The Relationship between the Information Society and Regional Innovation Performance in the Central and Eastern European Regions

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Abstract

It has been an important challenge for Central and Eastern European (CEE) regions to find their own opportunities after the transition in the frame of the new economic regulations and environment. One of these opportunities might be the adoption of innovative and new products. These might open the door to gain competitive advantages for a given region and they might have an effect on establishing new regional entrepreneurships or new cooperation, as well. The regional socioeconomic and cultural environment has an important role as the background of the regional innovation processes. This setting has been determined by the growing amount of information and technological innovations in the last decades. The information and the use of info-communication technologies have got a central role in the socio-economic processes by the permanently developing technology and faster communication opportunities. Therefore it can be assumed that there is a relatively strong relationship between the development of information society and the regional innovation performance. This paper focuses on this relationship in the Central and Eastern European regions. The "Regional Index of Information Society" is applied to characterize the information society in the analysed regions. This index measures the development level of information society in the European regions and it has been created from statistical indicators regarding information society. The regional innovation performance is measured by the Regional Innovation Scoreboard of the European Commission in our analysis. The goals of the paper are to discover and characterise this connection between these two processes.

Key words: regional development, regional innovation, information society

JEL Classification: O18, R11

1 Introduction and Theoretical Background

Knowledge, learning, innovation activities and their relations have been playing more and more important role in the regional development processes in the last two to three decades. Innovative products may give competitive advantages for a given territory and they may have an impact on establishing new entrepreneurships or new cooperation. However, there are many direct and indirect factors which have influence on the innovation process. The establishment of innovative products depends on the firm's capacities (researches, human resource, financial background), primarily. Beside the direct factors, the indirect influencing aspects has also crucial role in the innovation process. Namely, the heterogeneous regional environment and opportunities may explain why some regions are more innovative than others. The information infrastructure and its use have had emerging role in the economy and in innovation processes, as well. Therefore we study the relationship of the innovation performance and information infrastructure in this paper. First of all we summarize shortly the theoretical background.

The information and the info-communication technologies have got a central role in the socio-economic processes of the last two to three decades by the permanently developing technology and faster communication opportunities. The social and economic environment has been determined by the growing scale of the information and the technological innovations more and more. The accelerated communication between organizations and individuals has speeded the stream and change of the information (Lengyel I., 2010). The quicker diffusion of information has opened new opportunities in the business and economic processes as well as in the social life and communication. Information has added to the economic processes and it has become a crucial factor in them.

The definition of the "information society" concept depends largely on the point from where it has been approached. The information society has six different dimensions: technology, occupational change, economy, space (spatial dimension), social and cultural (Webster, 1995). According to Masuda, one of the first scholars dealing with this concept, information society is such kind of society that has been built on the exploitation of information resources, and this kind of society progressively replaces the model of industrial and mass-production society. The information society also possesses a high-level intellectual creativity (Masuda, 1980; Szépvölgyi, 2008). Farkas (2002) has stressed the handling and application of information in his approach. The definition of OECD also underlines that many employees deal with handling, production and distribution of information in the information society (OECD, 1996). The infrastructural aspect can be observed, for example, in the description of the information society by Fodor (2000)[1] or Erdősi (2002). They have emphasized that a new lifestyle and, the accelerated stream of information have been realized through the technological development and innovations in info-communication technologies. Ropolyi (2006) claims that the regular use of information technologies (especially the internet) have created a new organizing form of community. However, it is not worth to term this organizing form as society, but it may be designated as "network entity". According to Z. Karvalics (2005), the real dimensions of information society should not be looked for only in telecommunication or computerization, but might be found through education, science, innovation, content and culture. Therefore, information society is a complex phenomenon that includes many factors (Z. Karvalics, 2005). Approaches like "knowledge society" or "post-industrialist society" relate more or less to the information society (Jakobi, 2007). The networks and the use of technologies play an important role in territorial inequalities of information society. The lack of adequate infrastructure may exclude the underdeveloped territories from the stream of information and knowledge, which may result in significant differences between the centre and peripheries. Graham (2000) provided some examples on how the development of information and communication technology (ICT) extends the digital divide among different regions or cities within a country. He claims that a close connection can be observed between ICTs, global urban polarization, and the extending power of transnational corporations. Thus, it "can compromise and erode the social, economic and cultural

[1] The approach of Fodor (2000) is accepted by most of those Hungarian researchers who deal with socio-economic aspects of information society (Jakobi, 2007).

powers of those groups and spaces that are rendered off-line or marginal” (Graham, 2000, 27). Similar observations have been made by van der Meer and his colleagues (2003) about the territorial differences in the ICT sector.

