

## **ANALYSIS OF THE CORRELATION BETWEEN INNOVATION AND ICT READINESS FOR THE EU-27 MEMBER STATES**

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### **Abstract**

Investing in research, development, education, and skills is a key policy area for the EU, as it is essential for economic growth and the development of a knowledge-based economy. But how investments in R&D and the most qualified segment of the workforce will influence innovation? Is there a link between these factors? In the last years, we investigated how Innovation and ICT are linked. Results obtained proved that there is a linear correlation between the two factors. In this paper we'll continue our research, extending the analysis with more recent data and using new indicators.

The analysis presented here refers to the EU-27 Member States and the indicators used are the Summary Innovation Index, published by the European Commission in the European Innovation Scoreboard and two indicators that measure the ICT Readiness, namely: the Human Resource Science and Technology Index (HRST) and the Gross Domestic Expenditure on R&D (GERD), both published by the Eurostat organism.

**Keywords:** ICT, innovation performance, correlation, Summary Innovation Index (SII), Human Resource Science and Technology Index (HRST), Gross Domestic Expenditure on R&D (GERD)

**JEL Classification:** M15

### **1. Introduction**

The European Union has prioritized pursuing growth based on innovation and directing resources to promote research and development. Investing in research, development, education and skills is a key policy area for the EU, as it is essential for economic growth and the development of a knowledge-based economy.

In this paper we'll investigate how investments in R&D and the workforce influence innovation. We consider the models provided as a first step in our effort to better understand the demand for and the supply of people with strong qualifications in science and technology and the necessity of investments in R&D.

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Regarding the material and method, all graphics and charts presented in this paper are realized by the author using MS Excel and data published in European Innovation Scoreboard (EIS) 2022 and Eurostat. The values for the HRST indicator have been updated on 27-09-2022. The values for the HRST indicator have been updated on 21-10-2022.

### ***Measuring the innovation performance***

The European Innovation Scoreboard is an initiative created by the European Commission aimed to offer a comparative analysis of innovation performance in European countries, at national and regional levels. The project was launched in 2010 and until 2015; it was published under the name “Innovation Union initiative”.

The European Innovation Scoreboard provides, yearly, a set of indicators, grouped into dimensions and blocks, aimed to offer an image over Research and Innovation in Europe. The EIS 2022 report was launched in September 2022 and it is the second edition published using the new measurement framework introduced in 2021. The EIS 2022 measures the innovation performance using 32 indicators, grouped in 12 innovation dimensions and 4 main types of activities. Every main type has 3 dimensions cumulating 8 indicators. The composite indicator Summary Innovation Index (SII) is an equal weight average of those indicators:

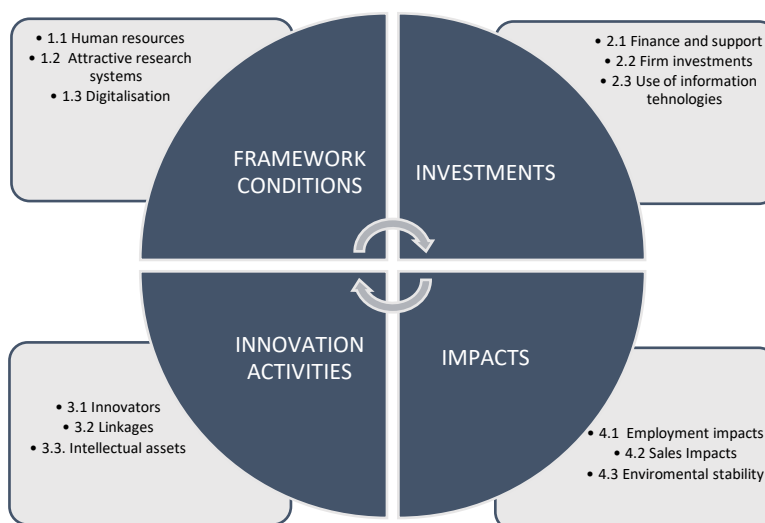


Figure 1. The structure of the Summary Innovation Index (SII) in 2022

Based on their innovation performance, the 27 Member States fall into four different performance groups (Figure 2):

