THE IMPACT OF ICT ON INNOVATION PERFORMANCE IN EUROPE. CASE OF ROMANIA

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ABSTRACT

The aim of this paper is to analyze the impact of Information and Communication Technologies (ICT) on the innovation performance of the European Union (EU) countries. We have used two composite indicators to measure the Innovation performance and the ICT performance of each of the EU-28 countries: the Summary Innovation Index (SII) – created on the initiative of the European Commission and computed yearly since 2001 – and the Networked Readiness Index (NRI) – created by the World Economic Forum, in collaboration with INSEAD, and published yearly since 2002. Using unifactorial linear regressions, we have modeled the relationship between SII and NRI at country level, respectively, between SII and each of the four subindexes of NRI. We've deepened our analysis for the case of Romania, in order to find effective ways to foster innovation through ICT.

Keywords: ICT, innovation performance, Summary Innovation Index (SII), Networked Readiness Index (NRI)

1. INTRODUCTION

The Innovation Union is one of the seven flagship initiatives of the Europe 2020 strategy for a "smart, sustainable and inclusive economy" [COM (2010)]. This initiative – that belongs to the "smart growth" priority – is aimed to support the development of research and innovation in EU, in order to create more jobs, build a greener society, improve the quality of life and maintain Europe's competitiveness in the global market. The Innovation Union plan has 34 action points grouped into 13 action lines. The financial instrument for implementing the Innovation Union is Horizon 2020 (H2020) – the biggest EU Research and Innovation Programme ever, with nearly €80 billion of funding available over 7 years (2014 to 2020). Adopted by the European Council in December 2013, Horizon 2020 has the political backing of Europe's leaders and the Members of the European Parliament, who have agreed that research is an investment in our future (European Union (2013)). H2020 couples research with innovation having three main objectives: (1) to make Europe a world-class science performer ("Excellent Science" priority, €24 billion), (2) to remove obstacles to innovation ("Industrial Leadership" priority, €17 billion), and (3) to revolutionize the

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way public and private sectors work together in delivering innovation ("Societal Challenges" priority, €29 billion).

ICT is a key enabler of innovation and new employment, having an increasing importance for long-term competitiveness and well-being. ICT can contribute to the reduction of the competitiveness gap between EU and US/other international competitors, which represents one of the main objectives of the Europe 2020 strategy.

Over the past decade, assessing ICT developments has been the object of much policy attention due to "the potential high returns that ICT can provide in transforming nation's economy and increasing its citizens' well-being" [GITR 2014, p.5]. Investments in ICT account for 50% of all European productivity growth, and thus, Horizon 2020 includes ICT-related topics in all its priorities, increasing by 25%, compared to FP7, the corresponding funds[4].

Our study investigates the relationship between innovation performance and ICT, in order to find efficient ways to increase innovation. We have used two composite indicators to evaluate ICT performance (readiness), respectively, innovation performance of each EU-28 country: the Networked Readiness Index (NRI) and the Summary Innovation Index (SII). If the relationship exists, we'll extend our study to check the relationship between innovation and some variables featuring ICT, at country level. A special emphasis will be put for the case of Romania.

