DATA ANALYSES OF THE CONNECTION BETWEEN IT&C AND THE ECONOMIC PERFORMANCE IN EUROPEAN UNION. STUDY CASE: ROMANIA

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Abstract

Technology, especially IT&C, is vital to national competitiveness and has become a key factor for increasing economic performance and quality of life. But how could the relationship between IT&C and the economic performance be described? This paper will propose three data analyses using two indicators: GDP per capita, as a measure of the economic development of a country, being also an indicator of living standards, and ISOC - Individuals computer use, as a measure of the IT&C skills penetration into the population. The results highlight the importance of the development of the information society, as a critical step towards meeting the demands of society and the EU economy.

Keywords: IT&C, GDP, data analysis, clustering, trendline, regression

JEL Classification: C22, J24, M15

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1. Introduction

Computer skills are essential for efficiency in all aspects of our fast changing world. The usage of IT&C by the population is in a direct relationship with its welfare and with the economic development of the country. In this paper we'll

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describe the connection between IT&C and the economic performance, proposing three data analyses at national level for the 28 European Union countries.

We used two indicators:

- GDP per capita, as a measure of the economic performance of a country;
- ISOC - Individuals computer use (percentage of individuals), as a measure of the IT&C skills penetration into the population.

For both indicators we have use historical data from 2006 until nowadays, obtained for the 28 European Union countries. The data are provided by EuroStat, a portal maintained by European Union as its "statistical office" with the task of providing the EU with statistics at European level that enable comparisons between countries and regions [3].

The three data analyses are:

(1) a 4-partitions clustering of the 28 EU countries using the two indicators. The 28 EU countries were divided into 4 clusters with similar properties related to their GDP and ISOC indicators. For every cluster, the most representative country was selected;

(2) an analysis of the time series of the individual usage of computers in some EU countries. We've considered two selections: first, the four countries selected at the previous step, as the most representatives for their cluster, and, second, the five countries in cluster 3, containing Romania as well;

(3) a description of the relationship between the GDP per capita and the individual usage of computers in Romania in the last years.

2. Clustering the European Union-28 countries in 2014

In this section, a 4-groups clustering of the 28 EU countries is proposed, emphasizing the relationship between the development stage of a country and the level of computer usage among population. For every cluster, the most representative country was selected.

The partitioning was obtained using the K-means algorithm for two series of data: the GDP-per capita and the ISOC indicators for 2014. The method is an iterative process that aims to partition n objects (the 28 countries) into k clusters in which each observation belongs to the cluster with the nearest mean (centroid), serving as a prototype of the cluster [8]. We've run the K-means algorithm for k=4 clusters.

For short, the algorithm consists in reiterating the next three steps until the system stabilises:

- compute the distance between every object to every centroid;
- for every object, determine the nearest centroid;
- move the centroids in the middle of their cluster.

Initially, the centroids are placed anywhere; for computational reasons, we placed them in the first k=4 objects. The algorithm was implemented by the author in C++ programming language using the Visual Studio IDE. After stabilisation, for every centroid the nearest object (country) was selected, as the most representative of its group.

In order to provide a relevant analysis, the two series were normalized. The results of the clustering process are tabled below. The countries in every cluster are listed according to their GDP per capita value (from the lowest to the highest). In the Annex 1 the 4-partitions clustering is graphically represented.

Table. 1. Grouping the 28 EU countries into four clusters

Cluster 1	Cluster 2	Cluster 3	Cluster 4
1. Italy (IT)	1. Luxembourg (LU)	1. Bulgaria (BG)	1. Malta (MT)
2. France (FR)	2. Finland (FI)	**2. Romania (RO)**	2. Cyprus (CY)
3. United Kingdom (UK)	3. Denmark (DK)	3. Portugal (PT)	3. Estonia (EE)
4. Germany (DE)	4. Austria (AT)	*4. Greece (EL)*	4. Latvia (LV)
	5. Belgium (BE)	5. Poland (PL)	5. Lithuania (LT)
	6. Sweden (SE)		6. Slovenia (SI)
	7. Netherlands (NL)		7. Croatia (HR)
	8. Spain (ES)		8. Slovakia (SK)
			9. Hungary (HU)
			10. Czech Republic (CZ)
			11. Ireland (IE)

The first cluster contains four countries with a very high GDP indicator. Even the highest state of development of these four, the usage of computers is not so extended; in case of Italy, for instance, less than 60% were reported as IT&C users.

The second cluster has a very high performance in IT&C terms, the largest majority of the countries (7 of the 8) trespassing 80% computer use.

