Clustered Approach to ICT Services Utilization Analysis[1]

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The paper describes clustered approach to ICT services utilization analysis based on the WSA method. It allows extracting coherent groups of countries with nearly the same level of ICT services utilization based on the number of indicators analyzed. Approach is explained on case of the Czech Republic and its position in the European peloton with using available Eurostat data.

Key words: Informatization, clustering, WSA method, ICT Services

1   Preface

In[2] today's global network economy (Kelly, 1998) competitiveness of countries significantly depends on ICT (Information and Communication Technologies) adoption from the macroeconomic level perspective. In particular, the key point is the ability of governments to identify and invest in relevant knowledge, which could be applied into the production processes of everyday life. This phenomenon is based on general consensus (European Comission, 2006) about the positive impact of ICT investment and ICT services on economic growth and employment. Currently we have a large number of studies dealing with the positive impact of ICT supporting economic growth e.g. (World Economic Forum, 2007, World Economic Forum, 2009, Economist Intelligence Unit, 2004, World Competitiveness Center, 2007, European Commission, 2010). European economy is lagging behind the U.S. in productivity growth in ICT services (O'Mahony, 2003 Van Ark Van Ark Inklaar 2005, Denis et al. 2004). Van Ark and Piatkowski (2004) argue that ICT has supported restructuring of production industries mainly in Central and Eastern Europe.

When we would like to compare particular country and its technological advancement with its competitors, we should also, according to the **(World Economic Forum, 2010) analy**sis, concentrate on ICT (Information and Communication Technology) technological environment and on ICT services use. Examples of such studies could be found in (Götz, 2010) and (Gryczka, 2011).

We are seeking answers to the following questions:
- How is the country population using ICT services?
- Which countries have a similar level ICT services utilization?
- Who are the leaders in different aspects ICT services of utilization?

There have been a number of studies performed in this area on the international level (e.g., (World Economic Forum, 2010), (Economist Intelligence Unit, 2010)). Our approach differs from them by using the clustering method for data analysis, which allows us not only to compare countries based on a single criterion (or weighted set of criterions), but also elaborate clusters of countries with similar results. It allows analyzing close competitors of a particular country and their distance from the leaders in a specific set of indicators.

In this paper we present the use of the above described method and present it on case of the Czech Republic being compared with the rest of European countries.

2   Methodology

For the purpose of our research we drew on data that are listed in different data sources. In particular, the survey's publication (European Commission, 2009) and the data processed by the Czech Statistical Office (ČSÚ, 2009). Data sources were processed and resulting tables have been prepared by using

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a cluster analysis method. That enabled us to find out which European countries have reached the closest results for each analyzed set of criteria.

Cluster analysis of data from the years 2004 - 2008 was processed using the TOPSIS method (Techniques for Preference by Similarity to the Ideal Solution) and WSA (Weighted Sum Approach). The TOPSIS method (Hwang & Yoon, 1981) nowadays ranges among standard methods of cluster analysis. This method assesses the options in terms of their distance from the ideal and the basal variations. The value index is then calculated between the values 1 and 0. The value of 0 corresponds to the variant basal value, while the value of 1 corresponds to the ideal scenario (Yoon et al., 1995). Therefore, the results in tables that appear in the text are ranked from the best outcome to the worst outcome.

The aim of our analysis was to divide countries into groups, within which the countries are "similar" in terms of observed characteristics. Due to the computing environment (MS Excel) and the possibility of better display and interpretation of intermediate results, we decided to use the methods of multicriteria evaluation of options. These methods are based on the assumption of the existence of a matrix including a final list of options (alternatives) evaluated according to the final number of criteria. Elements of such matrix represent the information about options by various criteria, either in the form of ordinal (ranking alternatives according to the criteria) or cardinal (real value options according to individual criteria in different units). Depending on the type of information available they can be divided into the methods of problem solving, methods based on ordinal information and methods of using the cardinal information (Fiala, 2008).

The aim of multicriteria evaluation of options may be either configuration options in order to find effective alternatives and determine the winning compromise variant. According to these objectives, we can distinguish various methods used to solve the problem. For ordering of options we can use methods based on the principle of maximizing profit, minimizing the distance from the ideal option, or using certain methods of preferential trade (see e.g. Fiala, 2008, Triantaphyllou, 2000).

The evaluation covers the year 2008. In some rare cases, there were missing values in the reference criteria for the year. If there were values available from the previous year, we used these data as an approximation, but if they were also missing, we used the average value of the criteria in the EU as an approximate. It could certainly lead to overestimation or underestimation of the country, but these were only isolated cases which did not have a significant bias effect on the sum of the effects of multiple criteria.