2. NATIONAL INDICATORS FOR ICT READINESS AND INNOVATION PERFORMANCE

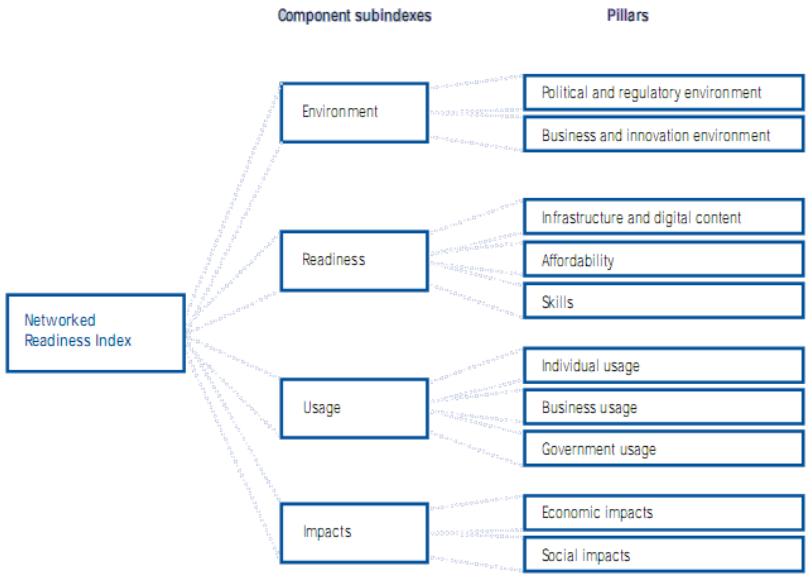
I. The Networked Readiness Index

The Global Information Technology Report (GITR) was created by The World Economic Forum in order to offer to policymakers, business leaders, and civil society a "useful conceptual framework to evaluate the impact of ICTs at a global level and to benchmark the ICT readiness and usage of their economies" [GITR2014, p.3]. The report has been published annually, for more than 13 years. It proposes an indicator, computed every year, which measures the impact of ICT at country level: the Networked Readiness Index. The structure of the NRI indicator has changed in time. In 2014 NRI has four equal weighted dimensions (subindexes), every of them being evaluated through a set of pillars (as figure 1 shows):

- the *"Environment"* for ICT: is composed of two pillars which measure the general business and innovation environment, respectively, the political and regulatory environment, that facilitate the ICT access and use;
- the *"Readiness"* to use ICT: measures the ICT infrastructure level of development and the accessibility of digital content, the cost of accessing ICT (affordability), and the ability of the society (the skills) to effectively use ICT; it is composed of three pillars;

[4] http://ec.europa.eu/programmes/horizon2020/en/area/ict-research-innovation

- the *"Usage"* of ICT: a three pillars subindex that measures the extent and the quality of ICT usage by all main stakeholders, respectively: individuals, businesses, and government;
- the *"Impact"* of ICT: measures, through its two pillars, the economic and social effects of ICT (on competitiveness and well-being).



Source: GITR 2014, p. 7

Figure 1: The structure of the Networked Readiness Index 2014

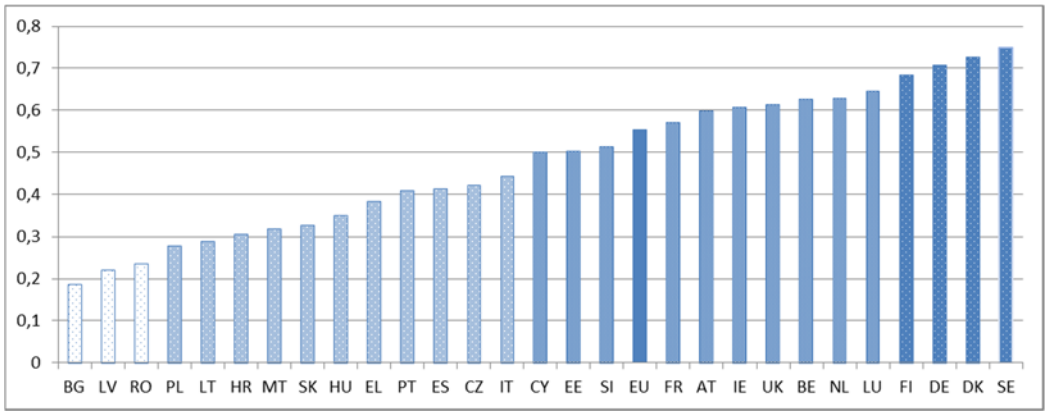
II. The Summary Innovation Index

The Summary Innovation Index was created at the request of the European Council in Lisbon in 2000, and has been published annually in the Innovation Union Scoreboard (IUS), starting with 2001. SII measures the overall innovation performance of an economy, and, just like NRI, is a composite index based on three categories (subindexes): "Enablers" of innovation, "Firm activities" and "Outputs", each of them having several pillars (named "dimensions"), and indicators (variables). As a general overview, SII structure comprises: 3 categories, 8 dimensions, and 25 indicators.

Using the SII indicator, the countries analyzed in the scoreboard are classified, every year, into four groups/clusters (figure 2):

- *Innovation leaders* (Sweden, Denmark, Germany and Finland) – perform in innovation well above the EU-28 average;
- *Innovation followers* (Luxembourg, Netherlands, Belgium, UK, Ireland, Austria, France, Slovenia, Estonia and Cyprus) – innovate below the leaders, but close to or above that of the EU-28;

- *Moderate innovators* (Italy, Czech Republic, Spain, Portugal, Greece, Hungary, Slovakia, Malta, Croatia, Lithuania and Poland) – perform in innovation below the EU-28 average;
- *Modest innovators* (Romania, Latvia and Bulgaria) – innovate well below the EU-28 average (their innovation performance is less than half that of the EU-28).



