worldwide that account for over 98% of the world GDP. In order to run a comprehensive research, NRI is the mixture of quantitative and survey data. 25 out of 53 indicators are from the executives opinion survey, rest 28 are taken from other sources such as International Telecommunication Union, the World Bank or the United Nations.

Methodology

Although all analysed BSR countries were ranked by means of the Networked Readiness Index (NRI) (Dutta, Bilbao-Osorio, 2012), we decided to make a modified ranking for the needs of this article. The main reason for such state of things was that the construction of the Index is heavily based on indicators measured on a 1-to-7 (best) scale. Such quasi-quantitative variables cannot be used in our analysis because we cannot perform basic mathematical operations on them and also

because we are unable to say if the difference between, let's say 1 and 2 are the same as between 2 and 3. Therefore we left the following quantitative (hard data) indicators:

1. Environment sub-index:
– Software piracy rate, % of the software installed;
– No. procedures to enforce a contract;
– No. days to enforce a contract;
– Total tax rate, % profits
– No. days to start a business;
– No. procedures to start a business
2. Readiness sub-index:
– Electricity production, kWh/capita;
– Mobile network coverage, % pop.;
– Int'l Internet bandwidth, kb/s per user;
– Secure Internet servers/million pop.;
– Mobile cellular tariffs, PPP $/min.;
– Fixed broadband Internet tariffs;
– Internet & telephony competition, 0–2 (best);
– Adult literacy rate, %;
3. Usage sub-index:
– Mobile phone subscriptions/100 pop.;
– Individuals using Internet, %;
– Households w/ personal computer, %;
– Households w/ Internet access, %;
– Broadband Internet subscriptions/100 pop.;
– Mobile broadband subscriptions/100 pop.;
– PCT patents, applications/million pop.;
– Government Online Service Index, 0–1 (best);
4. Impact sub-index:
– ICT PCT patents, applications/million pop.;
– Knowledge-intensive jobs, % workforce;
– E-Participation Index, 0–1 (best).

The first stage of the analysis was ranking the countries. Although there are many other classification methods, such as Models with Varying Parameters (Batog, Wawrzyniak, 2011), Generalised Distance Method (Walesiak, 2006) and many others, we decided to use the simple and well-known Taxonomic Measure of Development (TMD) (Pluta, 1986). Of all above listed variables the following: electricity production, mobile network coverage, international Internet bandwidth, secure Internet servers, fixed broadband Internet tariffs; Internet & telephony competition; adult literacy rate, mobile phone subscriptions, individuals using Internet, households with personal computer, households with Internet access, broadband Internet subscriptions, mobile broadband subscriptions, PCT patents, Government Online Service Index; ICT PCT patents, knowledge-intensive jobs, E-Participation Index were considered as stimulants (the higher their values, the better) and all the remaining variables were destimulants.

The stages of calculation of the TMD were:

– changing destimulants into stimulants (by calculating the inverse values of the corresponding variables);

– standardisation of variables;

– finding maximum value for each variable;

– calculation of Euclidean distances between each variable in each country and maximum value;

– calculation of sum of products of distances and weights (in our case all variables had equal weights) for each country and calculation of square roots of this sum;

– calculation of pattern of development as maximum value of above-calculated numbers;

– calculation of the TMD. The higher TMD is, the higher rank the country has (Nowak, 1990; Ostasiewicz 1998).

The second stage was cluster analysis by means of the k-means method (Pociecha, Podolec, Sokolowski, Zajac, 1988). First we divided the analysed 9 countries into 3 homogeneous clusters with respect to all the variables. Next we made clusters for each 4 sub-indices. All variables were standardised and clusters were calculated with the assumption that distances between cluster were maximal.

Results of the analysis

Ranking of the BSR countries obtained by means of the TMD was compared to the global (for 142 countries) and local (for the BSR) ranking obtained by the NRI. The results are presented in Table 1.