It is important to notice that the territorial analyses of the information society are determined by the concept and data what the scholars use (Jakobi, 2007). Therefore, the approach and the data sources may determine those factors that are taken into consideration if the information society is analysed. There are factors which would be out-of-date during the last years and others will be taken into consideration. These processes have formed the data and the indicators, as well. Some indicators have gained more attention, and new data sources have been discovered by the use of smart phones or social media (Jakobi, 2014). The (territorial) inequalities can be also observed in the information society. The networks and the use of technologies play an important role in these processes. The lack of the adequate infrastructure may exclude the underdeveloped territories from the stream of information and knowledge and it may cause big differences between the centre and peripheries.

In this paper we measures the use of information (Internet) infrastructure, although the concept of “information society“ may be much wider if the social factors are taken into consideration, as well.

The innovation processes have been a relevant research topic especially for the last third of the 20th century. The literature contains vast number of studies and many models on how innovations are created or what kind of factors influence these processes. Therefore we highlight here only some articles that refers on the relationship of the innovation process and information infrastructure. Caraça and his colleagues (2009) have distinguished two different models of innovation processes generally: the linear and the chain-linked model. Both of the models focus on the firm-level innovation processes. The linear model assumes that there is a one-way direct process from the basic science to the purchase of the final product (Rothwell, 1995; Godin, 2006). It represents that research is a prime impulse behind those technologies which may have a significant economic effect, as well. The chain-linked model introduces the formation of an innovation as an interactive process between the chain of innovation, knowledge and research (Kline and Rosenberg, 1986). According Kline and Rosenberg’s model the innovation process draws an interplay between the commercial and technological opportunities and constraints. It means that science may offer the latest technologies and research results (as in the linear model), but the commercial side may also force on the creation of science (Kline and Rosenberg, 1986; Caraça et al., 2009).

Caraça and his colleagues developed a third model (“the multi-channel interactive learning model”) which was built on the interactive mechanism of the chain-linked model “but stresses the particular relevance of the ubiquitous experience based in learning processes taking place within firms, the relations with users, suppliers and competitors and the relations with universities and other knowledge production, dissemination and transfer organizations” (Pinto and Perreira, 2013, p. 759). Furthermore, it takes into consideration those factors that may influence firms’ innovation process (Caraça et al., 2009; Pinto and Perreira, 2013). Hence there is a micro-environment (like suppliers, consultants or partners) which influence directly firms’ innovation processes and a macro-environment (for example the education system, regulators, finance or information infrastructure) in which the firms’ innovation process is embedded. If we compare this approach of the innovation process with the systematic approach of innovation, many similarities can be observed (Pinto and Perreira, 2013). Namely, the theoretical model of the regional innovation system represents the flow of knowledge, human resources as such parts which are embedded in the regional socioeconomic and cultural settings (see the model of Autio (1998) or Tödtling and Trippl (2011) among others). The regional environment doesn't have direct effects on the system, but it may determine the potential opportunities of the actors and the organizations in the regional innovation system. Therefore this regional setting may correspond to the macro-environment of the multi-channel interactive learning model. Thus, we assume that the regional information infrastructure as the part of the regional (macro) environment may have an indirect effect on the regional innovation performance.

In the next section we introduce our data sources and the methodology with which to analyse the relationship of regional innovation performance and information society. The results are presented in two parts: a European regional comparison on the one hand and a Central and Eastern European regional investigation on the other hand. Conclusions and further orientations of our research will be summarized in the closing part of the paper.

2 Data and Methodology

For measuring the relationship of regional information infrastructure and regional innovation performance, we used different data sources. It has to be noted that we used the "regional information society statistics" data of Eurostat for measuring "information society".
The regional information infrastructure has been measured by an index. It was developed in the frame of a research project which investigates the information society from different aspects. It captured the information infrastructure by five indicators which refer on its existence and use (see Appendix 1 for the detailed description of the indicators). Data have been accessed from the period between 2008 and 2013. We have attempted to measure these indicators in all of the NUTS 2 EU regions, but only NUTS 1[2] or NUTS 0[3] level data were available in some countries. Several regions have to been excluded from the analysis due to the lack of relevant data[4]. Altogether 180 regions have been included in our analysis. We describe here shortly how this index was calculated.