- *Innovation leaders* (Belgium, Denmark, Finland, the Netherlands, and Sweden) – perform in innovation well above the EU average;

- *Strong Innovators* (Austria, Cyprus, France, Germany, Ireland, and Luxembourg) – innovate below the leaders, but above the EU average;
- *Moderate innovators* (Czechia, Estonia, Greece, Italy, Lithuania, Malta, Portugal, Slovenia, and Spain) – perform in innovation below or equal to the EU average;
- *Emerging innovators* (Bulgaria, Croatia, Hungary, Latvia, Poland, Romania and Slovakia) – innovate well below the EU average.

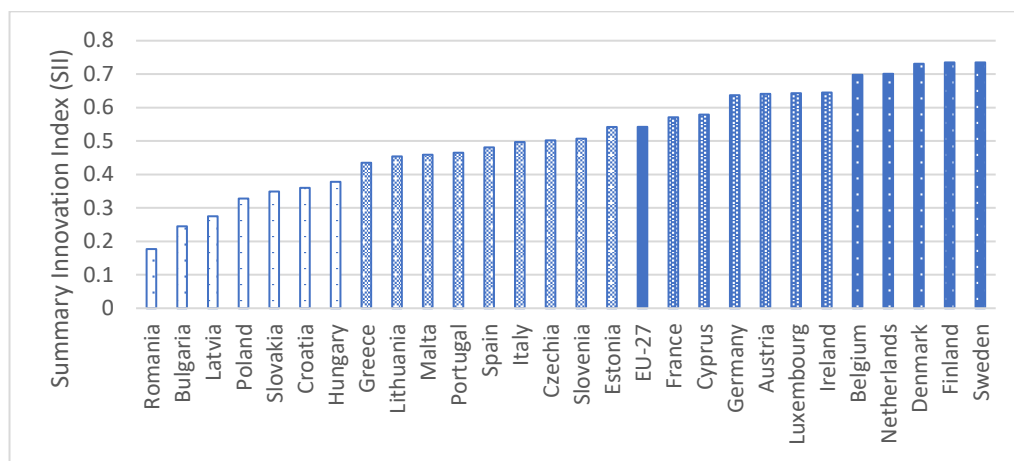


Figure 2: The four groups of EU-27 countries by their innovation performance (SII), in 2022

Next, we are studying the dynamics, at national level, for the 27 EU countries, in the period 2018-2022:

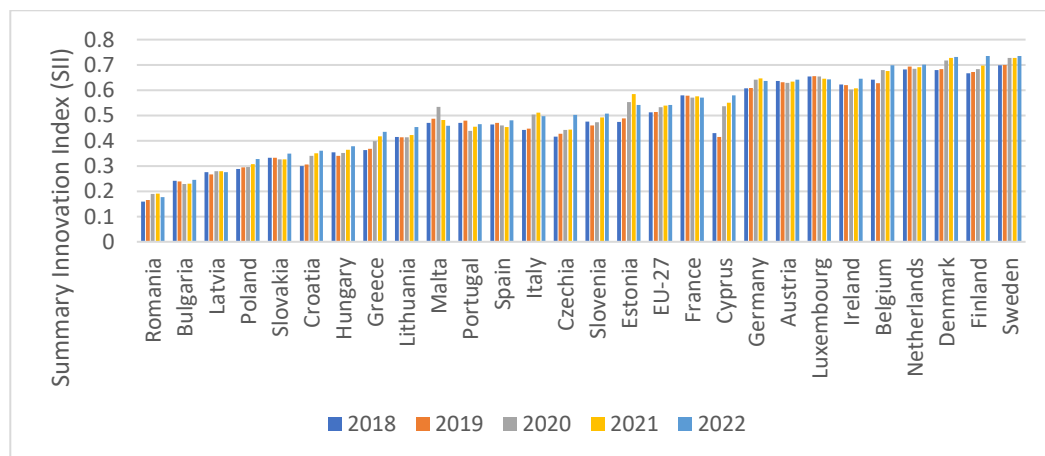


Figure 3: The dynamic of the innovation performance for the EU-27 countries for the period 2018-2022

We notice that in the last five years, most of the countries kept their position in the hierarchy. As exceptions, we can think at Cyprus, which rose in ranking from the Moderate Innovators group in the years 2018-2019 to the Strong Innovators group.

