Indexes of Economic, Social and Technological Development

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Abstract

The paper studies relationships and dependencies among several indexes, designed by international organisations, which are used for assessment of economic, social and technological (mostly information society related) development. Examination and analysis of correlations between these indexes can reveal interesting dependencies. Indexes assessing the level of a country's competitiveness, corruption, e-participation, e-readiness, etc. are studied and interdependencies are also investigated. Correlation coefficients between the individual indexes are calculated and identified dependencies discussed.

Keywords: *indexes, e-indexes, economics, correlation, information society*

JEL Classification: A13, B41, C10, E00, O30

Introduction

"What cannot be measured cannot be managed" – this common phrase in business today is probably one of the reasons why several international organisations have designed indexes assessing development of countries in social, economic, and/or technological areas. Individual countries are ranked based on values of these indexes. Examination and analysis of correlations between these indexes can reveal interesting dependencies. Socio-economic and technological indicators and indexes (assessing e.g. level of corruption, competitiveness, information society development etc.) are quite frequently published in mass

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media and widely discussed in professional communities. These discussions are mostly focused on position analysis of particular country for a specific index. Another important question however, which is not so widely discussed, is to what extent these indexes "overlap", whether and why they are correlated, and how this correlation can be interpreted.

In the approaching knowledge economy information and communication technologies (ICTs) play an important role of the driver of the economic growth. For this reason special attention in this paper is paid to indexes describing development of the Information society (e-Readiness, e-Gov Readiness etc.) and their relation to the competitiveness and growth and other socio-economic phenomena (e.g. corruption).

1. Research Methodology

Calculation of Correlation Coefficients among the Indexes

The following indexes were tested (shortcut of institution that defined the given index is indicated in parenthesis – detailed description is available on relevant URL link):

1. e-Participation Index (UN) – United Nations <http://www.un.org/>
2. Corruption Perceived Index – CPI (TI) – Transparency International <http://www.transparency.org/>
3. Growth Competitiveness Index (WEF) – World Economic Forum <http://www.weforum.org/> For this index also three its sub-indexes were tested:
   3.1. Public Institution sub-index (WEF)
   3.2. Technology sub-index (WEF)
   3.3. Macroeconomic Environment sub-index (WEF)
4. World Competitiveness (WCC) – World Competitiveness Center <http://www02.imd.ch/wcc/>
5. e-Readiness Index (EIU) – Economist Intelligence Unit <http://www.eiu.com/>
6. e-Gov Readiness (UN) – United Nations <http://www.un.org/>
7. Networked Readiness (WEF) – World Economic Forum <http://www.weforum. org/>
8. Economic Freedom of the World (TFI) – The Fraser Institute <http://www.freetheworld.com/>
9. Heritage Index of Economic Freedom (THF) – The Heritage Foundation <http://www.heritage.org/>

The research was done on a sample of 96 countries for all the indexes given above published for the year 2004. In the first step it was tested whether values of the individual indexes fit a normal (i.e. Gaussian) distribution. The Shapiro-Wilk test was used for this purpose. The results showed that only the Technology sub-index (WEF) and the World Competitiveness (WCC) index can be assumed to be normally distributed.

In the second step correlations were calculated. The most widely used bivariate test for correlation is the Pearson correlation. It is intended to be used when each variable is normally distributed. To analyze variables that are not normally distributed (or are ranked) the Spearman's rho test is used. Both tests compute the correlation coefficient *r*. If the *p*-value computed for every correlation coefficient is less than 0.05 (5%), the result is statistically significant.

Based on the normality tests results, the Pearson correlation test was used only for the pair – Technology sub-index (WEF) and the World Competitiveness (WCC) Index. In all the other cases the Spearman rank (i.e. non-parametric version of the test) was used for calculation of the correlation coefficients. Calculated correlation coefficients between all the indexes are presented in Table 1. Since all the *p*-values in Table 1 are less than 0.05, it can be said that all the computed correlation indexes are statistically significant.