The third cluster contains five countries, characterized by slowly increased GDP values, having the lowest percentages in computer use. Romania has a concerning low percentage of computer use, 55%, the lowest among the 28 EU countries in 2014. Even though, its GDP value trespasses the values of almost countries in the fourth cluster, excepting Czech Republic and Ireland.

The fourth cluster contains 11 countries characterized by low GDP values, but high performances in computer usage terms, the ISOC values are grouped around 70-80%.

As shown above, the nearest country to every centroid will be considered as representative of its cluster. Using the distances between every object (country) and every centroid, we selected the four representatives:

Table. 2. The coordinates of the four centroids and the most representative countries for every cluster

Clusters	Coordinates of the centroid		The most representative country
	GDP per capita*	ISOC*	
Cluster 1	76.13	25.78	France
Cluster 2	14.29	34.76	Belgium
Cluster 3	6.31	6.6	Greece
Cluster 4	1.93	21.21	Hungary

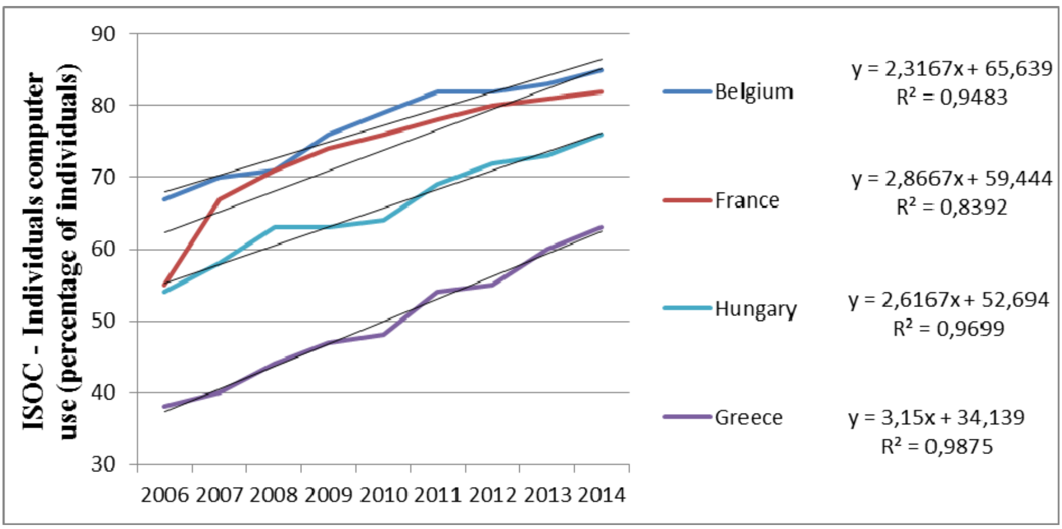
*) the values are normalized

3. The evolution of the individual usage of computers in the period 2006-2014 in some EU countries

Some European countries were selected in order to deeper analyse their state in terms of computer usage.

First, the four cluster representatives were considered: Belgium, France, Greece and Hungary. Plotting their ISOC indicators in the last nine years (2006-2014), it can be clearly noticed their linear evolution, demonstrated by the standard errors' high values.

Figure. 1. The evolution of individual computer usage indicator for the cluster representatives in the period 2006-2014



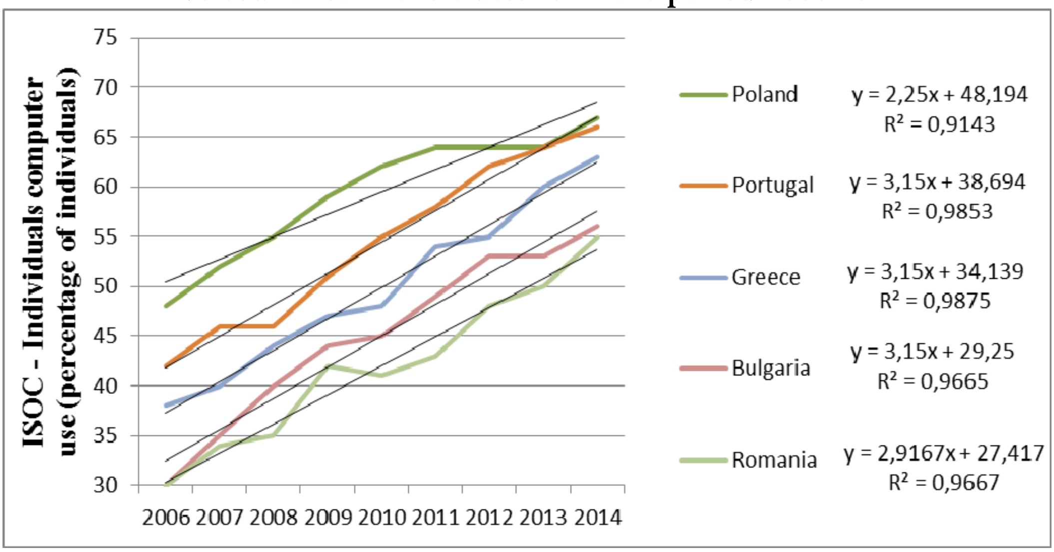
Belgium, France and Hungary have higher performances in this particular segment of IT&C usage, but Greece, the representative of the third cluster, has the most accelerated progress (slope 3,15).