Estonia also moved between groups: it improved its innovation performance in 2020-2021 comparing to the previous years, becoming a Strong Innovator. But, in 2022 it recorded a decrease, Estonia's current SII value is similar to that of EU and, therefore, it has been classified as a Moderate Innovator country in 2022.

We also notice that some countries (France, Luxemburg, Bulgaria, Romania) kept their profile during the years.

### ***Measuring the readiness in Science and Technology***

In order to measure the Science and Technology readiness we used two indexes published by the Eurostat organism:

- The Human Resource Science and Technology Index (HRST) and
- The Gross Domestic Expenditure on R&D (GERD)

The Human Resource Science and Technology Index (HRST) describes the current stock of people who have successfully completed tertiary education (IESCD) and or who are employed in science and technology. In our analysis, we used the Y15-74 set of data, corresponding to population between 15-74 years, measured in thousands of individuals.

Using the HRST index, we can rank the 27 Member States as follows:

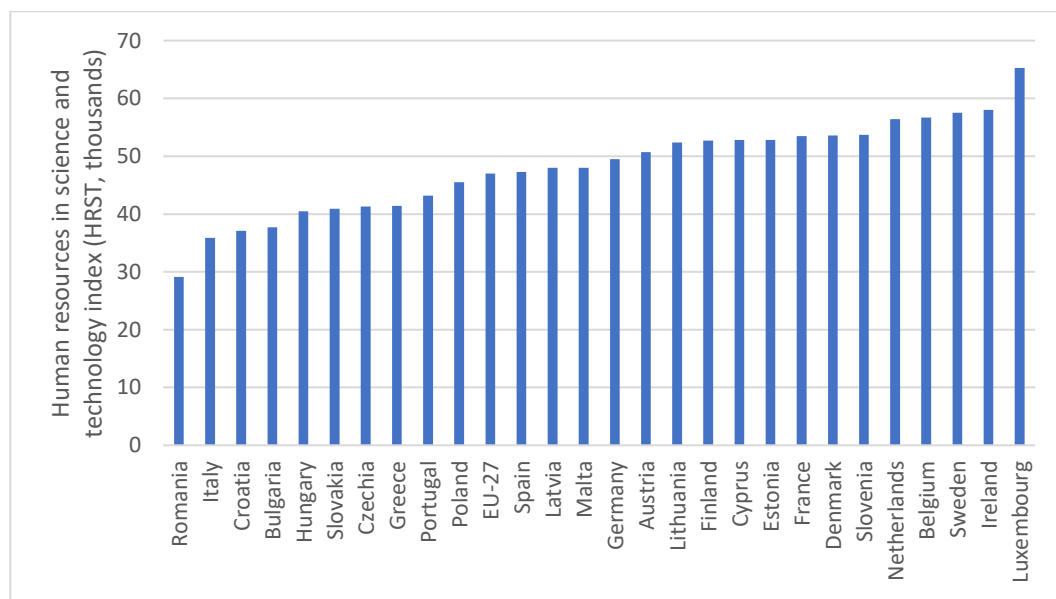


Figure 4: The EU-27 countries ranked by their S&T performance (HRST Index 2021)

The Gross domestic expenditure on R&D (GERD) is total expenditure (current and capital) on R&D performed by all resident companies, research institutes, university and government laboratories, etc., in a country during a specific reference period. In our analysis, we used the data published by Eurostat for the 27 Member States during 2015-

2020, for all sectors of performance (business enterprise, government, higher education and private non-profit sectors), measured in Euro per inhabitant.