Looking at the Correlation matrix (Table 1) at least two principal observations can be made:

- Correlations among the whole set of indexes, excluding e-Participation Index, are very high (taking into account complexity of the phenomena they are measuring) – from 0.73 up to 0.96;
- Correlations between the e-Participation Index and all the other indexes are on average lower than the correlations among the remaining indexes – these correlations are in the interval from 0.36 – the correlation between the e-Participation Index and the World Competitiveness, up to 0.70 – the correlation between the e-Participation Index and the e-Gov Readiness (this high correlation is understandable since these phenomena are closely related and mutually conditioned). Strictly speaking, also these correlations (for these phenomena depending on multiple factors) are still in absolute figures rather high, but significantly lower than the other correlation coefficients in Table 1.

2. Results of Correlation and Regression Analysis

Strong correlation between some indexes is obviously in some cases caused by similarity of methodology and used sub-indexes, e.g. similarity between the Technology sub-index of Growth Competitiveness Index (WEF) and Networked Readiness Index (WEF). On the one hand, these high correlations between the discussed indexes indicate also a possible duplicity, i.e. limited "information value added" of some indexes in relation to the other indexes. However, maybe the discovered dependencies between the individual indexes could also help to guide policy making (e.g. in a form of a rule "If you want to increase competitiveness of your country, first pay attention to the level of corruption" – see Graph 1 below).

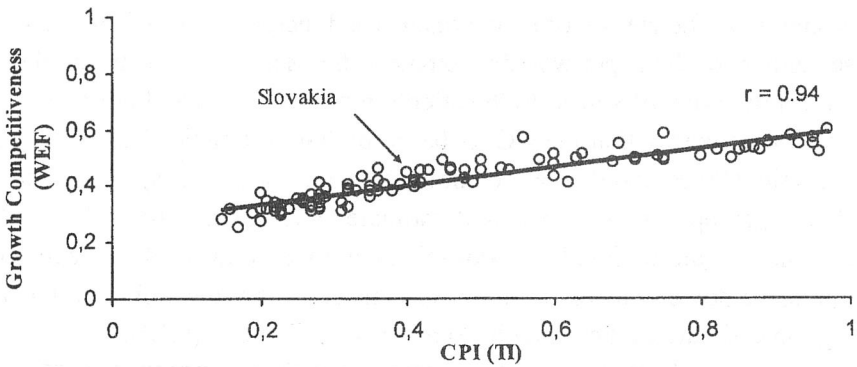
Table 1

Correlation Matrix (r – Correlation Coefficient, p – p-Value)