Source: Made by authors (IUS 2014)

Figure 2: The four groups of EU-28 countries by their innovation performance (SII), according to IUS 2014

3. THE RELATIONSHIP BETWEEN THE INNOVATION PERFORMANCE AND THE ICT READINESS

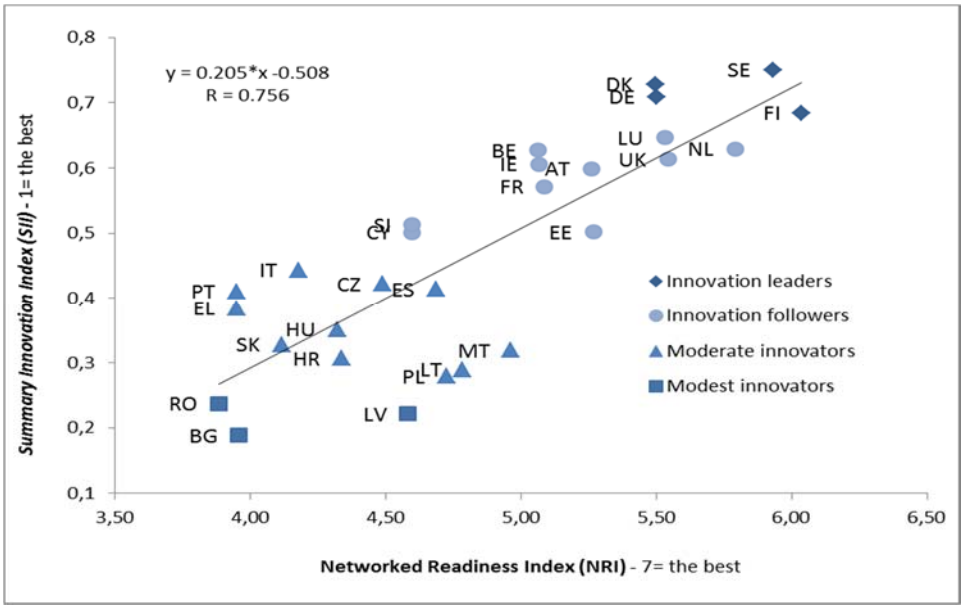
In order to emphasize the relationship between the Innovation performance, measured through the SII indicator, and the ICT Readiness measured through the NRI index and its subindexes, some econometric tests have been made.

a. Transectional analysis between SII and ICT Readiness, at global level, for the EU-28 countries

Using the data published in the first trimester of 2014 in the GITR and IUS reports, a strong correlation between SII and NRI corresponding to 2013 indicators has been proved for the EU-28 Member States.

Figure 3 graphically represents the position of the four groups of innovators regarding their ICT Readiness, and also the linkage between the two indicators, that follows a unifactorial regression model (the statistical results are presented in detail in Annex. Table1):

$$SII = 0.205*NRI - 0.508$$



Source: Made by authors (GITR 2014, IUS 2014)

Figure 3: Correlation between NRI and SII indicators for the EU-28 countries in 2013

The linkage is not accidental; it has been verified for the last 8 years, as Table 1 illustrates:

Year	2006	2007	2008	2009	2010	2011	2012	2013
Slope	0.232	0.241	0.237	0.245	0.262	0.228	0.220	0.205
Intercept	-0.652	-0.694	-0.677	-0.661	-0.728	-0.623	-0.523	-0.508
Correlation Coefficient	0.902	0.892	0.893	0.923	0.916	0.882	0.782	0.756