The ranking for 2020 is presented below:

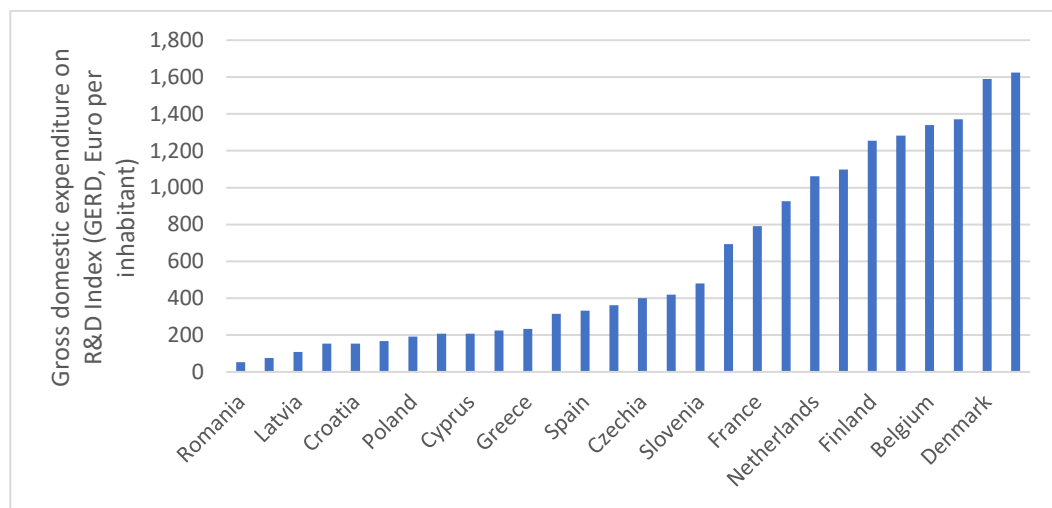


Figure 5: The EU-27 countries ranked by their S&T performance (GERD Index 2020)

## 2. Correlations between innovation and S&T for the EU-27 Member States

### 2.1 SII vs HRST

In the next section, we investigate if there is a linkage between the Summary Innovation Index (SII) and the Human Resource in Science and Technology Index. The diagram representing the two indicators for the 27 Member States in 2022 suggest that such a linkage exists.

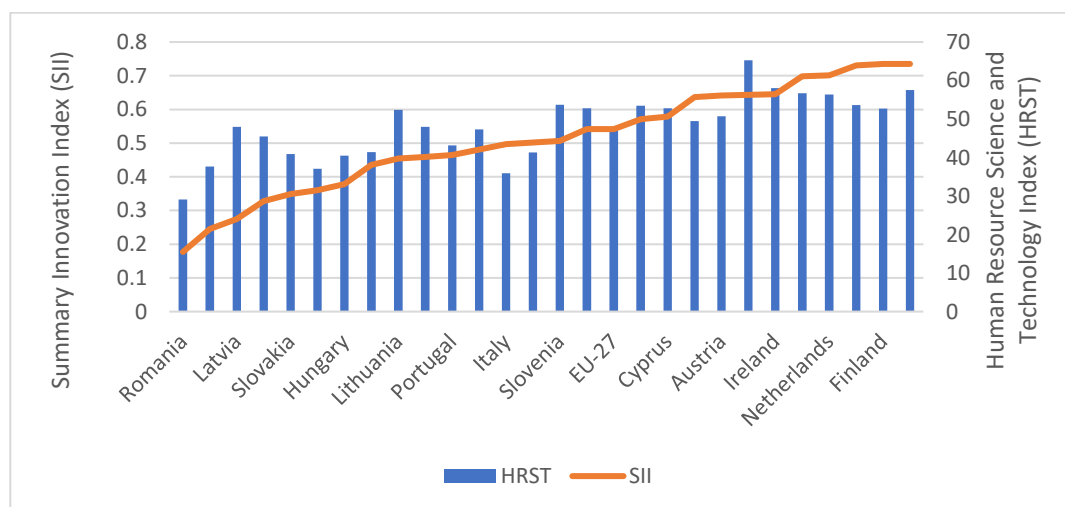


Figure 6: Correlation between SII and HRST indicators for the EU-27 Member States