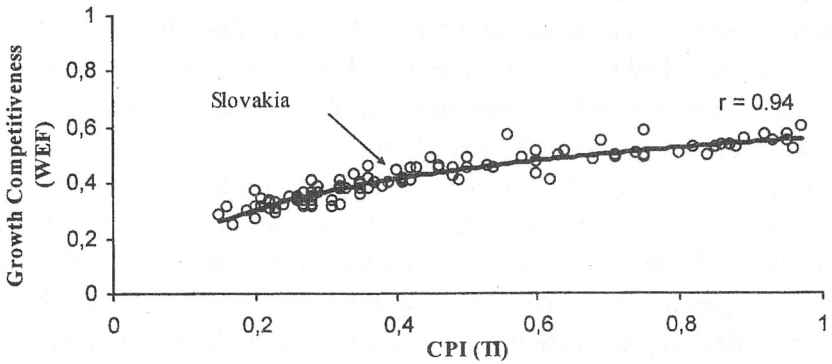
	e-Participation Index e-PI (UN)	Corruption Perception Index CPI (TI)	Growth Competitiveness Index GCI (WEF)	Public Institution-sub-index PISI (WEF)	Technology sub-index TSI (WEF)	Macroeconomic Environment sub-index MESI (WEF)	World Competitiveness Scoreboard WCS (WCC)	e-Readiness Rankingse RR (EIU)	e-Government Readiness e-GR (UN)	Networked Readiness Index NRI (WEF)	Economic Freedom of the World Index EFW (TFI)	Heritage Index of Economic Freedom HIEF (THF)	
e-Participation Index e-PI (UN)		**0.53**	**0.51**	**0.45**	**0.56**	**0.53**	**0.36**	**0.64**	**0.70**	**0.54**	**0.46**	**–0.41**	r
		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0129	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	p
Corruption Perception Index CPI (TI)	**0.53**		**0.94**	**0.95**	**0.87**	**0.86**	**0.85**	**0.94**	**0.74**	**0.90**	**0.80**	**–0.88**	r
	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	p
Growth Competitiveness Index GCI (WEF)	**0.51**	**0.94**		**0.95**	**0.95**	**0.91**	**0.86**	**0.92**	**0.84**	**0.96**	**0.80**	**–0.83**	r
	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	p
Public Institution sub-index PISI (WEF)	**0.45**	**0.95**	**0.95**		**0.86**	**0.86**	**0.85**	**0.92**	**0.76**	**0.92**	**0.79**	**–0.83**	r
	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	p
Technology sub-index TSI (WEF)	**0.56**	**0.87**	**0.95**	**0.86**		**0.82**	**0.73**	**0.90**	**0.89**	**0.93**	**0.69**	**–0.75**	r
	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	p
Macroeconomic Environment sub-indexMESI (WEF)	**0.53**	**0.86**	**0.91**	**0.86**	**0.82**		**0.85**	**0.86**	**0.74**	**0.91**	**0.77**	**–0.77**	r
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	p
World Competitiveness Scoreboard WCS (WCC)	**0.36**	**0.85**	**0.86**	**0.85**	**0.73**	**0.85**		**0.81**	**0.75**	**0.90**	**0.80**	**–0.79**	r
	0.0129	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	p
e-Readiness Rankings e-RR (EIU)	**0.64**	**0.94**	**0.92**	**0.92**	**0.90**	**0.86**	**0.81**		**0.94**	**0.88**	**0.87**	**–0.87**	r
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	p
e-Govermnment Readiness e-GR (UN)	**0.70**	**0.74**	**0.84**	**0.76**	**0.89**	**0.74**	**0.75**	**0.94**		**0.81**	**0.64**	**–0.73**	r
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	p
Networked Readiness Index NRI (WEF)	**0.54**	**0.90**	**0.96**	**0.92**	**0.93**	**0.91**	**0.90**	**0.88**	**0.81**		**0.76**	**–0.77**	r
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	p
Economic Freedom of the World Index EFW (TFI)	**0.46**	**0.80**	**0.80**	**0.79**	**0.69**	**0.77**	**0.80**	**0.87**	**0.64**	**0.76**		**–0.87**	r
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	p
Heritage Index of Economic Freedom HIEF (THF)	**–0.41**	**–0.88**	**–0.83**	**–0.83**	**–0.75**	**–0.77**	**–0.79**	**–0.87**	**–0.73**	**–0.77**	**–0.87**		r
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		p

For illustration purposes scatter-plots depicting dependencies between pairs of values of the indexes for individual countries will be presented below. In order to avoid different scales, all the indexes were normalized to the interval <0, 1>, where 0 – minimum, and 1 – maximum of the value the given index can take. Generally, one of the most examined indicators is the Corruption Perception Index (CPI), corruption being an important social phenomenon with negative impact on country economy. We have examined whether corruption has some dependency with economic indicators and indicators related to development of e-Society (which is in the heart of currently highly topical Lisbon agenda in the EU). The results show that high correlations exist between corruption and economic indicators. As an example, scatter-plots of the CPI and Growth Competitiveness Index (GCI) are presented in Graph 1 (a linear regression is also depicted) and Graph 2 (logarithmical regression – regression of course presupposes a casual relation between the two variables, for the time being it is considered as a hypothesis, without a strict theoretical proof).

Graph 1
Scatter Plot GCI versus CPI (liner approx)



Graph 2
GCI versus CPI (log approx)



