SOME ASPECTS CONCERNING THE CORRELATION BETWEEN ICT AND INNOVATION IN EUROPE

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In the context of the entire world's efforts to start recovering from one of the worst economic crisis, finding the main drivers of growth is increasingly important. The European Commission's new proposal – "Europe 2020"– states innovation as one of these main drivers, and promotes the development of a smart economy based on knowledge and innovation. But how innovation can be fostered? The present study focuses on the relationship between innovation and Information and Communications Technology (ICT), a supporting pillar of the "smart economy". This relationship has been studied at country level using two composite indicators: one for ICT – the "Networked Readiness Index"(NRI) published by World Economic Forum – and another for Innovation – the "Summary Innovation Index"(SII) from the European Innovation Scoreboard (EIS). The results represent a first step towards finding the best driving factors that can stimulate innovation.

Keywords: *Innovation, ICT, SII, NRI, correlation*

1. Introduction
Innovation and ICT, as main drivers of competitiveness and sustainable growth, enable the reducing of the digital, economic, and social divides within each country, and among countries.
A recent analysis made by the European Commission (European Commission, 2010) shows that even before the global economic crisis, Europe was not progressing fast enough relative to the rest of the world, and the productivity gap has widened over the last decade. This was due to many factors, including the insufficient use of ICT, the lower level of investment in R&D and innovation, the "reluctance in some parts of our societies to embrace innovation" etc. Thus, the importance of *the dynamic relationship between "the use of ICT" and "innovation"* is becoming more and more politically recognized.
But how does ICT connect with innovation? This research study – which was partially supported by the National Council for Scientific Research in Higher Education (CNCSIS) under the Project NPRDI - II, Contract No. 91-071/2007: "Innovation and competitiveness – the fundamental drivers of economic and social progress of Romania" – investigates the following aspects:
- the existence of a correlation between ICT and Innovation for 32 European countries in 2009; a cross-sectional regression analysis on the relationship between two composite indicators has been used: the Summary Innovation Index (SII) for Innovation, and the Networked Readiness Index (NRI) for ICT;
- the existence of a connection in time, related to different clusters of innovation, between SII and NRI; a dynamic regression analysis for the data of 27 European countries over six years (2004-2009) has been used;
- the relationship between NRI and SII for Romania during 2004-2009.

2. Composite Indicators - measures of ICT and Innovation performance
2.1. The Summary Innovation Index

SII (Summary Innovation Index) is a composite index that measures the overall innovation performance at national level. It was created at the request of the European Council in Lisbon in 2000 and since then has been assessed and published annually in the European Innovation Scoreboard (EIS). According to the methodology used since 2008, SII summarizes 7 innovation dimensions grouped into 3 main blocks: *"Enablers"*, *"Firm activities"* and *"Outputs"*. Each one of the innovation dimensions contains several indicators leading to a total of 29 indicators (EIS, 2009).

**Fig. 1. The structure of the Summary Innovation Index (SII)**
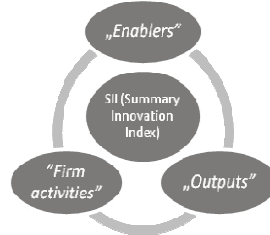
Based on a statistical cluster analysis of the SII scores over a five-year period, the EU Member States are divided into four groups:

- *Innovation leaders,* including countries with innovation performance well above that of the EU average;
- *Innovation followers,* including countries with innovation performance below those of the innovation leaders but close to or above that of the EU average;
- *Moderate innovators,* including countries with innovation performance below that of the EU average;
- *Catching up countries*, where the innovation performance is well below the EU average.

Figure 2 shows the four groups (clusters) according to EIS 2009 (with the most innovative country in the right side and the less innovative one to the left).

