

## **INNOVATION AND ICT DEVELOPMENT: AN ANALYSIS FOR THE EU-28 MEMBER STATES**

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**Abstract:** *This paper proposes a new analysis over the relation between the ICT performance and the innovation level for the 28 EU Member States. Two indicators were used:*

*(1) the ICT Development Index (IDI), a composite index that has been computed yearly, since 2009, by the International Telecommunication Union and published in the “Measuring the Information Society Report” (MISR), and*

*(2) the Summary Innovation Index (SII), a 10-dimensions composite indicator for innovation, computed yearly under the auspices of the European Commission and published in the European Innovation Scoreboard.*

*Several testes were verified: some analyzes between innovation and ICT development for the EU-28 Member States yielded to the conclusion that the two indicators follow a linear regression model with high confidence. This result is not accidental – over the past 7 years, IDI and SII have been strongly correlated, as related tests showed.*

**Keywords:** *ICT, ICT Development Index (IDI), innovation performance, Summary Innovation Index (SII)*

### **1. Introduction**

In today’s modern world, ICT plays a fundamental role, being one of the key drivers for improving the economic and educational prospects of a country. ICT is essential for attaining the UN Sustainable Developments Goals (SDGs), “boosting economic growth, enhancing communications, improving energy efficiency, safeguarding the planet and improving people’s lives” (MISR 2018, p.6).

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According to International Telecommunication Union statistics, more than half of the world's population is now online, connected to the Internet (MISR 2018, p.2), but the other half ("Connecting the Other Half" – initiative of the Broadband Commission for Sustainable Development in 2018) is unable to benefit from the social and economic resources of the digital world, and the knowledge gap increases by lack or limited connection to ICTs. The impact of ICT for economies and people depend not only on the infrastructure and access, but also on the efficiency in using ICTs and the level of the digital skills possessed.

There is a relation between ICT and digital divide. On one hand, ICT can contribute to an inclusive information society, by providing affordable broadband access for all, which reduces the digital divide. On the other hand, people of any gender, any age, any level of education must have the necessary digital skills in order to use, and to benefit from ICTs. Otherwise, even with the latest ICT technologies available and accessible, the digital divide will increase, as less and less people will be able to use the new devices.

There is another relation between ICT and innovation, as ICT is fostering innovation, and innovations are contributing to ICTs developments. The Connect 2030 Agenda [17] and the "Strategic plan for the Union for 2020-2023" [18] set Innovation as one of the 5 main goals for 2023, strengthening the fact that ICT plays a crucial role in the digital transformation of society, and the innovation in ICT is a key driver in this process. The Internet of Things (IoT), and the new emerging technologies, such as AI, Big Data Analytics, Blockchain, or cloud computing are transforming industries, services, and even our lives, "laying the foundations for smart societies" (MISR 2018, p.88).

There are many other connections between ICT and economic growth, sustainable development or quality of life. The more we understand these correlations the more we'll be able to action on the drivers for economic growth and welfare. Our study is intended to contribute to this understanding, by analyzing the links between the innovation performance and the ICT development level for the 28 EU Member States.

## **2. National indicators for ICT development and Innovation performance**

### ***2.1. The ICT Development Index (IDI)***

The *ICT Development Index (IDI)* is a composite index that has been reported annually, since 2009, by the International Telecommunication Union (ITU) in its "Measuring the Information Society Report" (MISR). The index is intended to measure the progress of each country towards the information society, respectively it is as a tool able to describe the current state of development of the ICT sector.

**Table 1: The structure of the ICT Development Index (IDI)**

<b>ICT Development Index (IDI)</b>		
<i>ICT access</i>		<b>40%</b>
1. Fixed-telephone subscriptions per 100 inhabitants	20%	
2. Mobile-cellular telephone subscriptions per 100 inhabitants	20%	
3. International Internet bandwidth (bit/s) per internet user	20%	
4. Percentage of households with a computer	20%	
5. Percentage of households with Internet access 100	20%	
<i>ICT use</i>		<b>40%</b>
6. Percentage of individuals using the Internet	33%	
7. Fixed-broadband subscriptions per 100 inhabitants	33%	
8. Active mobile-broadband subscriptions per 100 inhabitants	33%	
<i>ICT skills</i>		<b>20%</b>
9. Mean years of schooling	33%	
10. Secondary gross enrolment ratio	33%	
11. Tertiary gross enrolment	33%	

Source: Made by the authors using the information on MISR 2017.