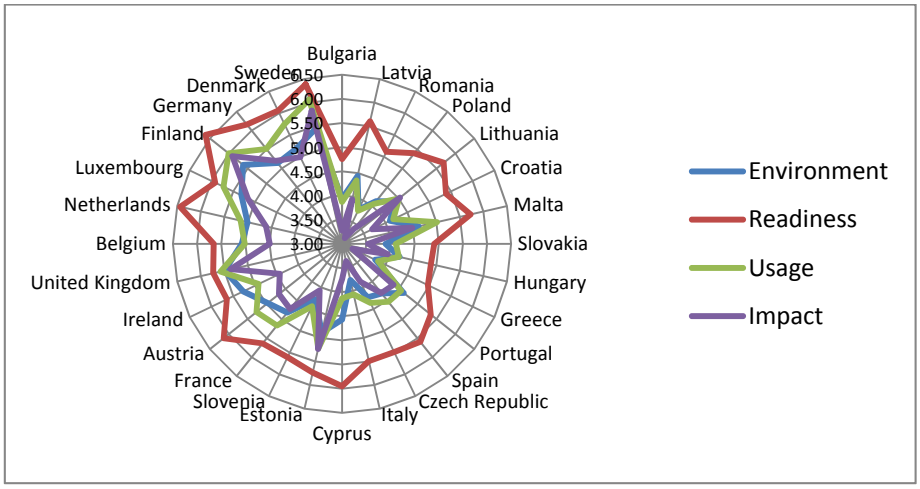
Source: Authors' calculations (GITR 2007-2014, IUS 2014)

Table 1: Transversal analysis of the correlation between SII and NRI at national level, for the EU-28 countries, in the period 2006-2013

The parameters of the regression equation have changed in time, but insignificantly. The high values of the correlation coefficients indicate a strong relationship between SII and NRI, which remained stable in time.

b. Transectional analysis between Innovation performance and ICT Readiness, at structural level, for the EU-28 countries, in 2013

First, we've analyzed the values of the four NRI subindexes, in 2013, for all EU-28 countries, ordered ascending, in clockwise direction, with regard to their innovation performance.



Source: Made by authors (GITR 2014)

Figure 4: NRI subindexes for the EU-28 countries, in 2013

The image in Figure 4 suggests that a linkage between SII and the individual subindexes of NRI could also exist. So, a second step in our analysis was to search in-depth – at structural level – the relationship between SII and each of the four NRI subindexes (Environment, Readiness, Usage and Impact).

SII	NRI subindex			
	Environment	Readiness	Usage	Impact
Slope	0.056	0.279	0.095	0.170
Intercept	0.230	-1.099	0.036	-0.262
Correlation Coefficient	0.412	0.775	0.603	0.787

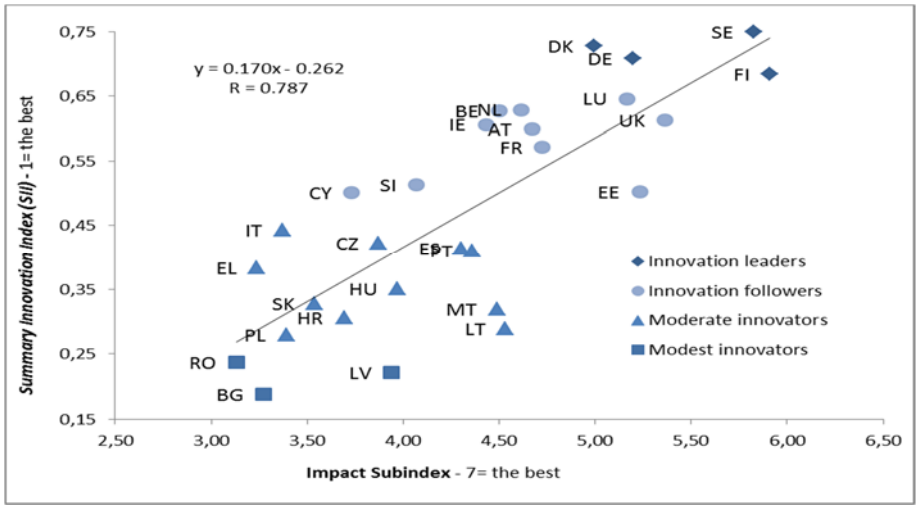
Source: Authors 'calculations (GITR 2014, IUS 2014)

Table 2: The correlations between SII and NRI subindexes, at national level, for EU-28 countries, in 2013

The results shown in Table 2 (high values for the correlation coefficient) highlight that each of the four NRI subindexes is related with the SII indicator. The most powerful relationship is between the Impact subindex and SII, the analysis made in section c) illustrating this fact.

c. Transectional analysis between SII and the Impact subindex of NRI for the EU-28 in 2013

The third analysis proves the strong relationship between SII and the fourth subindex of NRI - the Impact subindex (Figure 5).