Our next attempt was to describe this linkage with a linear model: the figure below shows that the Summary Innovation Index and the Human Resources in Science and Technology Index for 2022 are linearly correlated. The equation of the linear regression is:

$$SII = 0.015 \times HRST - 0.21$$

Correlation coefficient: 0.78

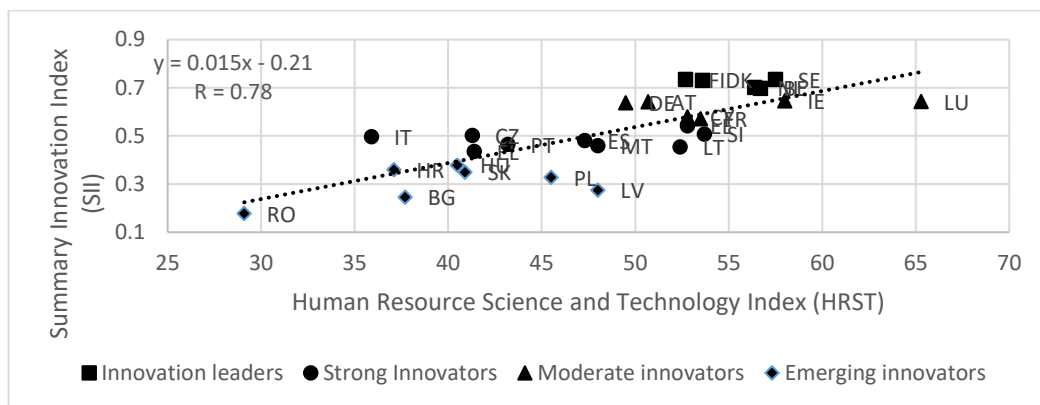


Figure 7: Correlation between SII and HRST indicators for the EU-27 Member States

The historical data of the two indicators considered proved that this linkage is constant; it was confirmed for the last 8 years as well:

Year	2015	2016	2017	2018	2019	2020	2021	2022
<b>Correlation Coefficient</b>	<b>0.79</b>	<b>0.81</b>	<b>0.82</b>	<b>0.83</b>	<b>0.82</b>	<b>0.81</b>	<b>0.82</b>	<b>0.78</b>
Slope	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Intercept	-	-0.24	-0.25	-0.26	-0.25	-0.23	-	-

Table 1: Correlation between SII and HRST at national level, for the EU-27 countries in the period 2015-2022

## 2.2 SII vs GERD

The second part of the analysis refers on how the Gross domestic expenditure on R&D (GERD) index influences innovation.

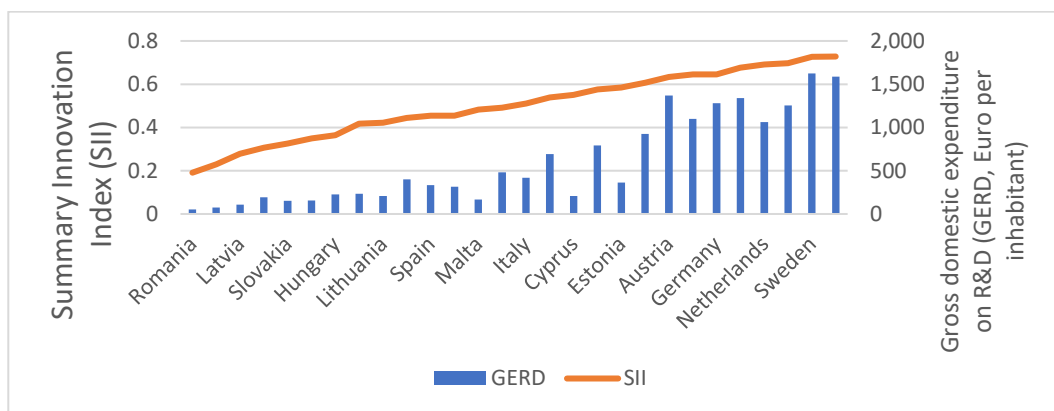


Figure 8: Correlation between SII and GERD indicators for the EU-27 Member States for the year 2020