IDI framework includes 3 dimensions which represent the combination of factors needed for each country in the process of transforming into / becoming an information or knowledge-based society: the availability of ICT structure and access, the level of ICT usage, and the capability to use ICTs effectively. Thus, IDI has 3 sub-indexes and 11 indicators. The “ICT access” sub-index includes 5 infrastructure and access indicators, the “ICT use” sub-index comprises 3 intensity and usage indicators, and the “ICT skills” sub-index includes 3 proxy indicators showing relevant skills for ICTs. Each IDI sub-index is calculated as a simple average of its indicators. The IDI is calculated as weighted average of its sub-indexes (40% Access, 40% Use, 20% Skills – see Table 1).

Figure 1 shows the IDI values for the 28 EU member states in 2017. Four groups of countries could be identified: *low performers* (below 90% of the EU-28 average; e.g. Romania), *moderate performers* (below the EU-28 average, but more than 90% of this value; e.g. Bulgaria, Poland, Hungary, Italy, ..., Slovenia), *good performers* (above the EU-28 average, but up to 110% of this value; e.g. Cyprus, Spain, ..., France), and *excellent performers* (above 110% of the EU-28 average; e.g. Germany, Sweden, Luxembourg, Netherlands, United Kingdom and Denmark).

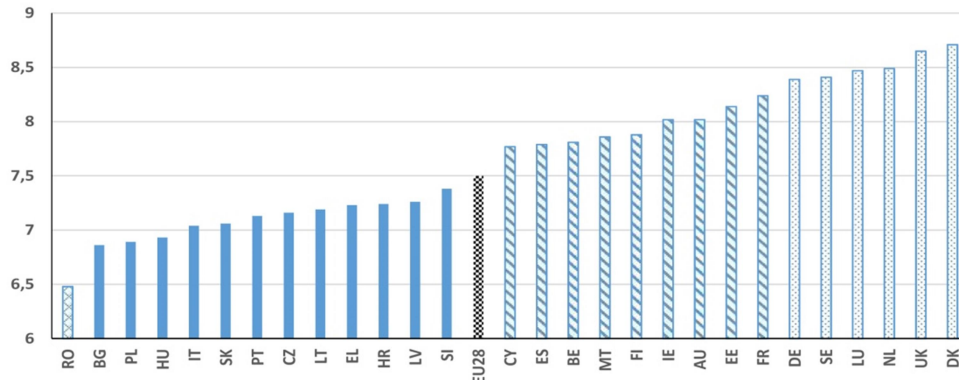


Figure 1: The EU-28 countries ranked by their ICT Development Index 2017  
 Source: Chart made by the authors using MS Excel, based on data published in MISR 2017

In 2017, ITU has decided to revise the IDI indicators, in order “to reflect changes in technology and markets over time, and improvements in the availability and quality of data” (MISR 2017, p. 27). The “new” IDI will have 14 indicators: 3 have been dropped (2 from Access sub-index, and 1 from Use sub-index) and 6 new indicators have been added (see Table 2).

Table 2. The future structure of the ICT Development Index (IDI)

ICT Development Index (IDI)		
<b>ICT access</b>		<b>40%</b>
Fixed-telephone subscriptions per 100 inhabitants	dropped	
Mobile-cellular telephone subscriptions per 100 inhabitants	dropped	
1. International Internet bandwidth (bit/s) per internet user	20%	
2. Percentage of households with a computer	20%	
3. Percentage of households with Internet access	20%	
4. Percentage of population covered by mobile networks (at least 3G and at least long-term evolution (LTE/WiMax) (NEW)	20%	
5. Fixed-broadband subscriptions by speed tiers (% of total) (NEW)	20%	
<b>ICT use</b>		<b>40%</b>
6. Percentage of individuals using the Internet	20%	
Fixed-broadband subscriptions per 100 inhabitants	dropped	
7. Active mobile-broadband subscriptions per 100 inhabitants	20%	
8. Mobile broadband Internet traffic per mobile-broadband subscription (NEW)	20%	
9. Fixed-broadband Internet traffic per fixed-broadband subscription (NEW)	20%	
10. Percentage of individuals who own a mobile phone (NEW)	20%	
<b>ICT skills</b>		<b>20%</b>
11. Mean years of schooling	25%	
12. Secondary gross enrollment ratio	25%	
13. Tertiary gross enrollment	25%	
14. Proportion of individuals with ICT skills (NEW)	25%	