Table 1. **Ranking of the BSR countries with respect to the TMD and NRI**

Country	Position in ranking by TMD	Position in global ranking by NRI	Position in BSR ranking by NRI
Denmark	1	4	3
Finland	2	3	2
Sweden	3	1	1
Germany	4	16	4
Estonia	5	24	5
Lithuania	6	31	6
Latvia	7	41	7
Poland	8	49	8
Russia	9	56	9

Source: Authors' own calculations on the basis of The Global Information Technology Report 2012 Living in a Hyperconnected World, edited by Dutta S., Bilbao-Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf.

As we can see from Table 1, the ranking of the BSR countries obtained by the TMD is very similar to the one obtained by the NRI. The only difference is on the first and third places. The TMD placed Denmark on the first place and Sweden on third. The NRI gave Sweden the first place and Denmark – the third. Positions of the rest BSR countries are the same with respect to both measures. Generally it can be stated that Scandinavian countries take the highest positions with respect to the general ICT and mobile usage in the economy. They are followed by Germany and then by the Baltic countries (Estonia, Lithuania and Latvia). The last but one place is occupied by Poland and the last – by the Russian Federation.

The results of cluster analysis with respect to all the indicators are presented in Table 2.

Table 2. **Results of cluster analysis with respect to all indicators**

Cluster 1	Cluster 2	Cluster 3
Russia	Estonia	Denmark
	Latvia	Finland
	Lithuania	Germany
	Poland	Sweden

Source: Authors' own calculations on the basis of The Global Information Technology Report 2012 Living in a Hyperconnected World, edited by Dutta S., Bilbao -Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf .

All indicators gave 3 visible clusters. The first cluster contained only one country – Russia, the second one – Poland and Baltic states and the third – Scandinavian countries and Germany. This division clearly reflects the level of development of the analysed countries – first cluster contains the lest developed country, the second one – countries inbetween the first and the third cluster.

Interesting results may be obtained if we divide the BSR countries with respect to subsequent subindices. The first one is the environment subindex. The results of cluster analysis in this subindex are presented in Table 3.

Table 3. **The results of cluster analysis in the environment subindex**

Cluster 1	Cluster 2	Cluster 3
Denmark	Poland	Estonia
Finland	Russia	Germany
		Latvia
		Lithuania
		Sweden

Source: Authors' own calculations on the basis of The Global Information Technology Report 2012 Living in a Hyperconnected World, edited by Dutta S., Bilbao-Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf.

Although the results of cluster analysis with respect to all the variables were quite obvious, clusters obtained for the environment subindex were a bit surprising. While the first cluster is quite evident, the second one shows that with respect to economic and legal indicators Poland is similar to the Russian Federation. The indicators creating analysed subindex showed that the Baltic states are similar to Germany and Sweden.

The readiness subindex contains indicators that show the availability of mobile and Internet services and population's skill to use them. The results of clustering with respect to these indicators are presented in Table 4.

Table 4. **The results of cluster analysis in readiness subindex**

Cluster 1	Cluster 2	Cluster 3
Denmark	Sweden	Estonia
Finland		Latvia
Germany		Lithuania
		Poland
		Russia

Source: Authors' own calculations on the basis of The Global Information Technology Report 2012 Living in a Hyperconnected World, edited by Dutta S., Bilbao-Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf.

Table 4 shows that with respect to the availability of mobile and Internet services and population's skills the first two clusters contain developed countries, while the

third one contains all remaining countries in the BSR. Poland, the Baltic states and the Russian Federation are still behind Germany, Denmark, Finland and Sweden with respect to readiness of using mobile and Internet services. This is also because mobile cellular tariffs in these countries are much more expensive with respect to the population's incomes.

The application of a sub-index shows the degree of use of the ICT and mobile technologies by individuals, households, companies and government. The results of clustering with respect to this sub-index are presented in Table 5.

Table 5. **The results of cluster analysis in the usage subindex**

Cluster 1	Cluster 2	Cluster 3
Denmark	Estonia	Russia
Finland	Latvia	
Germany	Lithuania	
Sweden	Poland	

Source: Authors' own calculations on the basis of The Global Information Technology Report 2012 Living in a Hyperconnected World, edited by Dutta S., Bilbao -Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf.