The correlation between the Growth Competitiveness Index (GCI) and CPI is very high, correlation coefficient $r = 0.94$! Although this high correlation can be partly explained by the methodology of the GCI calculation (GCI contains also Corruption sub-index), still the weight of GCI Corruption sub-index in overall score is rather low (1/6 for so called "non-core" and 1/8 for "core innovators", see Global Competitiveness Report). This can hardly explain such high correlation. Of course, the correlation itself cannot be interpreted as a casual relation. But still, since correlation between the growth competitiveness, as a multi-facet phenomenon, measured be a complex set of factors (see the composition of GCI in Global Competitiveness Report), and a level of corruption, measured by a small subset of these factors, is so high, we can formulate a presumption that the level of corruption belongs to a "core" factors determining country competitiveness (our presumption is that contribution of "non-core" factors to the determination of the level of competitiveness is of limited significance). A formal justification of this hypothesis would require further research and/or also use of other techniques (e.g. knowledge discovery and data mining techniques). Finally, influence of corruption on competitiveness is not surprising, economic impact of corruption (in addition to its harmful non-economic impact) is well known – it results in non-effective and non-efficient use of public finance and increases cost of businesses. In any case, authors of the paper would recommend this dependency between the CPI and the level of competitiveness to the attention of politicians and policy makers.

It is also noteworthy that the GCI is based on hard (statistical) as well as soft data, while the CPI is based solely on soft data (opinion surveys). Since the soft data reflects perceptions, opinions and estimates (which may be influenced by current economic and political situation) this can in general result in decrease of their expressive power. However, in this case it seems that the soft data (CPI) are a pretty good estimate of the Growth Competitiveness Index (GCI).

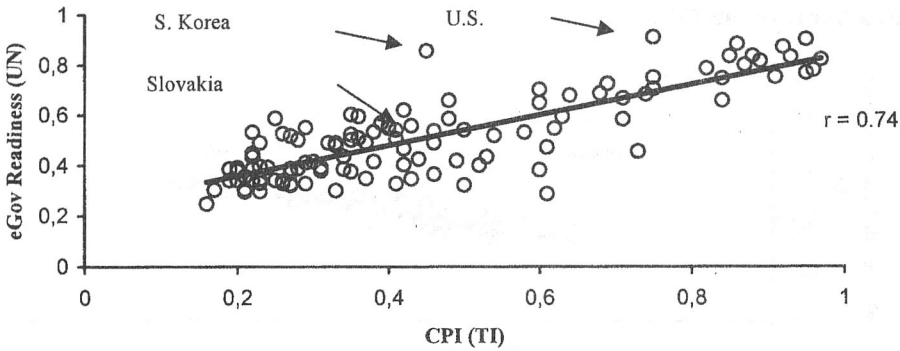
Table 1 also shows that correlations among the GCI and its sub-indexes are high, note for example correlation between the CPI and the Public Institution sub-index (which includes the Corruption sub-index).

Similar conclusions as about the GCI can be made about the World Competitiveness Scoreboard (WCC). In this paper we have, however, focused on the GCI because data on its sub-indexes was also available. Let us now suppose that corruption has a direct or indirect "casual" influence on country competitiveness, i.e. CPI is an explanatory and GCI a response variable. Under this presumption, regression can be calculated – see Graph 2 for a dependence of the GCI on the CPI. In case of linear regression *the coefficient of determination* is 0.84 and for logarithmic regression the *coefficient of determination* is a bit higher – $R^2 = 0.88$. For logarithmical approximation it is typical that at the lower end (i.e. low CPI,

low GCI) dependency between variable have a strongly non-linear character. The question is whether the cause of this non-linear dependency at the "lower end" is for example in a distortion of the CPI data (e.g. statistical average of collected data on CPI close to zero (i.e. very high corruption) is biased towards higher data since marks below zero could not be awarded), or it is a consequence of phenomenon known in psychology – people are quite good at estimation of probabilities of phenomena in the middle of the scale, but "less good" at probability estimation of extreme situations (they have a tendency to overestimate very low probability and underestimate very high probability) – in this case underestimating very high corruption. According to this logarithmical approximation, the GCI would be more sensitive to changes of low CPI values (i.e. very high corruption) than to changes of high values of CPI (i.e. very low corruption).