Source: Made by the authors using the information on “The ICT Development Index (IDI) - Methodology, indicators and definitions (as of Feb. 2019)”, pp. 7-9 and MISR 2017, p.29

The introduction of the new IDI indicators imposed additional efforts for all countries to collect data. Unfortunately, the 10<sup>th</sup> edition of the MISR – MISR 2018 – could not publish IDI 2018 (due to the lack of data) and the launching of the “new” IDI was postponed for 2019 or even later. This means that, for the moment, there is no composite index available – on a yearly basis – for the ICT sector/development, since NRI (Networked Readiness Index, published by INSEAD in Global Information Technology Report series) ceased to be published in 2017, and now, IDI is confronting with problems (last available data for IDI being IDI 2017). Recently, in October 2019, ITU formulated a new proposal in order to calculate IDI 2018 and 2019 – to use the old methodology (applied until 2017) - but there is no consensus yet [12].

**2.2. The Summary Innovation Index (SII)**

The 2019 European Innovation Scoreboard (EIS 2019) is the 19<sup>th</sup> edition of the European Innovation Scoreboard (EIS), published yearly by the European Commission, since its introduction in 2001. The innovation performance of each country is measured using a composite indicator called *Summary Innovation Index (SII)* – an aggregation of 27 indicators, grouped into 10 dimensions, in 4 areas (Figure 2). SII is calculated as unweighted average of its 27 indicators.

AREAS	DIMENSIONS	INDICATORS
<b>1. Framework conditions</b>	1.1 Human resources	1.1.1 New doctorate graduates 1.1.2 Population aged 25-34 with tertiary education 1.1.3 Lifelong learning
	1.2 Attractive research systems	1.2.1 International scientific co-publications 1.2.2 Top 10% most cited publications 1.2.3 Foreign doctorate students
	1.3 Innovation-friendly environment	1.3.1 Broadband penetration 1.3.2 Opportunity-driven entrepreneurship
<b>2. Investments</b>	2.1 Finance and support	2.1.1 R&D expenditure in the public sector 2.1.2 Venture capital expenditures
	2.2 Firm investments	2.2.1 R&D expenditure in the business sector 2.2.2 Non-R&D innovation expenditures 2.2.3 Enterprises providing training to develop or upgrade ICT skills of their personnel
<b>3. Innovation activities</b>	3.1 Innovators	3.1.1 SMEs with product or process innovations 3.1.2 SMEs with marketing or organizational innovations 3.1.3 SMEs innovating in-house
	3.2 Linkages	3.2.1 Innovative SMEs collaborating with others 3.2.2 Public-private co-publications 3.2.3 Private co-funding of public R&D expenditures
	3.3. Intellectual assets	3.3.1 PCT patent applications 3.3.2 Trademark applications 3.3.3 Design applications
<b>4. Impacts</b>	4.1 Employment impacts	4.1.1 Employment in knowledge-intensive activities 4.1.2 Employment fast-growing enterprises of innovative sectors
	4.2 Sales Impacts	4.2.1 Medium and high-tech product exports 4.2.2 Knowledge-intensive services exports 4.2.3 Sales of new-to-market and new-to-firm product innovations

Figure 2. The structure of the Summary Innovation Index (SII) in 2018  
 Source: Chart made by the authors based on data published in EIS 2019

Using the SII indicator, EU-28 Member States are classified, every year, into four groups (Figure 3):

- *Innovation Leaders* (Sweden, Finland, Denmark and the Netherlands) – perform in innovation above 120% of the EU-28 average;
- *Strong Innovators* (Luxembourg, Belgium, United Kingdom, Germany, Austria, Ireland, France, and Estonia) – the innovation performance is between 90% and 120% of the EU-28 average;
- *Moderate Innovators* (Portugal, the Czech Republic, Slovenia, Cyprus, Malta, Italy, Spain, Greece, Lithuania, Slovakia, Hungary, Latvia, Poland and Croatia) – the innovation performance is between 50% and 90% of the EU-28 average;
- *Modest Innovators* (Bulgaria and Romania) – innovate well below the EU average, their innovation performance level being below 50% of the EU-28 average.