Source: Made by authors (GITR 2014, IUS 2014)

Figure 5: The correlation between SII and the Impact subindex of NRI in 2013, for the EU-28 countries, grouped by innovation clusters

Innovation leaders (excepting Finland) and Innovation followers (excepting United Kingdom and Estonia) are close to the EU trend, with an innovation performance usually above the "expected value". The Moderate innovators are spread in a balanced manner around the regression line. The Modest innovators – Romania, Bulgaria and Latvia – have an innovation performance well below that "expected".

4. ROMANIA'S PROFILE IN THE PERIOD 2011-2013

Year	NRI*	NRI Subindex				SII*
		Environment*	Readiness*	Usage*	Impact*	
2011	3.90 / 27	3.69/28	5.19/22	3.50/28	3.21/28	0.258/26
2012	3.86 / 28	3.70/28	4.98/23	3.66/28	3.12/28	0.229/27
2013	3.95 / 28	3.79/26	5.11/24	3.76/28	3.13/28	0.237/26

*Score/Rank within EU-28

Source: Made by authors (GITR 2012-2014, IUS 2014)

Table 3: NRI, its four subindexes and SII for Romania, in the period 2011-2013

According to the 2012-2014 GITR and IUS reports, the situation in Romania could be synthetized as follows (Table 3):

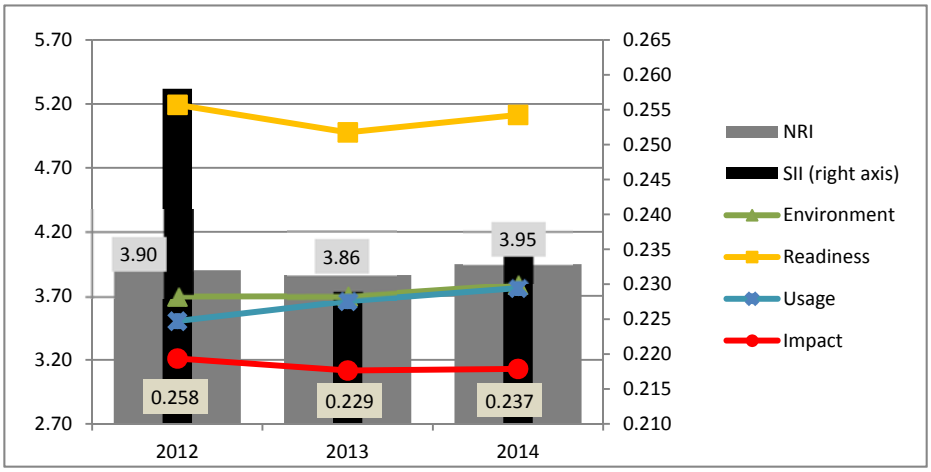
- regarding the **innovation level:** Romania is included in the Modest Innovators group, along with Bulgaria and Latvia, but with the best performance inside this group (in 2011 and 2013). The evolution in the last three years is marked by a

slightly instability: a decrease of the SII indicator by 11% in 2012 compared to 2011, followed by a sensible return (3.4%) in 2013;

- regarding **ICT readiness**: Romania's NRI has a score that decreased by 1% in 2012 compared to 2011, and then increased by 2.4% in 2013; the rank of Romania's NRI was the lowest within EU-28 in 2012 and 2013.

In the effort to identify which of the four NRI subindexes should be boosted to impose Romania on a better position within EU-28, we've noticed that:

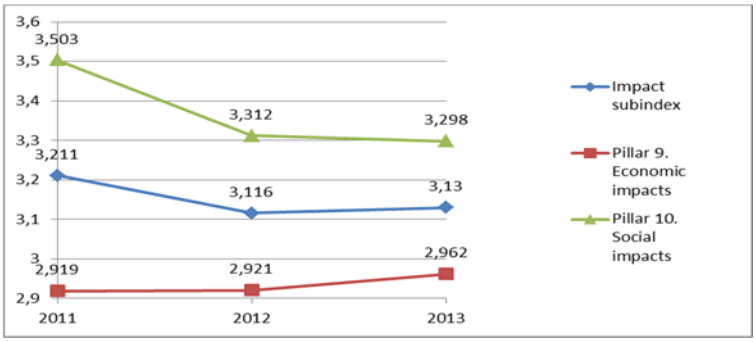
- the *Environment subindex*, although it constantly grew (scores from 3.69 to 3.79), placed Romania on the last position in 2011 and 2012, and on the 26th position in 2013;
- the *Readiness subindex* had fluctuant values (with a decrease in 2012); its rank within EU-28, although the best among the other NRI subindexes, constantly decreased (from 22 in 2011 to 24 in 2013);
- the Usage and Impact subindexes had the lowest values in EU-28 all over the period, but their evolution in the last three years was very different: the Usage subindex continuously increased its value (but insufficient for a better rank within EU-28), while the Impact subindex registered a serious decrease in 2012, and very slowly recovered in 2013.