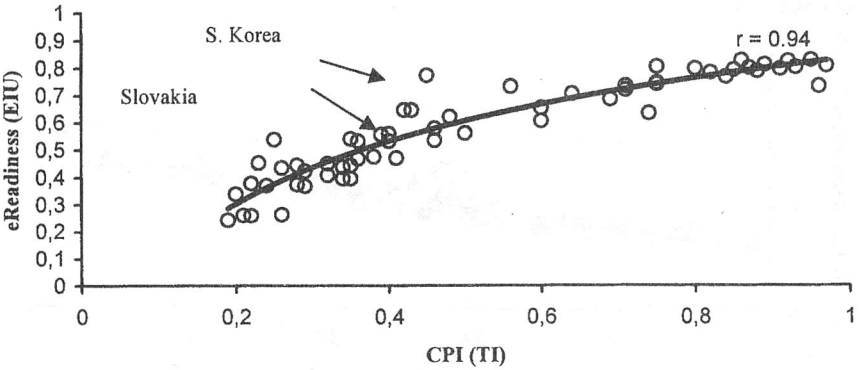
Graph 3

e-Gov Readiness versus CPI (liner approx)



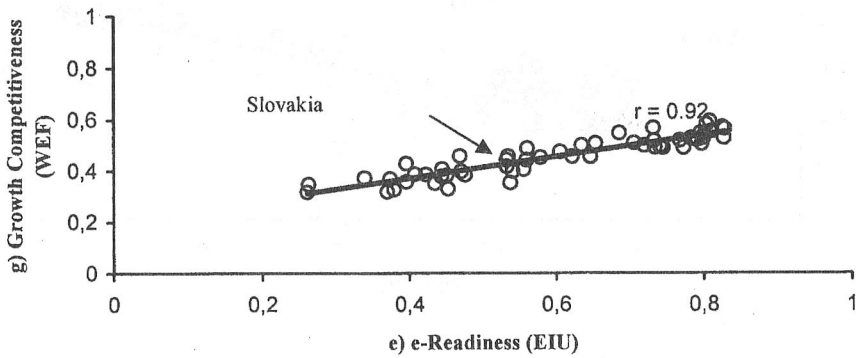
Graph 4

e-Readiness versus CPI (log approx)

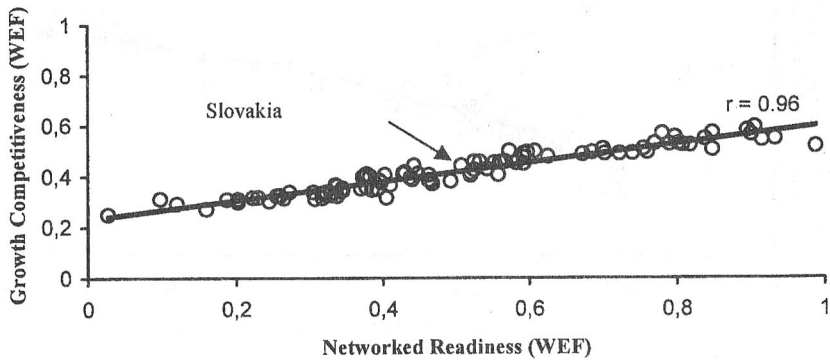


When we are examining correlation of "e-indexes" (i.e. indexes assessing development of Information society – i.e. e-Gov Readiness, e-Readiness, Networked Readiness) with CPI, we can also see strong correlation – see Graph 3 and Graph 4 (illustrating again also a logarithmic regression). Another interesting issue is examining dependency between e-indexes and "classical" economic indicators (e.g. competitiveness). Although correlations cannot answer questions like: "Is for all countries with healthy economy typical highly developed e-Society?" or vice versa "Will development of e-Economy/e-Society (automatically) lead to an increase of the country competitiveness?", they can at least show, which "e-phenomenon" is more strongly correlated with "classical" economic and social phenomena. Looking at Table 1 we can see that especially Networked Readiness Index (together with e-RR – see Graph 5) exhibits high correlation with competitiveness – GCI (see Graph 6) as well as with WCS. High correlation of NRI with GCI can be explained by a similarity of the GCI Technology sub-index to NRI.

Graph 5
e-Readiness versus GCI



Graph 6
NRI versus GCI



It is also noteworthy that the e-Readiness Ranking (e-RR) and the Networked Readiness Index (NRI) have higher correlation with CPI than e-Government Readiness Index (e-GRI). It can be caused by the character of e-RR and NRI, which (directly or indirectly) reflect also legal, regulatory, policy issues necessary for low corruption environment. A proper use of technology can increase transparency in public sector and thus reduce corruption, but obviously it does not work without legal and social environment (or put it in another way "It is not about technology, it is about ethical values, rules, and people") (Douček, 2001).