Firstly, we created two main indicators from the five starting variables by multiplication: "households" (two indicators) and "individuals" (three indicators). The descriptive statistics[5] and correlation coefficients of the original indicators and the main indicators were checked. We paid attention to the skewness of the original indicators and also the new main indicators. If the skewness of an indicator fell out of the [-1;1] range, then this indicator had to be transformed. We had one main indicator which was out of this range ("individuals"). We used Box-Cox transformation (1).

[2] In Finland, France, Germany, Greece, Poland, Slovenia and the United Kingdom
[3] We have got NUTS 0 level data where the NUTS 2 level involves the whole country.
[4] Northern Ireland, the overseas region of France and the African part of Spain had to be excluded due to the lack of data.
[5] The detailed table can be found in the appendices of the paper.

$$y_i = \begin{Bmatrix} \text{if } \lambda \neq 0, \text{then } \phi(y_i) = \frac{y_i^{\lambda}-1}{\lambda} \\ \text{if } \lambda = 0, \text{then } \phi(y_i) = \ln(y_i) \end{Bmatrix} \quad (1)$$

We followed the EU Regional Competitiveness Index (Annoni and Kozovska, 2010) and the REDI Index (Regional Entrepreneurship and Development Index) (Szerb et al., 2014) to use this transformation method. The values of "households" and transformed values of "individuals" were normalized by using formula (2).

$$z_i = \frac{x_i}{\max(x_i)} \qquad (2)$$

Therefore the maximum value of each indicator was 1 in every year, and the other values were computed to the [0;1] scale. After normalization, the aggregated index was composed which measures the "information society" in European regions on a scale from 0 to 100.
We calculated the index values for each year between 2008 and 2013. But some modifications had to be conducted in the index before the comparison with the regional innovation performance. The average values were computed for this period, but the indicator values raised from year to year due to the development of regional "information society". Therefore we computed three different average values: arithmetic average (IS_AVG), weighted average (IS_W_AVG) which represented the growth of the index values year by year and "min-max" average (IS_MINMAX_AVG) value which was computed from the lowest and the highest value of the investigated time period. We compared them to each other and they didn't represent significant differences. The correlation with regional innovation performance values was checked and it was almost the same in each case of the averages. Thus we decided to calculate the min-max average values in the final investigation.

The data of regional innovation performance were collected from the measurement of the Regional Innovation Monitor's database. The Regional Innovation Scoreboard has 12 regional level indicators: two refers on the enabler factors of innovation process (like rate of population's tertiary education or public R&D expenditures), five represents the "firms' innovation activities" (for example, business R&D expenditures or SMEs collaboration) and four indicates the outputs of the innovation process (like new products and their sales) (Regional Innovation Scoreboard, 2014). Altogether 190 European regions were involved in the scoreboard but some countries (Estonia, Latvia, Lithuania, Luxembourg, Cyprus and Malta) were missed out. Most of the involved regions are from the European Union but Swiss and Norwegian territories were included, as well. In our analysis, we excluded Swiss, Norwegian and Croatian regions[6]. Furthermore, we had to fit the involved territories of information infrastructure investigation to the regions of Regional Innovation Scoreboard. We used normalized regional data of the indicators from 2007, 2009, 2011 and 2013. These data were collected from the Regional Innovation Scoreboard reports. Firstly, we involved all of the indicators, but the rate of population's tertiary education indicator had to been excluded, because its content was modified for the latest measurement. Formerly, this indicator was measured for adult population aged 25 to 64 years, but only the population aged 30 to 34 years was surveyed in 2013.

[6] We have excluded Croatia because the Regional Innovation Scoreboard used the old NUTS classification and the new territorial classification has been used in the measurement of information infrastructure.

We have computed average values for the three groups of the indicators (enablers, firm activities and output). The means of the three group values (Enablers_avg, Firmact_avg and Outputs_avg) have been calculated for every region (Threepillar_avg), because it captured better the change in values from 2007 to 2013 than the arithmetic average value. We have checked the correlation values for the regional innovation scoreboard and regional information society index values. Then we have conducted a cluster analysis with the two index values and we have decided to create 5 clusters. The F values of the ANOVA have confirmed our decision.