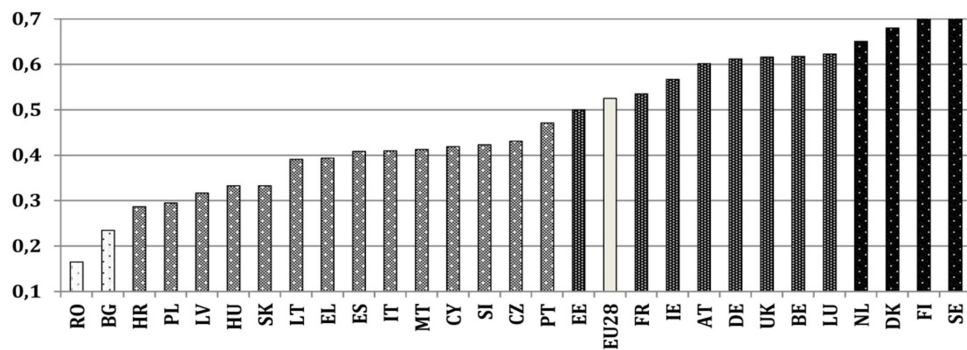


Figure 3: The four groups of EU-28 countries by their innovation performance (SII 2018)  
 Source: Chart made by the authors using MS Excel, based on data published in EIS 2019

A similar structure at EU level can be noticed for the 2017 year (Figure 4).

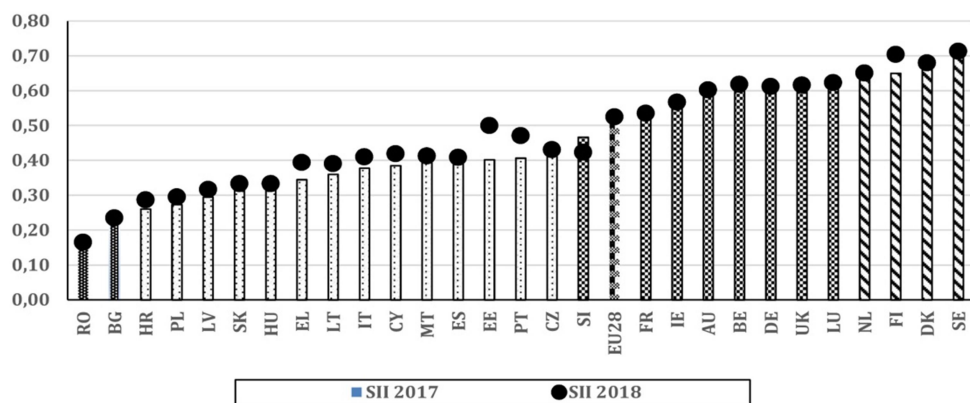


Figure 4: The EU-28 countries by their innovation performance (SII) in 2018 vs. 2017  
 Source: Chart made by the authors using MS Excel, based on data published in EIS 2019

It can be noticed that the Innovation Leaders are also leaders in ICT Development terms (see Figure 5), and the Strong innovators follow them.

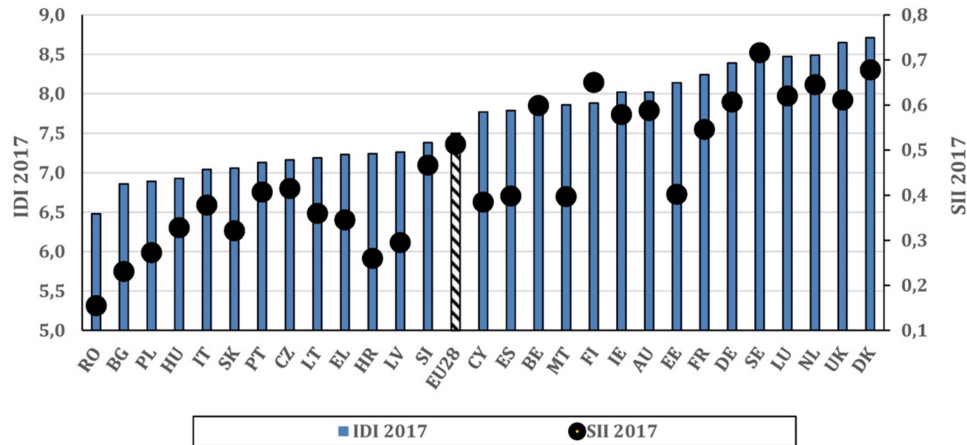


Figure 5: Comparison between the IDI and SII indicators for the 28 EU countries in 2017

Source: Chart made by the authors using MS Excel, based on data published in EIS 2019 and MISR 2017

Strong innovators register high values in ICT. On the other hand, the Modest innovators, Romania and Bulgaria register modest results in ICT as well. This observation yield to the question: are the two indicators linked together? How strong is this link? In the next sections we'll try to describe this relationship.