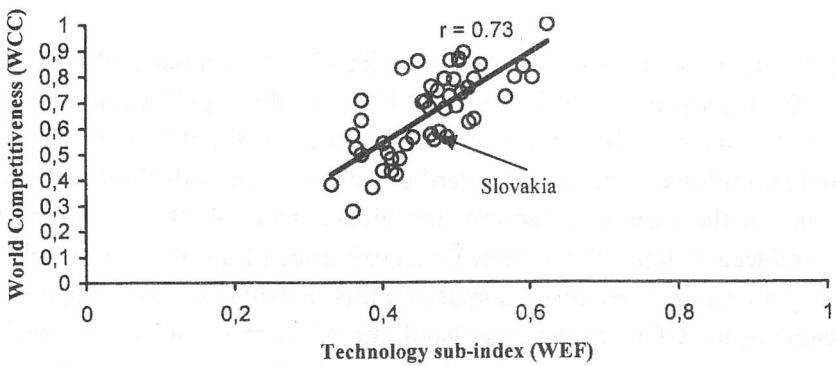
In the current economy ICTs are usually presented as a driving factor of economy growth and productivity (National Statistics Online, 2005). What do correlations of indexes say about this? Correlation of the Technology sub-index of the GCI with the GCI itself is higher (0.95) than with the World Competitiveness Scoreboard (0.73 – see also Graph 7), which is not surprising. However, does it mean that the WCS is less technology biased?

Graph 8 illustrates a situation when we compared two indexes which are not based on the same (or similar) sets of data – the Macroeconomic Environment sub-index (WEF) and the Networked Readiness index. Again, surprisingly high correlation (r = 0.91) indicates an important role of ICT in macro-economic environment.

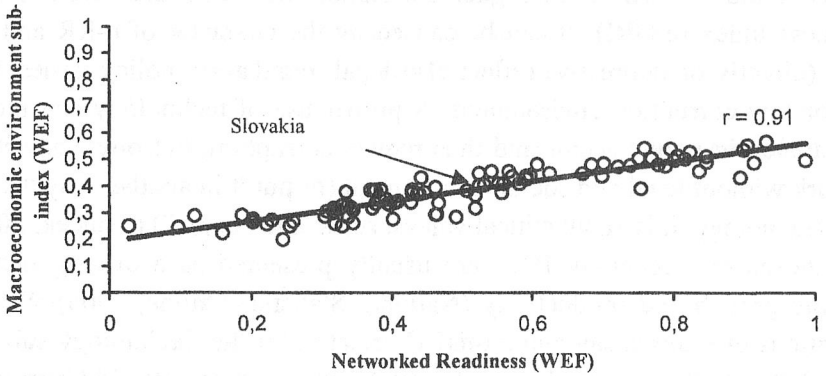
Another issue, which could be investigated, in addition to correlation, is how "sensitive" is a change of one index to a unit change of another index – for dependencies between two indexes approximated by a line (see e.g. Graphs 1, 3, 5, 6, 7, 8 above) slope of this line corresponds to this "sensitivity". Of course, this makes sense only for highly correlated indexes. Then we can for example investigate a sensitivity of the competitiveness to the Technology sub-index change. Does a small change of the Technology sub-index result in a significant change of competitiveness?