Fig. 2. Summary Innovation Index (SII) for EU-27 in 2009
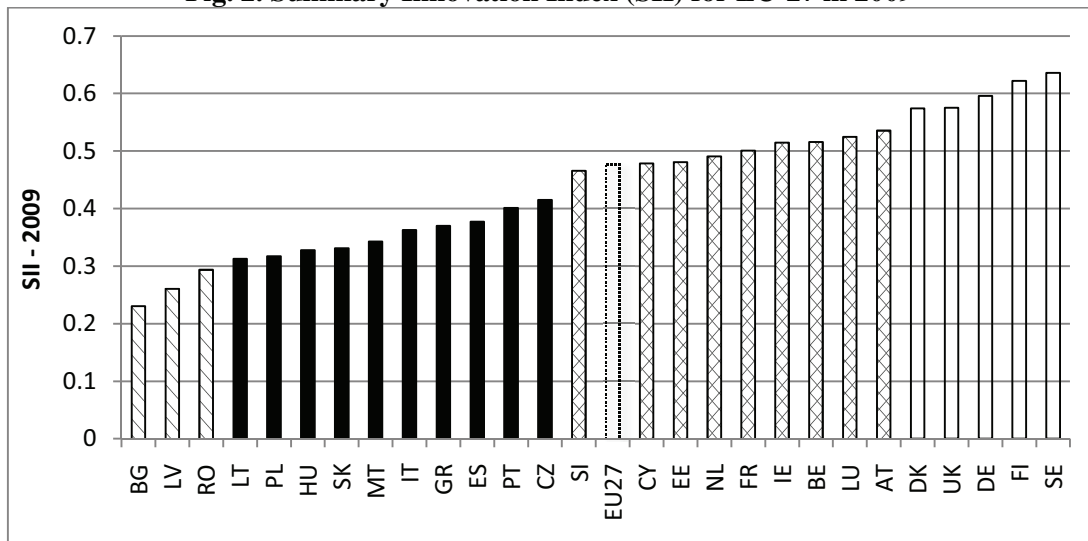

Source:(EIS, 2010)

The *Innovation Leaders* are Sweden, Finland, Germany, the UK and Denmark. The group of the *Innovation followers* includes the following nine countries: Austria, Luxembourg, Belgium, Ireland, France, Netherland, Estonia, Cyprus and Slovenia. The *Moderate innovators* are: Czech Republic, Portugal, Spain, Greece, Italy, Malta, Slovakia, Hungary, Poland and Lithuania, whereas Romania, Latvia and Bulgaria are regarded as *Catching up countries.*

2.2. The Networked Readiness Index (NRI)

The Networked Readiness Index has been published annually, since 2001, in *The Global Information Technology Report* produced by World Economic Forum, in collaboration with INSEAD. The index is a composite of 3 components (fig.3):

- the *environment* for ICT offered by a given country;
- the *readiness* of the economy's key stakeholders (individuals, businesses, and governments) to use ICT;
- the *usage* of ICT among these stakeholders.

Fig. 3. The structure of the Networked Readiness Index (NRI)
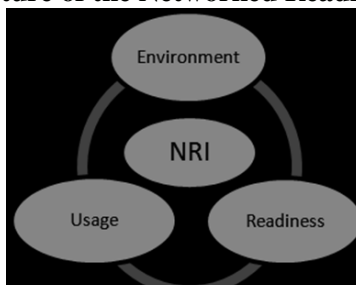
Each of the NRI components contains 3 sub-indexes ("pillars") composed of variables, the total number of variables included in NRI being of 68 (WEF, 2010).

**Fig. 4. The Networked Readiness Index (NRI) for EU-27 in 2009**
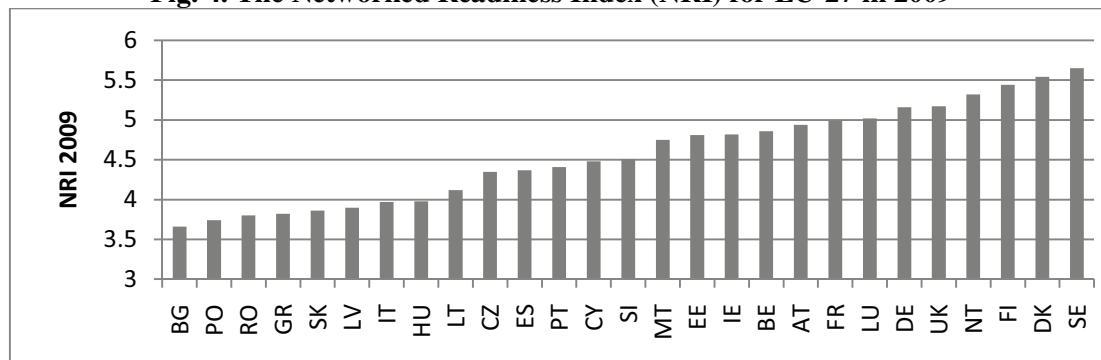
Source:(WEF, 2010)

3. Econometric tests

3.1. The correlation between NRI and SII for 32 European countries in 2009

To get an overview of the degree of correlation between ICT and Innovation at EU level, a cross-sectional analysis of NRI and SII in 2009 for 32 European countries has been achieved. The results of the statistical tests performed are listed in Annex, Table 1.