Since the aim was to divide countries into groups, we have chosen methods that ultimately determine the overall arrangement (sequence) variations. However, it was important to interpret the order based on values. Therefore, we have chosen WSA and TOPSIS methods that provide an overall utility in %, respectively in relative distance from the basal (hypothetically the worst) option in%.

In this paper, due to its limited scale, we are discussing only the WSA method results. Therefore, we will describe only that method in detail.

2.1 WSA method

Method WSA (Weighted Sum Approach) operates on the principle of utility maximization, i.e., arranges the order of options for the overall utility, taking into account all the criteria represented by (Anderson, Sweeney, & Williams, 1994). The value of the utility options in the range of á0,1ñ, the higher is the option appropriate to the individual criteria, the higher is its value. Total utility would have been a tagged variant, which is the best by all criteria. Utility of zero indicates the contrary, an alternative that is the worst according to all criteria. The calculation procedure is as follows (Fiala, 2008):

2.1.1 Normalization of input data

The aim of this step is to abolish the influence of different units and different scales of large numbers. Normalized values vary on a scale of 0 to 1 for each criterion, indicating the percentage meeting the maximum or minimum value (depending on the type of criteria that can be either maximization, i.e., preferring higher values, preferences, or minimization of lower values).

The weighted sum method uses for maximization type criteria formula:

$$r_{ij} = \frac{y_{ij} - D_j}{H_j - D_j},$$

In case of minimization type criteria uses formula:

$$r_{ij} = \frac{H_j - y_{ij}}{H_j - D_j}, \text{ where}$$

i... index of option,
j... index of criterion,
y_{ij} ... original value of option i based on criteria j,
H_j ... ideal option which comprises a maximum value according to each criterion,
D_j ... basal option composed of the minimum values according to each criterion,

An option, which, according to the criteria achieves the best partial utility $r_{ij}=1$, the worst option then partial utility $r_{ij}=0$.

2.1.2 Total utility evaluation

We will obtain total utility u_{ij} by multiplying the partial utilities r_{ij} by weights of particular criteria and by summarizing them:

$$u(a_i) = \sum_{j=1}^{k} r_{ij} \cdot v_j, \text{ where}$$

$u(a_i)$ ... total utility of option a_i,
r_{ij} ... normalized values from the previous step (partial utilities),
v_j ... weight of j-th criterion,
k ... number of criteria.

While evaluating selected countries, the WSA method was first applied within the individual categories (where we received a total utility of all countries in each category) and then again in each category as a whole, where the original total utilities of countries in each category were used as input values for further calculations. The weights of all criteria were equivalent (i.e. equal to 1/k, where k is the number of criteria). Countries were ordered according to their total utilities and subsequently grouped based on similarity of total utility (in one group the difference between the utilities does not exceed 10%).

3   Method application – ICT services in the Czech Republic compared with other European countries

The use of the above described method is presented on case of the Czech Republic being compared with the rest of European countries. As the aim of the paper is to present the use of above defined method, which is applied in the same way principally in all the detailed ICT services utilization areas being analyzed, we will discuss only the selected detailed results.

For the purpose of this paper we include E.U. member states and Croatia, Macedonia, Norway and Iceland among European countries.

The development of ICT services in the Czech society is in accordance with generally applicable procedures in the European Union, which are monitored annually. The problem of evaluating data in the long run lies in the fact that monitored services are gradually changing, and therefore, the data sample differs through the years. An example might be the deployment of ADSL technology, which was almost never used (and monitored) ten years ago (Tabel 1). Currently monitored ICT services could be divided into two major areas. The first are **Infrastructure services** (which technologies we use in our society), and the other are **Data services** (Internet use and activities performed there).

3.1   Infrastructure services – Internet connections

The progress of informatization of the Czech Republic can be seen in the following table, where we first list the progress of the broadband technology use in the Czech Republic, and attention is paid to different types of connections. In addition, the table contains basic technological characteristics of the prevalence of Internet use.

From the results of the below calculation (Table 2), it is clear that in this area the Czech Republic belongs to average countries in Europe (average value for the cluster index is 0.4882). It is also obvious that it belongs to the top of new countries in the European Union. Denmark, Sweden and Norway represent the absolute peak among the European countries.