Table. 3. The trendlines' coefficients corresponding to the four cluster representatives

Cluster	Country	Slope	Standard error
1	Belgium	2,31	0,94
2	France	2,86	0,83
3	Greece	2,61	0,96
4	Hungary	3,15	0,98

At cluster level, we compared to evolution of the five countries in cluster 3, including Romania.

Figure. 2. The evolution of individual computer usage indicator for the five countries in the cluster 3 in the period 2006-2014



The coefficients of the trendlines prove again a constant progress in time; the growing degree is similar in case of Greece (the representative of the cluster), Bulgaria and Portugal (slope 3,15). The slowest evolution corresponds to Poland, the country in the group having the highest values for ISOC.

Table. 4. The trendlines' coefficients corresponding to the five countries in the third cluster

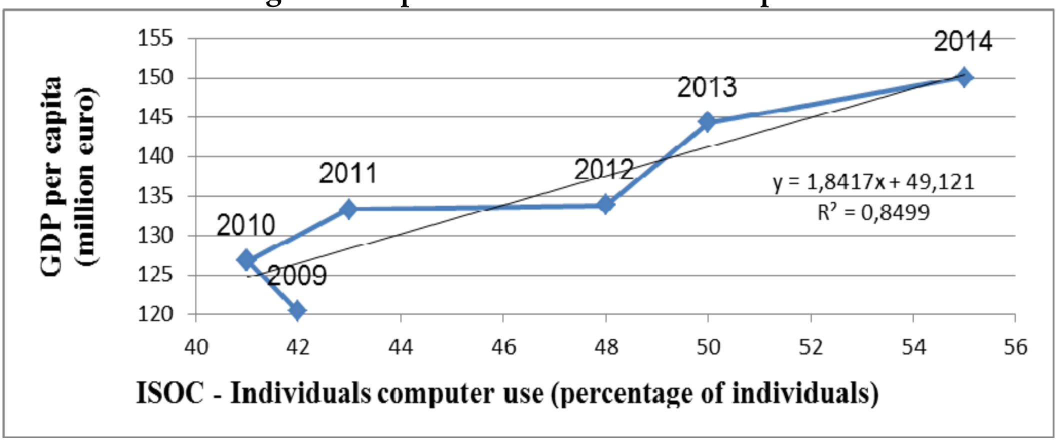
Country	Slope	Standard error
Poland	2,25	0,91
Portugal	3,15	0,91
Greece	3,15	0,98
Bulgaria	3,15	0,96
Romania	2,91	0,96

In case of Romania, the computer usage has been increasing in time, although it has the lowest values in the considered period in comparison with the other states, indicating a constant gap between Romania and the other four countries in the cluster.

4. The relationship between the GDP per capita and the individual usage of computers in Romania in the period 2009-2014

In the last analysis, we measured the strength of the relationship between the GDP per capita and the individual usage of computers in Romania. We considered the values of the two indicators in the last six years (period 2009-2014).

Figure. 3. The relationship between the GDP per capita and the individual usage of computers in Romania in the period 2009-2014



As figure 3 shows, the dynamics of the ISOC indicator is characterised by a slow decrease, in 2010, followed by a constant improvement. The coefficients of the regression line suggest that the two indicators ISOC and GDP per capita are in a strong relationship. The Anova analysis is detailed in Annex 2.