Fig. 4. The correlation between NRI and SII for 32 European countries in 2009


$y = 4.3159x + 2.7132$
$R = 0.85$
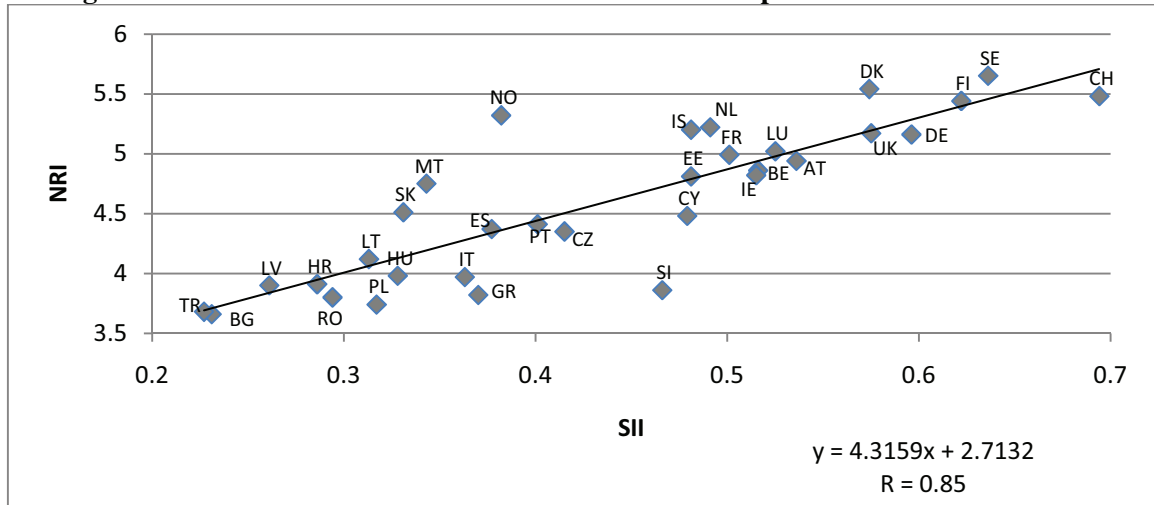
As shown in figure 4 there is a strong correlation between NRI and the innovation index (SII), the regression coefficient having a value of 0.85. In the right-upper corner, countries which are "leaders" in innovation also have the highest values for NRI. In the second group of countries, the "followers in innovation", the low performance in ICT opening of Slovenia and Cyprus must be noted. The "moderates" in innovation are spread in the lower left corner, registering a wide range of NRI values, from 4.75 for Malta to 3.74 for Poland. The "catching-up in innovation", Romania, Latvia and Bulgaria, have also wide spread NRI-SII values: Romania (3.8, 0.294), Latvia (3.9, 0.261) and Bulgaria (3.66, 0.231).

3.2. The correlation between NRI and SII for 24 countries from European Union, during 2004-2009
Using a linear (unifactorial) regression analysis, the relationship between NRI and SII for 24 EU countries over a period of six years (2004-2009) has been studied. The results obtained are presented in Annex, Table 2. Figure 5 shows the correlation degree for each of the 24 states, grouped by innovation cluster. The "leaders in innovation" (cluster 1) appear on the right, and those who are "catching up in innovation" (cluster 4) appear at the left.

Fig. 5. The correlation degree between NRI and SII for 24 UE countries during the period 2004-2009, grouped by cluster of innovation
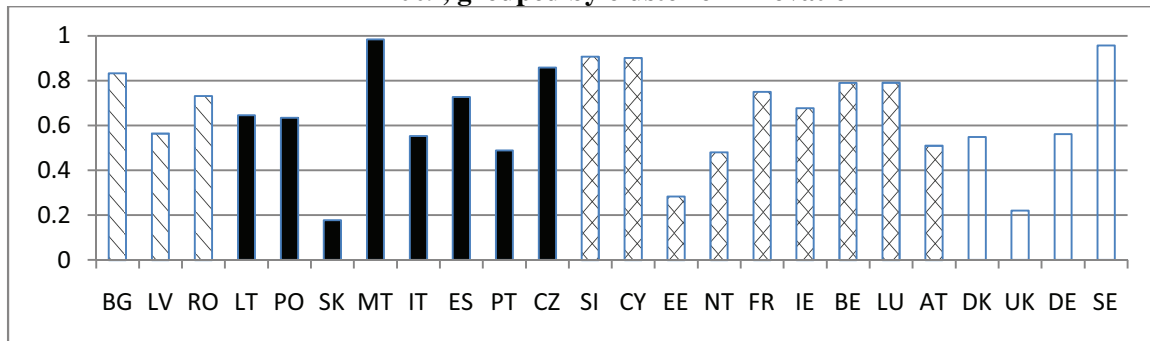

All clusters in innovation have similar properties, namely they are composed by countries where the correlation between NRI and SII is relevant, and countries for which this correlation is not significant. For "innovation leaders", Sweden is the only country for which there is a strong correlation between NRI and SII. In the "followers in innovation" cluster, there are strong correlations recorded for Cyprus and Slovenia, and significant correlations for Luxembourg, Belgium, Ireland and France. Similar results can be observed in the case of

"moderates in innovation". Among "catching-up in innovation", just for Romania and Bulgaria the connection between the two indicators is significant.