The linear regression below is described through the model:

$$SII = 0.0003 \times GERD + 0.3349$$

Correlation coefficient: 0.8825

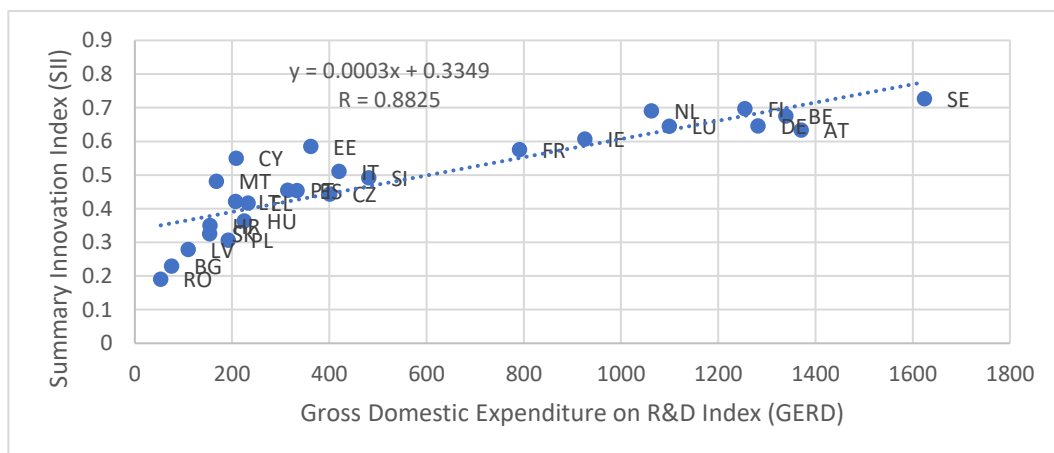


Figure 9: Correlation between SII and GERD indicators for the EU-27 Member States, in 2020

Year	2015	2016	2017	2018	2019	2020
<b>Correlation Coefficient</b>	<b>0.9153</b>	<b>0.9085</b>	<b>0.8928</b>	<b>0.8907</b>	<b>0.8768</b>	<b>0.8825</b>
Slope	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Intercept	0.3056	0.3163	0.3264	0.3202	0.3332	0.3349

Table 2: Correlations between SII and HRST at national level, for the EU-27 countries, computed yearly in the period 2015-2020

### 3. Analysis of historical data

Next, we've performed tests on historical data for the 27 Member States in the period 2015-2022, considering the SII-ICT performance pairs. Results show that for some countries, a linear regression can be described, but the relationship cannot be extrapolated to all of them.

<b>Country</b>	<b>Correlation SII - HRST</b>	<b>Correlation SII - GERD</b>
Romania	0.200	0.410
Bulgaria	0.001	-0.851
Latvia	0.795	0.409
Poland	0.888	0.856
Slovakia	0.561	-0.948
Croatia	0.790	0.975
Hungary	0.910	0.475
Greece	0.970	0.990
Lithuania	0.924	0.708
Malta	0.653	0.389
Portugal	0.484	0.344
Spain	0.728	0.530
Italy	0.938	0.882
Czechia	0.915	0.953
Slovenia	0.283	-0.124
Estonia	0.902	0.941
France	-0.593	-0.712
Cyprus	0.889	0.933
Germany	0.911	0.832
Austria	0.849	0.655
Luxembourg	-0.486	0.465
Ireland	0.344	-0.846
Belgium	0.872	0.890
Netherlands	0.885	0.820
Denmark	0.854	0.846
Finland	0.587	0.957



Sweden 0.920 0.651

Table 3: Historical correlations between SII and the ITC performance indicators, at national level, for the EU-27 countries, in the period 2015-2020

Let's consider one of the Innovation Leaders, Netherland (see figure below). In this case:

- SII and HRST are strongly correlated, following the model:

$$HRST = 162.82 \times SII - 59.305, R = 0.885$$

- SII and GERD are strongly correlated, following the model:

$$GERD = 4777.1 \times SII - 2287.8, R = 0.820$$

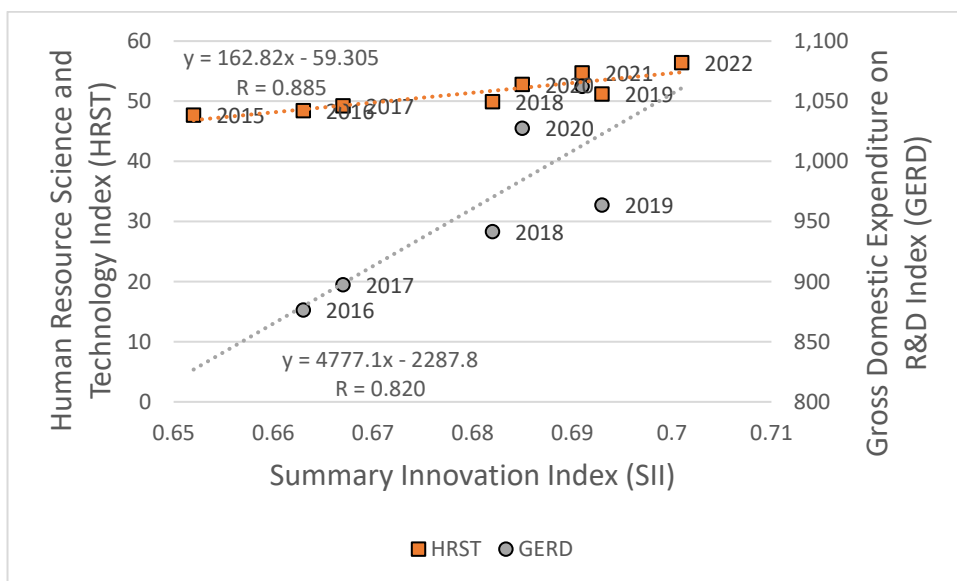


Figure 10: Correlation between SII and ITC indicators for Netherland, in the period 2015-2022

On the other hand, there are countries where there is no evidence of a linear linkage. For instance, Romania, one of the Emerging Innovators, neither SII and HRST, nor SII and GERD are linear correlated, as the next figure shows:

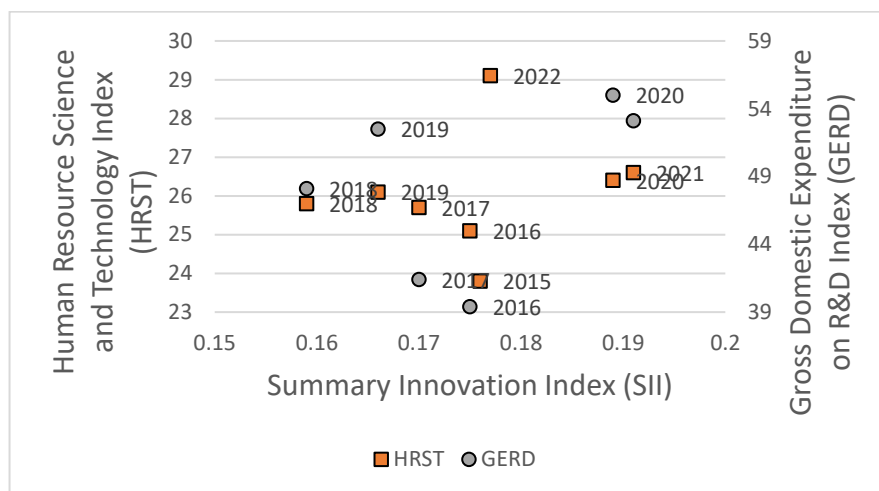


Figure 11: The dynamic of the SII and ITC indicators for Romania, in the period 2015-2022

#### 4. Conclusions

Previous steps we performed proved a strong link between innovation and ICT:

In 2019 we investigated the relationship between SII and the ICT Development Index (IDI), a composite index computed yearly, since 2009, by the International Telecommunication Union and published in the “Measuring the Information Society Report” (MISR), at European level (28 Member States).