3 Results

The correlation analysis shows that there is a medium-strong relationship among the regional innovation performance and information infrastructure. We represent here not only the chosen but all the three average values of information infrastructure. It reveals on the very small differences among the three values in the correlation to the regional innovation performance. We have checked the correlation between the different groups and information infrastructure, as well. According to the coefficient values, the strongest relationship can be observed among the "firm's activity" indicators, while the other two indicator groups ("enablers" and "output") have moderate relationship to the information infrastructure (Table 1).

Tab. 1 Correlation coefficients between regional innovation performance and information infrastructure

Correlation (168 European regions involved)	Enablers_avg	Firmact_avg	Outputs_avg	**Threepillar_avg**
IS_MINMAX_AVG	0.516	0.791	0.513	**0.694**
IS_AVG	0.509	0.787	0.500	**0.685**
IS_W_AVG	0.499	0.785	0.499	**0.679**

Note: All correlation coefficient values are significant at the 0.01 level (2-tailed).
Source: own calculation

Weaker correlation coefficient values can be observed as we analyse only the Central and Eastern European regions. The coefficient values of "firm's activity" group decreased much more than in the case of other two groups. It may refer on the relatively weaker performance of CEE regions compared to the Northern and Western European regions in those indicators which measure firms' innovation activities (table see in the Appendix).

After checking the correlation coefficients we have conducted a cluster analysis for the European regions. We have involved 168 regions from 21 European Union countries and five clusters were created. The clusters differ significantly from each other according to the ANOVA F-values. The values correlate to each other as the correlation coefficients proved. Hence the better a region in information infrastructure perform the higher values in innovation performance may it have. The best performing cluster in innovation has the second best values in the information infrastructure and conversely (Table 2).

Tab. 2 Mean values of the clusters

Name of clusters	**B.P.I.**	**B.I.I.**	**A.A.**	**B.A.**	**W.**
Regional Innovation Performance (AVG)	0.55	0.50	0.43	0.34	0.28
Regional Information Infrastructure (AVG)	75.99	87.83	58.40	42.63	22.00
Number of regions	26	28	34	61	19

Legend: B.I.P. – Best performing regions in innovation; B.I.I. – Best performing regions in information infrastructure; A.A – Above average performing regions; B.A. – Below average performing regions; W. – Weakest performing regions

Source: own calculation

If we see about the geographical location of the members of different clusters, we can see that the best performing regions locate in Northern and Western Europe (Figure 1). They have unambiguously better performance than the Southern and Eastern European regions. The highest values have Dutch, Swedish and Danish regions. The differences between the West and the East German territories can be observed more or less clearly and the dominance of the capital city region in France[7] as well. It can be concluded that the best performing regions are the most developed and highly urbanized Northern and Western European regions. The weaker performing Western European regions (like Irish or East German regions) and the best performing Southern European and CEE regions belong to the above average regions. Slovakia, Slovenia and the most developed Spanish (Catalonia, Basque county and Madrid), Czech (Prague and it surroundings) and Hungarian (Budapest and Central Transdanubia) regions are in this cluster. From this aspect underdeveloped regions (members of Cluster 4) are in Central and Eastern Europe (like Romanian and Bulgarian regions) as well as in Southern Europe (Greek, Southern Italian and Portuguese regions).

[7] We had only NUTS 1 values from France and it may overlap the differences among the regions.