Graph 7

WCS versus Technology sub-index of GCI

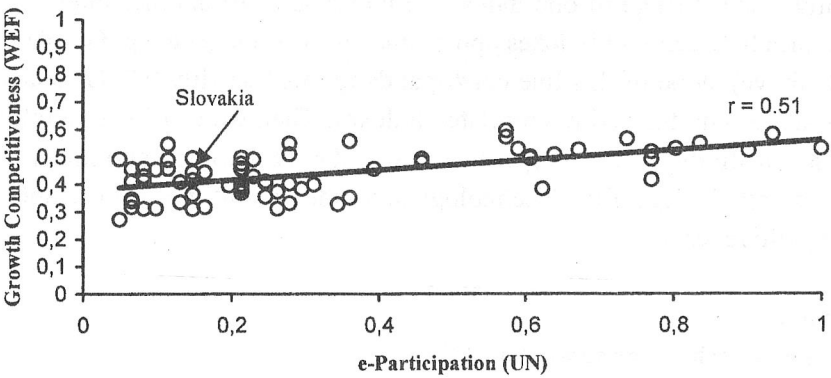


Graph 8
NRI versus Macroeconomic Environment sub-index



Another interesting domain is issue of e-Participation. As mentioned above, correlation of the e-Participation index with other indexes is significantly lower than correlation coefficients among the other indexes (see Table 1). Graph 9 depicts dependency between the e-Participation and GCI (correlation coefficient r = 0.51).

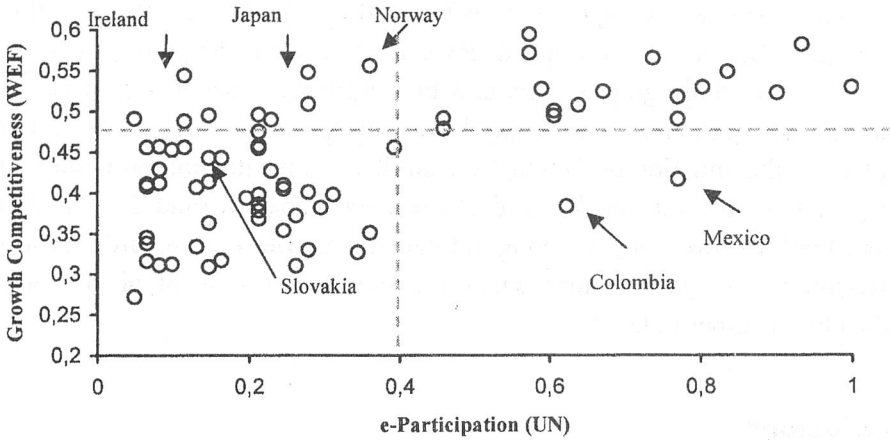
Graph 9
GCI versus e-Participation



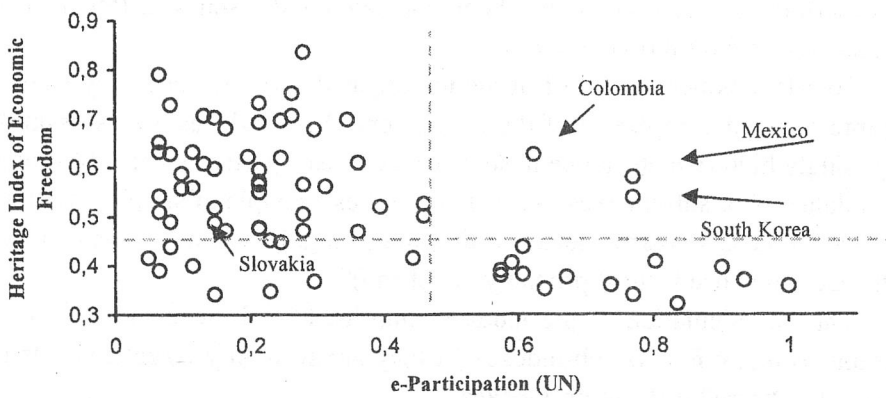
However, when we exclude two "out-liars" – Columbia and Mexico (see Graph 10), we see that after achieving a kind of "threshold" value of e-Participation 0.4, values of GCI are from the interval <0.48, 0.58>. In the case of e-Participation lower than 0.4, standard deviation of Growth Competitiveness is 0.084, but in the case of e-Participation higher than 0.4, standard deviation of GCI is reduced to 0.03. It can indicate an existence of a critical threshold of the e-Participation Index, countries surpassing this threshold of e-Participation have high value of the GCI. On the other hand, there is a group of three countries (Japan, Norway and Ireland) with the GCI around 0.55 with e-Participation Index

lower than 0.4. So, with a grain of simplification, we could make a following conclusion: "If you want to achieve higher competitiveness, first you have to achieve a critical level of e-Participation (which is a specific form of participation of citizen in public matters)." There is a similar situation when comparing the e-Participation Index (e-PI) and the Heritage Index of Economic Freedom (IEF) – see Graph 11. There are three "out-liars" – Columbia, Mexico and South Korea, and in this case the threshold value of the e-Participation Index is about 0.46. IEF for countries with the e-PI greater than 0.46 (without the three outliers) is from the interval <1.5, 2.2> and standard deviation is 0.22. For countries with the e-PI less than 0.46 standard deviation of IEF is 0.66.

