

10. DISPARITIES, GAPS AND EVOLUTION TRENDS OF INNOVATION, AS A VECTOR OF ECONOMIC DEVELOPMENT, IN THE COUNTRIES OF THE EUROPEAN UNION

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Abstract:

Innovation has been a subject of interest at the level of the European Union ever since its formation as the European Community, being regarded as the main factor of progress facilitating the transition to a knowledge-based economy. In many studies, the R&D sector has been identified as a vector of economic development, as it can provide technological innovation streams to help deliver products with high added value. In this context, for evaluating the performance of each member state, but also of the Union as a whole, at the European Commission level has been developed a progress assessment tool in the innovation area (European Innovation Scoreboard – EIS), which publishes a composite indicator of the innovative performance of EU Member States (Summary Innovation Index - SII), as well as a comparative analysis of the progress of their research and innovation systems.

The 2018 edition of this innovation assessment tool in the European Union (analyzing the 2010-2017 period), based on 27 indicators grouped into 10 main categories, highlights the existence of major disparities and gaps between member countries, these being divided into 4 categories: Innovation Leaders; Strong Innovators; Moderate Innovators and Modest Innovators. To highlight these gaps in the paper we will use indicators of descriptive statistics (mean, standard deviation), but also the Herfindahl - Hirschman and Gini - Struck concentration / diversification coefficients. The analysis reflects an upward trend for the innovation index while preserving significant gaps between Innovation Leaders in Northern and Western Europe and Moderate and Modest Innovators, mainly located in Central and Eastern Europe.

Keywords: Innovation; economic development; concentration; Gini-Struck; Herfindahl - Hirschman.

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1. Introduction

Innovation is the main factor for a knowledge-based economy with smart and sustainable growth. This requires concrete measures to improve education, research and innovation systems, and to encourage the creation and development of innovative businesses. In many studies, the R & D sector has been identified as a vector of economic development, as it can provide technological innovation streams to help deliver high added value products.

To measure the innovative performance of each Member State, as well as of the Union as a whole, at the European Commission level has developed a tool for assessing progress in innovation (European Innovation Scoreboard – EIS), which publishes a composite indicator of innovation at the level of the EU Member States (Summary Innovation Index – SII), as well as a comparative analysis of the progress of their research and innovation systems. The analysis of the data provided by the European Commission through EIS 2018 highlights the existence and maintenance of major gaps between Northern and Western European countries, on the one hand, and Central and East European countries, on the other hand, with major implications for the level of economic development in these states.

2. Literature review

The issue of innovation and its impact on economic development has been a widely debated topic in the literature but also a major concern of the European Commission. One of the three priorities of the Europe 2020 strategy is smart growth, namely the development of an economy based on knowledge and innovation (European Commission, 2010, p. 12). In line with this priority, the Green Paper on Innovation states that "meeting the objectives of smart, sustainable and inclusive growth of the Europe 2020 strategy depends on research and innovation as the key drivers of social and economic prosperity and environmental sustainability" (European Commission, 2011, p. 2).

In this context, the innovation performance achieved by each EU Member State is conditional on the overall performance of the Union as a whole, which necessitated the creation of a regular monitoring system for them.

Innovation is a key driver of technology development and economic growth. It provides means of satisfying the demands of the current market and the potential needs of future markets. Innovation is achieved through more effective products, processes, services, or technologies that are readily available to the current market (Raghupathi and Raghupathi, 2017, p. 1). In the study, the two authors analyzed dependence between the innovation indicators (the ratio of patents owned by foreign residents and the number of patent applications in each industry in the technology sector) and a set of economic indicators: GDP, gross national income, labor cost, R&D expenditure, real minimum wage, tax revenue, and education enrollment. The results show that low GDP countries are based on collaboration with foreign residents for innovation; education enrollment stimulates innovation; among the sectors, government and higher education have higher R&D expenditures than private and non-profit sectors.

The link between innovation and economic development was approached in many other papers (Maradana et al., 2017, Hudson and Minea, 2013, Cinnirella and Streb, 2017, Pessoa, 2010 etc.), most of which concluded that innovation, regardless of the indicators it measured, has a direct and strong influence on economic development, which is why states have to support and stimulate investment in innovation activities.