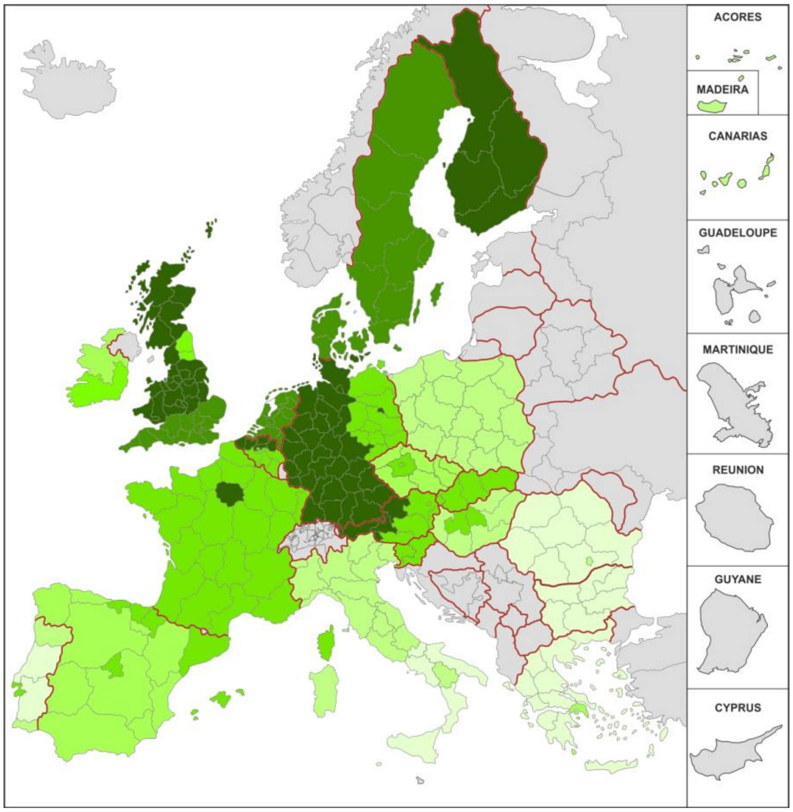

Fig. 1 The results of the cluster analysis of the European regions
Legend: B.P.I. – darkest green, B.I.I. – dark green, A.A. – green, B.A. – light green, W. – lightest green,
Source: own calculation

We have repeated the analysis only for the Central and Eastern European regions. According to the previous investigation, these regions perform relatively weak compared to the Northern and Western European regions. We have analysed not only the main index values but also the three indicator group values (Table 3). 47 regions form seven countries have been involved. The best performing regions have the highest scores from most of the aspects (except "Firm's activity" indicator group). Compared to the other clusters they have very high scores in "Enablers" indicator group. The second best group ("D.CEE") has above average performance. Moreover these regions perform best in "Firm's activity" indicators. The "A.CEE" group includes more than a half of the CEE regions. It constitutes a transition group between the better and weaker performing regions. There is a relatively large break between the "A.CEE" and "U.CEE" clusters in the values of information infrastructure and "Firm's activity" indicators. The "U.CEE" cluster has the weakest scores in "Firm's activity" and "Outputs" indicators. However, it has relatively good values in "Enablers" indicators.

Tab. 3 Mean values of the clusters of CEE regions

Name of cluster	**B.CEE**	**D.CEE**	**A.CEE**	**U.CEE**	**W.CEE**
Enablers	0.55	0.25	0.25	0.26	0.12
Firm's activity	0.34	0.35	0.28	0.19	0.21
Outputs	0.49	0.41	0.29	0.24	0.26
Regional innovation performance (AVG)	0.46	0.34	0.27	0.23	0.20
Regional information infrastructure (AVG)	60.86	52.45	43.72	24.86	16.61
Number of the regions	3	9	26	2	7

Legend: B.CEE – Best performing CEE regions; D.CEE – Developed CEE regions; A.CEE – Average performing CEE regions; U.CEE – Underdeveloped CEE regions; W.CEE – Weakest performing CEE regions
Source: own calculation

The result of cluster analysis has classified Central and Eastern Europe regions into two main groups: better (Czech Republic, Hungary, Poland, Slovakia and Slovenia) and weaker performing (Bulgaria and Romania) territories. The best performing regions are three capital city regions in Central Europe: Prague, Bratislava and Central Hungary with Budapest. The "developed" cluster includes the other Slovakian regions, the Slovenian regions, the more developed Hungarian regions (Central and Western Transdanubia) and the Czech "Southeast" region. Polish regions had relatively balanced performance in innovation and also in information infrastructure. However, it should be noticed that we had only NUTS 1 data about the latter and it may influence the final results. The capital city region overtops the other regions also in Romania and Bulgaria. Only the Romanian "Vest" region represent higher scores compared to the other, non-capital city regions (Figure 2).