In 2016 we investigated the relationship between the Networked Readiness Index (NRI), created by the World Economic Forum, in collaboration with INSEAD, and published yearly since 2002 and: (1) the Global Innovation Index (GII), published yearly since 2007, by INSEAD in collaboration with WIPO, Cornell University and their Knowledge Partners, and (2) the Summary Innovation Index (SII).

Results over the transactional relationships are confirmed for the SII and the Eurostat indicators HRST, respectively GERD, yearly, after 2015. Historically, for some countries there is a relationship, for other, this is not evident. We include here Romania, one of the Emerging Innovators.

#### References

- [1] COM (2010) 546 final, “Europe 2020 Flagship Initiative Innovation Union”. Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0546:FIN:EN:PDF>
- [2] COM (2010) 2020 final, “EUROPE 2020 - A strategy for smart, sustainable and inclusive growth”. Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF>

- [3] Crișan D.A., Potecea O., Preda A.M., Stănică J.L., “*ICT determining factors in increasing the innovation in Romania*”, Journal of Information Systems and Operations Management (JISOM), Vol. 5 No. 1 / May 2011, 2011, pp. 94-99, 2011.
- [4] Crișan D.A., Preda A.M., Coculescu C., Altăr-Samuel A.N., “*Some aspects concerning the correlation between ICT and innovation in Europe*”, The 6<sup>th</sup> International Conference "European Integration – New Challenges", 28 - 29 May 2010, Univ. Oradea, Romania, pp. 2436-2442, ISBN 978-606-10-0149-1, 2010, published in „Analele Universității din Oradea, Seria Științe Economice”( Journal: Annals of the University of Oradea : Economic Science Year: 2010 Vol: 1 Issue: 2 Pages/record No.: 1183-1189), ISSN-122569, vol I, issue 2, pp. 1183-1189, 2010;
- [5] European Commission (2021)  
<https://ec.europa.eu/docsroom/documents/46013/attachments/1/translations/en/renditions/native>
- [6] European Commission (2022)  
<https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard>
- [7] Eurostat, <https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>
- [8] Preda A.M., Crișan D. A., Stănică J.L., “The Impact of ICT on Innovation Performance in Europe. Case of Romania”, Journal of Information Systems and Operations Management (JISOM), Vol 8 No 1, 2014, pp. 1-12, Ed. Universitara, 2014.
- [9] Preda A.M., Crișan D.A., Potecea O., “A study on the relationship between ICT and innovation in Europe”, The 17th International Economic Conference – IECS 2010 "Economic world' destiny: Crisis and Globalization", May 13-14, 2010, Univ. Lucian Blaga, Sibiu, Romania, proceedings: pp.178-183 (CD Version), 2010.
- [10] Preda A.M., Crișan D.A., Stănică J.L., “Modeling the impact of ICT on innovation performance”, presented at the 19th International Economic Conference – IECS 2012, “The persistence of the global economic crisis: causes, implications, solutions”, June 12 2012, Univ. Lucian Blaga, Sibiu, Romania, published in proceedings: (CD Version), 2012;
- [11] Preda A.M., Stănică J.L., Crișan D.A., Coculescu C., “*E-Government: A Driving Factor For Stimulating Innovation Performance In Romania?*”, Proceedings of the 7th International Conference *European Integration – New Challenges*, 7th Edition, May 2011, Univ. Oradea, Romania, 2011, pp. 125-130, ISBN 978-606-10-0521-5; Journal: Annals of the University of Oradea : Economic Science Year: 2011 Vol: 1 Issue: 1 Pages/record No.: 125-130, ISSN (print): 1222-569X, 2011.
- [12] EUAgenda, <https://euagenda.eu/publications/european-innovation-scoreboard-2022>