### 3. Regression analysis between Innovation and ICT development for the EU-28 Member States

The relationship between Innovation and ICT development is obvious, as Figure 5 shows. But how strong is it? We tested this linkage using a regression analysis at national level between SII and IDI.

It has been verified that SII and IDI indicators in the year 2017 for the EU-28 Member States follow a linear regression model:

$$SII = 0.22 \times IDI - 1.20 \quad R = 0.88$$

Figure 6 shows the four groups of innovators and their ICT development levels. The correlation coefficient R=0.88 proves that there is a strong link between the two indicators in 2017. This linkage is not accidental – the second analysis will use historical data from the last 7 years (see Table 3).

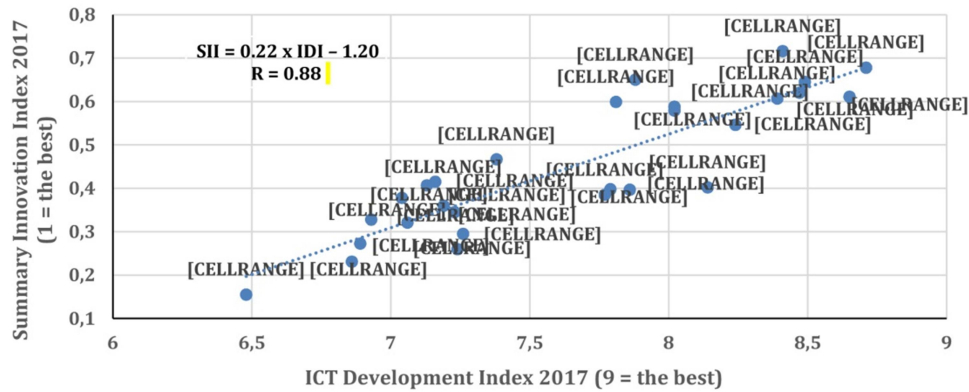


Figure 6: Correlation between SII 2017 and IDI 2017 indicators for the EU-28 Member States

Source: Chart made by the authors using MS Excel, based on data published in EIS 2019 and MISR 2017

Table 3: Correlation between SII and IDI in the period 2011-2017 at national level, for the EU-28 countries

Year	2011	2012	2013	2014	2015	2016	2017
<b>Correlation Coefficient</b>	<b>0.85</b>	<b>0.88</b>	<b>0.87</b>	<b>0.89</b>	<b>0.85</b>	<b>0.89</b>	<b>0.88</b>
Slope	0.18	0.16	0.17	0.19	0.20	0.20	0.22
Intercept	0.82	-0.74	-0.79	-1.00	-1.12	-1.07	1.20

Source: Computed by authors, based on data published in EIS 2019 and MISR 2011-2017

The correlation coefficient for each year shows the existence of a strong link between Innovation (measured by SII) and the ICT Development (measured by IDI).

## 5. Conclusions

As statistical data has shown, innovative countries have remarkable results in ICT, while regarding modest countries in innovation, there is a gap even in ICT. Therefore, a natural concern is to investigate if there is a relationship between the two characteristics and how it can be described.

In recent years, the authors of this paper have investigated this relationship and the results have been promising: there is a close statistical correlation between ICT and innovation, at the global level of the European Union, but also at the country level.



Different indicators were used to test the working hypotheses: Networked Readiness Index (NRI) as a measure for the absorption level of ICT, and, respectively: Summary Innovation Index (SII) and Global Innovation Index (GII) for the innovation degree.

In this article, the indicators used were Summary Innovation Index (SII) and ICT Development Index (IDI). The tests used most recent available data and historical data, and they confirmed the linkage exists and has a similar structure for the last 7 years.

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