Source: Made by authors (GITR 2012-2014, IUS 2014)

Figure 6: The dynamics of the SII indicator, the NRI index and its subindexes for Romania, in the period 2011-2013

Taking into account the observations that, on one hand, at European level, the Impact subindex of NRI is the most correlated with the innovation performance, and, on the other hand, that the situation in Romania for the Impact subindex is very concerning, we have proceeded further to investigate the evolution of the two pillars composing the Impact subindex: Pillar 9 - Economic impacts and Pillar 10 -Social impacts.



Source: Made by authors (GITR 2012-2014, IUS 2014)

Figure 7: The dynamics of the Impact subindex and its two pillars - Economic impacts and Social impacts - in Romania, in the last three years

As Figure 7 shows, in Romania, in the last three years, the values for the Economic impacts pillar register a constant growth. Meanwhile, the Social impacts pillar constantly involutes from 3.503 to 3.298, forcing the Impact subindex to maintain its low values and register a strong decrease from 2011 to 2012.

5. CONCLUSIONS

Innovation Union Scoreboard 2014 reveals that there is still a gap in innovation performance between EU-28 and some international leaders in innovation, such as: South Korea, US and Japan. Also, this document shows that "innovation performance among the Member States is converging but the convergence process slowed down" [IUS2014, p6]. In this context, it is of great importance for all EU-28 countries, and especially for those that are "Modest innovators", to accelerate the increase of their innovation performance. All policy makers have to concentrate their efforts to identify and strengthen the factors that could contribute to this process.

Our study showed that, for the EU-28 countries, there is a relationship between the innovation performance (measured by SII) and the ICT readiness (measured by NRI), which can be modeled by a unifactorial linear regression. This relationship proved to be valid for a long period of time (2006-2013). Moreover, the study revealed the existence of a correlation (modeled also by a unifactorial linear regression) between SII and each of the NRI subindexes, for all EU-28 countries, in 2013. The strongest relationship proved to be that between SII and the Impact subindex of NRI. We've deepened the analysis for the case of Romania and found that the Social impacts pillar of the Impact subindex could be a responsible factor for country's poor performance in innovation. Improving the extent to which ITC is present in education, and also, the efficiency of ITC use by the government could be successful means to accelerate the increase of innovation in Romania.

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ANNEX

Table 1. Statistical analysis of the unifactorial linear regression

between global indicators SII and NRI, at national level,

for EU-28 countries, in 2013

Regression Statistics	
Multiple R	0.76
R Square	0.57

Adjusted R Square	0.55
Standard Error	0.11
Observations	28

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.44	0.44	34.66	3.29382E-06
Residual	26	0.33	0.01		
Total	27	0.76			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.508	0.168	-3.020	0.006	-0.85	-0.16
NRI - 2013	0.205	0.035	5.887	0.000	0.13	0.27

*SII = 0.205 * NRI - 0.508*
R = 0.76, strong correlation

Anova Analysis: Two statistical tests were used in order to verify the significance of the linear regression:

1. the Fisher-Snedecor test was used in order to determine whether the dependence between the selections of data is not random. For a significance level of $\alpha = 0.05$, one independent variable (NRI) and 28 observations (countries), we have 1 and 28-1-1=26 the two degrees of freedom, so the critical value of F is: $F_{critical}(0.05;1;26) = 4.225$. Since F-statistics = 34.66 >> $F_{critical}(0.05;1;26) = 4.225$, we conclude, at a significance level $\alpha = 0.05$, that the observed strong correlation between the variables did not occur by chance.

2. the "t" - Student test was used in order to determine whether the NRI parameter in the regression line is useful in estimating the SII value. Considering $\alpha = 0.05$ as before, the critical value of T distribution is: $T_{critical}(0.05;26) = 2.055$; since the T-statistics for the NRI variable is T-statistics(NRI)= 5.887> $T_{critical}(0.05;26) = 2.055$, we conclude that the estimation corresponding to the NRI variable is useful in the prediction line.