3. Data and Methodology

The study is based on data from the European Innovation Scoreboard (EIS), which is a tool that measures the Member States' innovative performance on an annual basis. It monitors the strengths and weaknesses of their innovative systems by comparing them with various other non-EU countries (associated, candidate, partner), as well as with the main global competitors of the European Union. Introduced in 2000 as an integral part of the Lisbon Strategy, the EIS was considered a relevant tool for measuring innovation, but was also criticized for not capturing all the important dimensions of innovation, using inadequate indicators, not taking into account structural differences between countries, as well as for its methodology to synthesize the innovative performance of each country through a composite index (Hollanders and Cruysen, 2008, p. 2). To respond to the criticisms made, annual EIS publications were constantly improved, with the most significant changes being made in the years 2005, 2008, 2010 and 2017. The changes focused on both the number and on the groups of indicators considered in the construction of the composite indicator, Summary Innovation Index (SII), the methodology for calculating it, the number of countries included in the study, the baseline information bases and how to analyze them.

The 2018 edition keeps the calculation methodology of the previous year, with the individual innovative capacity of each state being valued in a ratio of 27 indicators grouped into four main categories and ten dimensions of innovation, namely:

A. **Framework conditions**, includes three dimensions of innovation, with the role of reflecting the main "motors" of innovation, external to firms: Human resources; Attractive research systems and Innovation-friendly environment. Each dimension is quantified by a set of 2-3 specific indicators.

B. **Investments**, includes two dimensions of innovation that reflects investment in both the public sector and the business sector: Finance and support, respectively Firm investments. These are quantified by 5 specific indicators.

C. **Innovation activities**, includes three dimensions of innovation: Innovators; Linkages, and Intellectual assets. This category is intended for the business sector, measuring the share of SMEs that have introduced market innovations, collaboration with the public sector in the field of innovation, as well as different forms of intellectual property rights.

D. **Impacts**, indicators related to this category, the effects of innovation activities, on both employment and sales of products and services, are measured.

The data collected from each EU Member State for the 27 innovation indicators has been centralized and subjected to a processing methodology (described in EIS 2018 Methodology Report), resulting in a composite indicator - Summary Innovation Index, which measures innovative performance of each state.

The dynamic analysis of the values for the Summary Innovation Index, as well as for each of its 10 dimensions, will highlight the progress made in the field of innovation at EU-28 level. As the evolutions were different from one country to the other, but also between the 10 dimensions of the SII, we would use a set of indicators of descriptive statistics (average, variance amplitude, standard deviation, variance coefficient) to measure gaps between countries, but as well Herfindahl - Hirschman and Gini - Struck concentration / diversification coefficients. (Săvoiu and Siminică, 2016, p. 4).

The Herfindahl -Hirschman coefficient (H-H) is calculated by:

$$H-H = \sum g_i^2$$

where: $g_i = [y_i / \sum y_i]$

y_i – the individual values of the analyzed variable;

The theoretical values of this indicator are in the range $[1/n; 1]$, where n represents the number of units comprised of the statistical population surveyed, in the research carried out, the 28 EU Member States. The Gini - Struck coefficient is thus determined:

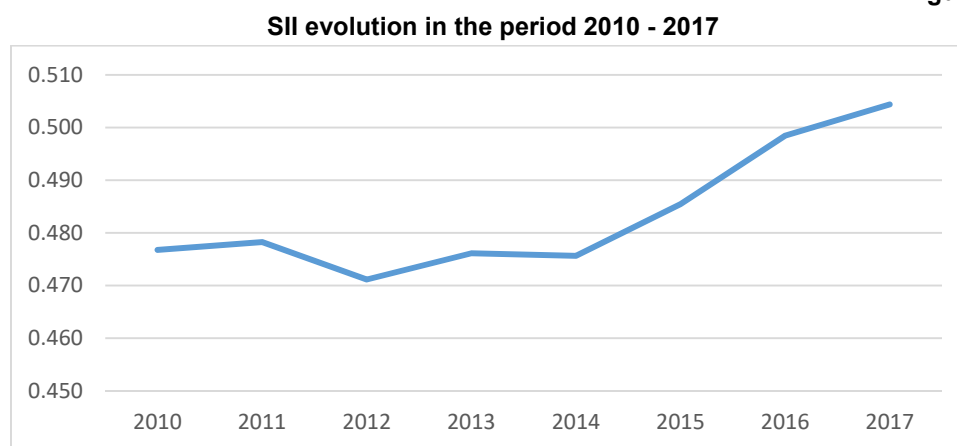
$$GS = \sqrt{\frac{n \sum gi^2 - 1}{n - 1}}$$

It can take values between 0 and 1. A rising level of the two indicators signifies the tendency of concentration of the analyzed variable, respectively the increase of the gaps between extreme values, while the decreasing values and close to the lower limit reflect the tendency of diversification and reduction of gaps between extreme values. These indicators will be calculated and analyzed at EU-28 level for each year of the period covered by the analysis, the values obtained reflecting the trend of increasing / reducing innovation gaps between Member States.