3.2   Internet data services - common

Another question is connected with the real use of ICT. Here we will be concentrating on ICT use for a better quality of life (such as reducing time spent shopping through the use

Table 1. Broadband and Internet use in the Czech Republic

Indicator/Year	2004	2005	2006	2007	2008	EU27	Rank in EU
DSL coverage (in % of inhabitants)		74,7	81,3	85,0	92,0	92,7	19.
DSL coverage in rural areas (in % of inhabitants)				75,0	85,0	76,6	13.
Broadband coverage (in % of inhabitants)	2,2	6,4	10,6	14,6	17,1	22,9	20.
Connection speed over 2 Mbps in % of all broadband connections			9,0	43,4	100,0	63,3	1.
% of households with Internet connection	19,0	19,0	29,0	35,0	46,0	60,0	23.
% of households with broadband connection	4,0	5,0	17,0	28,0	36,0	49,0	21.
% of enterprises with (landline) broadband connection	38,0	52,0	69,0	77,0	79,0	81,0	17.
% of inhabitants using mobile phone for UMTS Internet access			1,0	4,0	5,0	3,0	5.
% of inhabitants using laptop with wireless connection for Internet access outside home or work				3,0	7,0	12,0	18.
% of inhabitants using Internet at least once a week	25,0	26,0	36,0	42,0	51,0	56,0	17.
% of inhabitants using Internet daily or nearly daily	10,0	10,0	18,0	24,0	30,0	43,0	22.
% of inhabitants who have never used Internet		63,0	49,0	46,0	33,0	33,0	14.

Source: (European Commission, 2009)

Table 2. Broadband and Internet use – Analysis results

ID of cluster	Countries in Cluster	Average index
1	Denmark, Sweden, Norway	0,7873
2	Netherlands, Iceland, Luxembourg	0,6281
3	Finland, Great Britain, Austria, Spain	0,5458
4	Czech Republic, Slovenia, Germany, Portugal	0,4882
5	Ireland, Estonia, France, Belgium	0,4364
6	Hungary, Malta, Latvia, Croatia, Italy, Slovakia	0,3551
7	Cyprus, Poland, Greece, Bulgaria, Romania, Lithuania	0,2096

Source: own analysis

Table 3. Internet services use by the Czech society (in % of total population)

Indicator/Year	2004	2005	2006	2007	2008	EU27	Rank in EU
E-mail sending	27,0	27,0	37,0	42,0	51,0	53,0	15.
Searching information about goods and services	17,0	20,0	32,0	37,0	45,0	50,0	18.
Saving of created content					2,0	11,0	27.
Ordering goods or services for personal use	5,0	5,0	13,0	17,0	23,0	32,0	12.
Reading magazines or newspapers online	10,0	12,0	19,0	22,0	33,0	25,0	12.
Selling of goods and services (auctions)			5,0			10,0	
Internet Banking	5,0	5,0	10,0	12,0	14,0	29,0	20.
Downloading computer games or video games or their updates					5,0	9,0	26.
Downloading / listening / watching music or movies					19,0	28,0	22.
Payments for audiovisual services					4,0	5,0	12.
Listening to or watching radio or Web TV	3,0	3,0	6,0	8,0	13,0	20,0	21.
Looking up information about health, nutrition or health problems or injuries		3,0	10,0	11,0	14,0	28,0	23.
Looking for a job or a job application	3,0	2,0	4,0	4,0	5,0	13,0	25.
Studying online courses				1,0	2,0	3,0	20.
Searching for information in order to learn				17,0	10,0	26,0	26.

Source: (European Commission, 2009)

of e-commerce applications), for promotion of business activities and for the realization of personal interests and hobbies. Using of the Internet services for daily life is described in the Table 3, which shows the percentage of Czech population using selected services.

In the area of Common Internet services use in order to meet information needs in everyday life the Czech Republic is occupying very unflattering position. It belongs to the second worst group along with Portugal, Poland and Ireland. The average value of the index for this group is 0.2135, which is very low - close to the basal value. Europe's leaders in this area are represented by Finland, Norway and Iceland (Table 4).