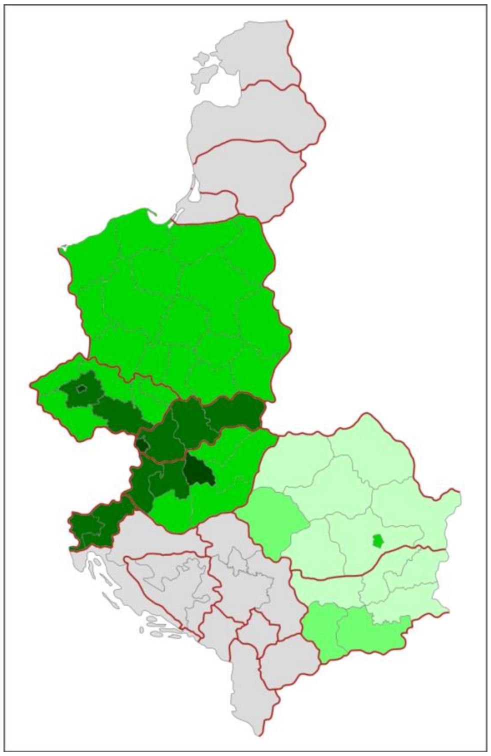

Fig. 2 The result of the cluster analysis on the CEE regions
Legend: B.CEE – darkest green, D.CEE – dark green, A.CEE – green, U.CEE – light green, W.CEE – lightest green
Source: own calculation

4 Conclusion

We have assumed that the existence of a well-established information infrastructure may influence the regional innovation performance positively. Therefore our aim was to analyze and characterize the relationship between the regional innovation performance and information infrastructure. We have used the data of Regional Innovation Monitor for measuring the regional innovation performance and a recently developed index ("Regional index of information society") for measuring the regional information infrastructure. According to the correlation analysis there is a strong-moderate relationship among the two analysed factors. The information infrastructure had the strongest correlation with "Firm's activity" indicators, while there was moderate relationship with two other indicator groups. Therefore we claim that the existence of information infrastructure influence positively the regional innovation performance. The cluster analysis also proved that those regions which perform well in the information infrastructure have higher scores in regional innovation performance. The best performing regions are the most developed and/or highly urbanized Northern and Western European territories. Only few of the Southern and CEE regions can reach the European average values both in innovation performance and information infrastructure and most of these regions are below the European average values. As we analysed only the CEE regions in the same way, it represented similar pattern. The relatively outstanding results of the capital city regions (like Prague, Bratislava, Budapest or Bucharest) may mean that the highly urbanized and most developed territories perform best in innovation performance and have most developed information infrastructure. The European analysis reveal on these facts, as well. Thus we claim that the information infrastructure may influence the regional innovation performance. Its lack may cause disadvantageous situation, but its existence doesn't mean a direct link to the development in innovation performance. It is obvious that the richer and more developed regions have better results in information infrastructure and we note that our data on information infrastructure cover only a thin part of the whole info-communication branch. Therefore our results have some limitations. It would be interesting to see which sub-indicators of information infrastructure play more important role and which have less importance. To have more accurate results we intend to develop our investigation by using more sophisticated statistical methods. We would like to broaden our database to conduct the analysis for all of the NUTS 2 regions at least in Central and Eastern Europe. We assume that there may be a relatively strong relationship between the economic development and the recently analysed factors. Therefore we plan to involve new socioeconomic factors.

Acknowledgements

This paper has been prepared in the frame of TÁMOP-4.2.2.C-11/1/KONV-2012-0005 "Jól-lét az információs társadalomban" (Well-being in the information society) research project.

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Appendices

Appendix 1 – Detailed indicator description of the "Regional index of information society"

Indicator	Explanation
Access to the Internet at home	Percentage of households
Households with broadband access	Percentage of households
Individuals who regularly use the Internet	Percentage of individuals who use the Internet at least once a week
Who have never used a computer	Percentage of individuals
Who ordered goods or services over the Internet for private use	Percentage of individuals who purchased online at least once for private use in the last 12 months.

Appendix 2 – Correlation coefficient values of the CEE regional analysis

Correlation (47 CEE regions involved)	Enablers_avg	Firmact_avg	Outputs_avg	Threepillar_avg
IS_MINMAXAVG	0.461	0.547	0.440	**0.600**
IS_AVG	0.431	0.536	0.395	**0.561**
IS_WAVG	0.453	0.536	0.432	**0.589**

All correlation coefficient values are significant at the 0.01 level (2-tailed).

Appendix 3 – ANOVA for the cluster analysis of all involved regions

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
IS_MINMAXAVG	17954.590	4	18.326	163	979.715	0.000
Threepillar_avg	0.233	4	0.079	163	2.959	0.022

Appendix 4 – ANOVA for the cluster analysis of CEE regions

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
IS_MINMAXAVG	1805.301	4	7,544	42	239,294	0.000
Threepillar_avg	0.045	4	0.006	42	7,391	0.000