3.3. The correlation between NRI and SII for Romania during 2004-2009
For Romania, the correlation between the two composite indices over the period 2004-2009 is illustrated in figure 6.

Fig. 6. The correlation between NRI and SII for Romania, during 2004-2009

$y = 0.046x + 3.6307$
$R = 0.732$
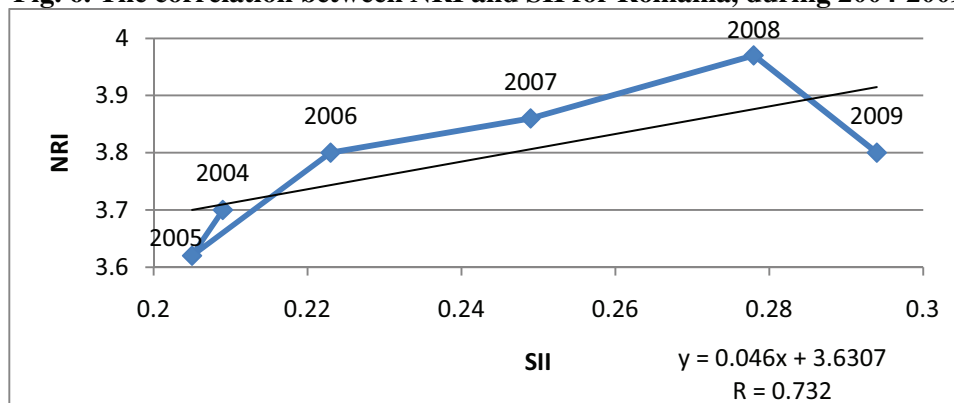
Statistical analysis of the correlation is shown in detail in Annex, Table 3. The 0.732 value of the correlation coefficient for Romania confirms that there is a relationship between ICT and innovation. To be noted the regress registered in Romania in 2005 over the previous year. In 2009, although the degree of innovation has increased significantly, from 0.278 in 2008 to 0.294, a regression in terms of opening for ICT can also be noted.

4. Conclusions
The study shows, through the econometric tests performed, that there are significant correlations between NRI and SII:
- at the European level - proved by the transverse analysis corresponding to year 2009 and the dynamic analysis for the period 2004-2009;
- at the national level – proved by the dynamic analysis for Romania in the period 2004-2009.
The results represent a first step towards finding the best driving factors that can stimulate innovation and increase its efficiency.

5. References
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Annex

Table 1. Statistical analysis of the correlation between NRI and SII for 32 European countries [1] in 2009

Regression Statistics	
Multiple R	0.855
R Square	0.731
Adjusted R Square	0.722
Standard Error	0.333
Observations	32

ANOVA

	df	SS	MS	F	Significance F
Regression	1	9.073	9.073	81.579	4.634E-10
Residual	30	3.336	0.111		
Total	31	12.409			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	2.713	0.216	12.552	1.799E-13	2.272	3.155
SII - global	4.316	0.478	9.032	4.634E-10	3.340	5.292

[1] The 32 European states analyzed are: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom and Switzerland, Norway, Turkey, Croatia, Iceland.

Table 2. The correlation coefficient between NRI and SII for 24 EU countries[2] during 2004-2009 (by cluster of innovation)

State	Correlation coef.	State	Correlation coef.	State	Correlation coef.	State	Correlation coef.
BG	0.833	LT	0.646	SI	0.907	DK	0.549
LV	0.564	PO	0.634	CY	0.901	UK	0.220
RO	0.732	SK	0.178	EE	0.283	DE	0.561
		MT	0.984	NT	0.481	SE	0.957
		IT	0.553	FR	0.751		
		ES	0.726	IE	0.678		
		PT	0.488	BE	0.790		

CZ	0.858	LU	0.791
		AT	0.510

[2] The 24 European states analyzed are: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, France, Germany, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom.

Table 3. Statistical analysis of the correlation between NRI and SII for Romania during 2004-2009

Regression Statistics	
Multiple R	0.732
R Square	0.536
Adjusted R Square	0.420
Standard Error	0.093
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.04	0.040	4.619	0.098
Residual	4	0.035	0.009		
Total	5	0.074			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	3.206	0.275	11.643	3E-04	2.441	3.97
SII	2.412	1.122	2.14916	0.098	-0.704	5.528