3.3 Internet data services - economical

We have also analyzed a number of indicators from the area of Economical Services. We have been concentrated on measurement of the following three particular areas:

- E-government - public and government e-service provisioning, such as submitting of electronic forms to government or use of these services by citizens and legal persons,
- E-commerce - e-commerce services, sale and purchase of goods or services through the Internet,

Table 4. Internet services use – Analysis results

ID of cluster	Countries in Cluster	Average index
1	Finland, Norway, Iceland	0,6860
2	Great Britain, Luxembourg, Netherlands, Sweden, Denmark	0,5866
3	France, Germany	0,4648
4	Slovenia, Estonia, Lithuania	0,3850
5	Malta, Slovakia, Latvia, Belgium, Austria, Spain, Hungary	0,2874
6	Czech Republic, Portugal, Poland, Ireland	0,2135
7	Bulgaria, Romania, Cyprus, Greece, Italy, Croatia	0,1242

Source: own analysis

- E-business - electronic services supporting business activities such as deployment of ICT for integration of internal processes (ERP systems) or the use of information technology to support customer relationship management (CRM) or supply chain management (SCM).

In this paper we will discuss only the results from the e-government area.

The Czech Republic is among countries that are promoting these services with very good experience. It was one of the first countries to introduce the legal possibility of using the electronic signature or compulsory electronic mailboxes for legal persons.

The data in Table 5 summarize the use of electronic services by citizens and organizations. Low percentage of people using electronic services is in our view given by the availability of these services. The analyzed data also show that the trust of citizens and organizations to fill out and send electronic forms to the state and government authorities is low, and therefore little used. It may be also associated with low digital literacy of citizens.

The calculations position the Czech Republic to the group which comes third from the bottom of the list, along with Greece and Belgium (Table 6). Norway is at the top of European countries in e-government indicators. In general, Czech companies significantly lag behind trends in the EU in the field of e-government.

3.4 ICT services utilization

European society today is certainly one of the most advanced in terms of deployment and use of ICT. General view across all above analyzed areas of ICT services utilization of Europe is provided in the following table.

At the front of the hypothetical peloton of European countries in the field of informatization are the Scandinavian countries Norway and Denmark, respectively. The Czech Republic belongs to the group of countries together with Slovakia, Slovenia and Spain. On the positive side, the Czech Republic ranks among the leading countries of the new EU members (excluding the Baltic countries of Estonia and Lithuania).

Table 5. E-government services use by the Czech society

Indicator/Year	2004	2005	2006	2007	2008	EU27	Rank in EU
% of basic public services for citizens fully available online	17,0		8,0	25,0		51,0	21.
% of basic public services fully available for business online	50,0		63,0	100,0		72,0	
% of population using e-government services	7,0	5,0	17,0	16,0	14,0	28,0	24.
% of population using e-government services for submission of completed forms					4,0	12,0	24.
% of companies using e-government services	75,0	79,0	76,0	73,0	73,0	68,0	17.
% of companies using e-government services for submission of completed forms	24,0	32,0	32,0	34,0	35,0	50,0	24.
% of companies using e-government services for the submission of completed forms for contracts bidding (e-procurement)		16,0	10,0	12,0	8,0	9,0	17.

Source: (European Commission, 2009)

Table 6. E-government services use – Analysis results

ID of cluster	Countries in Cluster	Average index
1	Norway	0,7340
2	Ireland, France, Austria, Sweden	0,6272
3	Portugal, Denmark, Estonia, Iceland, Netherlands	0,5773
4	Finland, Great Britain, Latvia, Slovakia	0,5020
5	Croatia, Luxembourg, Malta, Germany	0,4331
6	Slovakia, Hungary, Italy, Spain	0,3758
7	Greece, Czech Republic, Belgium	0,3307
8	Lithuania, Poland, Romania	0,2581
9	Bulgaria, Cyprus	0,2131

Source: own analysis

Table 7. Level of European countries informatization (all analyzed areas)

ID of cluster	Countries in Cluster	Average index
1	Norway	0,7855
2	Denmark	0,7176
3	Finland, Ireland, Netherlands, Sweden, Great Britain, Iceland	0,6087
4	Austria, Belgium, France, Luxembourg, Germany	0,5150
5	Estonia, Lithuania, Malta, Portugal	0,4389
6	Czech Republic, Slovakia, Slovenia, Spain	0,3790
7	Hungary, Italy, Latvia, Poland, Croatia	0,3132
8	Bulgaria, Romania, Cyprus, Greece	0,1829

Source: own analysis

Table 7 shows that for further development of information society in our country, we should draw on particular experience of the Nordic countries.

4 Conclusions

Clustered approach provides added value to existing country rankings or indicator analyses in the area of ICT services utilization by extracting coherent groups of countries. This approach should not replace current country rankings, but in addition to simple ordered lists of countries allows particular country to identify its real competitors in the areas being analyzed.

This has been demonstrated on the case of the Czech Republic being compared with the rest of European countries.

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