5. Conclusion

Increasing ICT adoption is a key piece of Europe's productivity, with direct links to the economic development of a country. Through three data analyses we've described the nature of this relationship. First, we depicted the four groups of European Union countries with similar features, choosing a representative for every partition. Then we analysed the behaviour in time of the representatives, and we provided a second analysis dedicated to Romania: we compare the trendlines of Romania and the other four countries in its group. As a conclusion, we can state that there are obviously gaps between clusters (through their representatives) and also at cluster level, in term of computer usage, but, at some point, the progress is more significant in countries less performant. The third data analysis focused on the relationship between computer usage and the economic performance of Romania. There is a strong linkage between the two variables, suggesting that improving IT&C skills among Romanian population could be a key factor toward Romania economic development.

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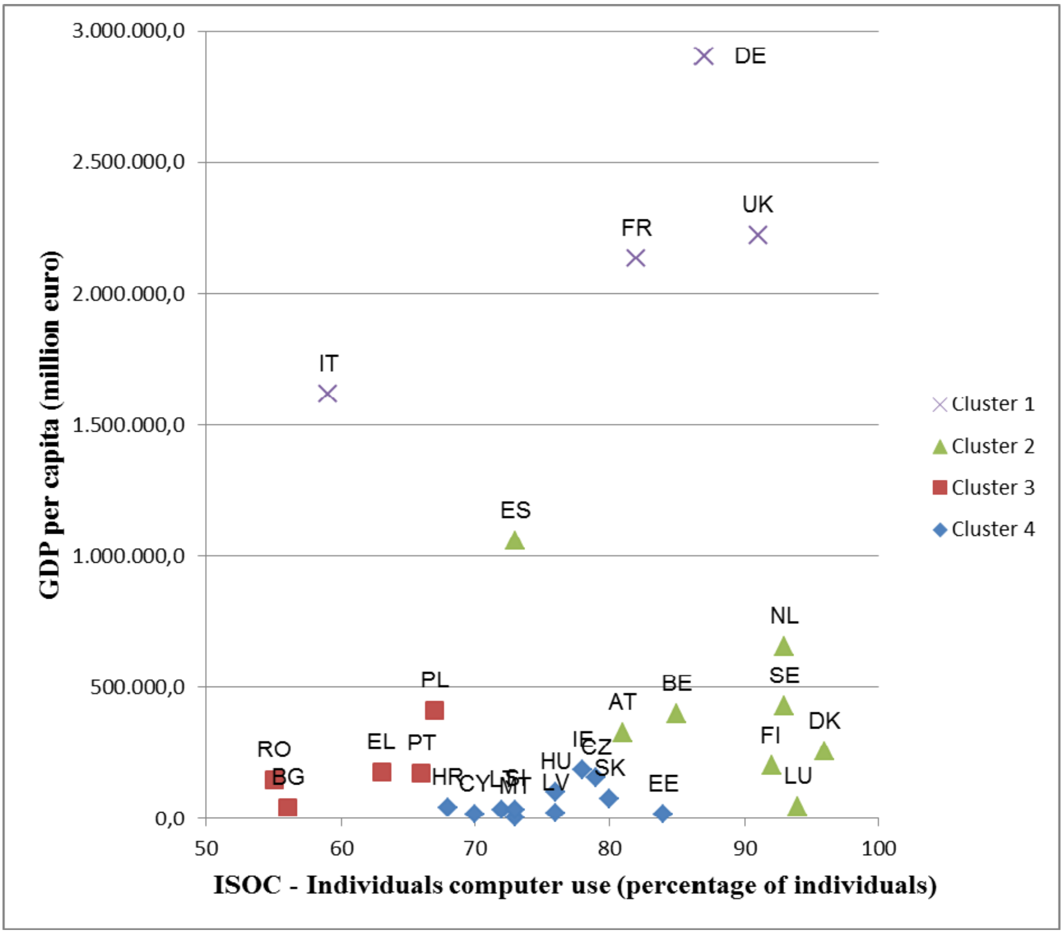
Annex 1. The four clusters of the 28 EU* countries showing the relationship between GDP per capita and individual computer usage (ISOC)



*) The 2014 GDP per capita value for Luxemburg was estimated through extrapolation, being not available at the time of writing this paper.

Annex 2. The Anova analysis for the linear relationship between the GDP per capita and the individual usage of computers indicators in Romania in the period 2009-2014

Regression line equation: *GDP per capita = 1,8417 * ISOC + 49,121*

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,921876
R Square	0,849855
Adjusted R Square	0,812319
Standard Error	4,732569
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	507,0928	507,0928	22,6409	0,008917
Residual	4	89,58883	22,39721		
Total	5	596,6817			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	49,12149	18,10161	2,713653	0,053335	-1,136642	99,37963
ISOC	1,841718	0,387058	4,758245	0,008917	0,767072	2,916364