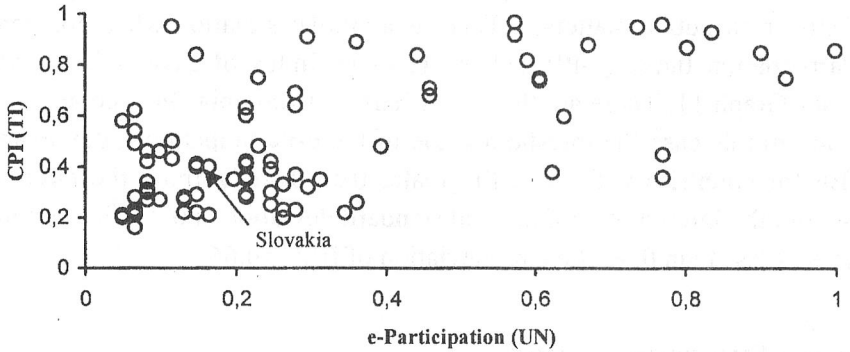
Graph 10
GCI versus e-Participation (in detail)



Graph 11
IEF versus e-Participation



Graph 12
CPI versus e-Participation



When looking at the dependency between the CPI and the e-Participation Index (Graph 12), an obvious dependency cannot be seen (the points are scattered almost on the whole graph). This is a bit surprising – according to Graph 12 higher e-Participation does not imply lower corruption, i.e. higher CPI (although graphically the situation on Graph 12 is similar to the situation on Graph 10). It is also noteworthy that in the case of the e-Participation (and Participation in general) cultural differences among individual countries (e.g. regarding forms of participation) can play a more important role than in case of phenomena described by the other indexes.

Conclusions

In the paper several indexes designed by international institutions with the aim to assess economic, social, and technological development on country level are described, correlation among them calculated and discussed. Results can be summarised in the following points:

• Correlations between most of the investigated indexes (especially when taking into account complexity of the phenomena these indexes are assessing) are surprisingly high (which can be in some cases at least partly explained by similarity of data and/or sub-indexes used). This implies a couple of simple questions:

– Do we need so many indexes if they are so highly correlated (and collection of the data they use is most probably not cheap)?

– Can be calculation of the indexes simplified? Is it necessary to take into account so many factors/sub-indexes (if they are so highly correlated)? Is there some set of "core" factors/sub-indexes?

• Special attention by policy makers should be paid to the identified high correlation between the level of corruption in a country (CPI) and the level of country competitiveness (GCI, WCS). Actually this can be in some sense a good message for Slovakia, since according to recent surveys made in 2005 (Gollaš, 2005), corruption in Slovakia has decreased, actually Slovakia is a leader among post-communist countries of Eastern Europe and Central Asia in the decrease of corruption. Does this mean that it will subsequently lead to an increase of competitiveness?

• Correlations between e-Participation and other indexes studied are relatively lower than correlations among other indexes studied. Although some dependencies were discussed, more research is needed, e.g. concerning identification of a critical level of e-Participation above which e-Participation leads to decreased corruption and increased competitiveness.

• Nature of dependency between so-called "e-indexes" (e-Readiness Ranking, Networked Readiness, e-Gov Readiness) and "classical" economic indexes indicates a critical role of ICTs in current economy – but more research is needed.

• Of course, methodology of calculation the indexes and data used are a big issue, the phrase "Be careful what you measure, because that is what you are going to get" applies also here. At the same time in principle we measure what *can* be measured, which is not necessarily the same as what *should* be measured.

As mentioned above, more research is needed and just the use of statistical methods will not be sufficient. The authors have tested also the use of data mining techniques. For example the use of association rules and/or decision trees (Paralič, 2002) can bring more insight into these dependencies. The authors have tested some of these techniques, but still more work is needed in this area. This will be subject of further research; achieved results will be published in next paper.

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