With respect to the degree of use of ICT and mobile technologies, all developed countries fell to the first cluster, developing EU countries (Poland and Baltic states) created the second one and the Russian Federation was alone in the third one. Developed countries (and especially the Scandinavian ones) have the largest ratio of individuals and households that use the Internet (especially broadband), mobile phones and, most of all, patents applications. Poland and Baltic states slightly fell behind them with respect of use of mobile services and the Internet, but had much less patents applications (by 2–3 orders of magnitude). The Russian Federation was alone in the third cluster mostly because of the smallest use of the mobile and Internet services.

The last subindex, the impact one shows how many patents petitions are within the ICT area, the ratio of knowledge-intensive jobs and e-participation in the processes involved in government and governance. The results of clustering with respect to this subindex are presented in Table 6.

Table 6. **The results of cluster analysis in impact subindex**

Cluster 1	Cluster 2	Cluster 3
Denmark	Latvia	Finland
Estonia	Poland	Sweden
Germany	Russia	
Lithuania		

Source: Authors' own calculations on the basis of The Global Information Technology Report 2012 Living in a Hyperconnected World, edited by Dutta S., Bilbao -Osorio B., 2012 World Economic Forum, http://www3.weforum.org/docs/Global_IT_Report_2012.pdf.

The results obtained by means of indicators creating the impact sub-index may be in some points surprising. The main reason for this may be that there are only 3 variables creating this sub-inedx. The first cluster contained Germany, Denmark, Estonia and Lithuania (mostly because of high level of e-participation index in these two Baltic states). But it seems that this group is not as homogenous as the third cluster, containing Finland and Sweden. In the second cluster, the most similar countries with respect to the usage of a subindex were Poland and Latvia, the Russian Federation had a significantly smaller e-participation index.

Conclusions

The performed analysis shows that the BSR countries vary with respect to the use of modern technologies significantly. Our ranking, performed by means of the TMD gave almost the same results as the NRI, with Scandinavian countries on the leading, they are followed by Germany, the next places are taken by the Baltic states, which are followed by Poland and the Russian Federation takes the last place.

Also, when grouping the countries by means of the k-means method, most Scandinavian countries create one cluster, sometimes with Germany. The Baltic states are somewhere in-between Poland and Russia and developed countries. In some fields (environment and impact sub-index) they are classified in the same group as developed countries, while in other fields (readiness and usage sub-index) – they are similar to Poland and Russia.

When comparing the results obtained by the NRI or TMD with the Global Competitiveness Index (GCI), we can see the differences.

Table 7. **Ranking of the BSR countries with respect to the GCI**

Country	Position in ranking by GCI
Sweden	3
Finland	4
Germany	6
Denmark	8
Estonia	33
Poland	41
Lithuania	44
Latvia	64
Russia	66

Source: The Global Competitiveness Report 2011 – 2012, edited by K. Schwab, World Economic Forum, Geneva, Switzerland 2011, http://www3.weforum.org/docs/WEF_GCR_Report_2011 - 12.pdf, p. 15.

As we see from Table 7, Scandinavian countries and Germany are close together in the ranking on the very top of it, they are followed by Estonia, Poland and Lithuania (which positions are quite close) with Latvia and the Russian Federation occupying the last positions in the BSR countries. So Poland and Germany are higher in the GCI ranking within the BSR countries than in the NRI one (both original and modified by means of the TMD), while Latvia takes much lower position in the GCI ranking than in the NRI ranking.

Besides these 3 differences, we can observe that country's competitiveness is highly correlated with its networked readiness, i.e. the use of modern technologies and their impact on social and economic development. So it seems quite obvious that less developed countries (Baltic states, Poland and the Russian Federation) should follow the Scandinavian countries and Germany in order to become more developed and competitive. It is also obvious that the use of modern technologies will be one of the main factors that determine their further social and economic development. Amongst both the EU and BSR countries we can observe high differentiation in policy and strategy of supporting innovations as well as R&D expenditures. For example, one out of 3 parts of funds spent on R&D in the EU was consumed by German, French and British companies (Grzybowski, 2012). It should be the governments' and companies' in developing countries, such as Poland, Baltic states and the Russian Federation goal to absorb as much of these funds as possible.

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