4. Results and discussions

The Summary Innovation Index - SII for EU-28 is presented in Annex 1. It had an upward trend over the period 2010-2017, rising from 0.477 points in 2010 to 0.504 points in 2017. Within the analyzed interval there were minor oscillations (increases / decreases) until 2014, after which the level of the indicator has been on an upward trend. The graphical representation of this evolution is shown in the following figure:

Figure 1



Source: EIS 2018

Such an evolution is favorable, indicating an increase in the level of innovative performance at EU level with potential beneficial effects on economic development.

An analysis carried out at the level of the 10 components of the SII reveals different evolutions in their level (Annex 1). Thus, the highest score was recorded for Sales impacts, being 31.9% higher than the SII level for EU-28, and the lowest for Intellectual assets, accounting for 85.5% of the SII level. Thereby, there are significant differences between the EU innovation score points. The low score level for the Intellectual assets dimension draws

attention to the existence of weaknesses in the recording of intellectual property rights for the results of innovative activities.

With regard to the evolutionary trend of the scores of the 10 dimensions of innovation, it was upward for 9 dimensions, with the highest growth rate (33.8% between 2010 and 2017) for the Innovation-friendly Environment. This is favorable because the indicators included in the Innovation-friendly Environment are the initial conditions of the innovative process, having a multiplier effect on the other dimensions of innovation. There was also a dimension, Innovators, for which the score decreased from 0.571 points in 2010 to 0.493 points in 2017. On the indicators that make up this dimension, we see a reduction in the share of SMEs introducing product or process innovations, marketing or organizational innovations, or internal innovation activities. This requires identifying incentives for innovative SMEs that carry out high added-value activities.

The upward trend for most innovation dimensions, recorded at EU-28 level, is not confirmed by all Member States, with significant gaps existing between them. Reducing disparities and gaps between EU Member States, both in terms of the level of economic and social development and in its decisive factors, by providing support to less developed regions is the main objective of the EU Treaty. Although cohesion policy has made a substantial contribution to smart growth and the reduction of disparities, low levels of innovation in many regions, persistent economic disparities and gaps in physical and digital networks still require considerable investment in the coming years and beyond the current programming period (Dijkstra, 2014, p. 1).

To highlight innovation disparities and gaps in the EU Member States, we will look at the Summary Innovation Index (SII) and the 10 dimensions of innovation, calculated for all EU-28 countries. To start, we will highlight the extreme (minimum and maximum) recorded values for the SII and its components, as well as a number of descriptive statistics indicators. The results for 2017, based on EIS 2018, are presented in the table below:

Table 1

Summary Innovation Index variation indicators

Indicators	Min	Max	EU-28 Average	A	A%	SD	Cv
Summary Innovation Index	0.157	0.710	0.504	0.553	1.097	0.154	0.305
Human resources	0.089	0.871	0.473	0.782	1.654	0.206	0.436
Research systems	0.117	0.886	0.448	0.769	1.717	0.240	0.537
Innovation-friendly environment	0.204	1.000	0.506	0.796	1.574	0.216	0.427
Finance and support	0.041	0.845	0.598	0.804	1.344	0.227	0.380
Firm investments	0.055	0.724	0.458	0.669	1.460	0.163	0.355
Innovators	0.000	0.838	0.493	0.838	1.700	0.254	0.515
Linkages	0.056	0.768	0.475	0.712	1.501	0.192	0.404
Intellectual assets	0.096	0.720	0.431	0.623	1.445	0.196	0.456
Employment impacts	0.187	0.891	0.540	0.704	1.303	0.170	0.315
Sales impacts	0.170	0.850	0.665	0.679	1.021	0.178	0.267

Source: Authors' own work after EIS 2018

where: A – absolute variation amplitude ($A = y_{\max} - y_{\min}$);

A% - relative amplitude ($A\% = A / \text{Average}$).

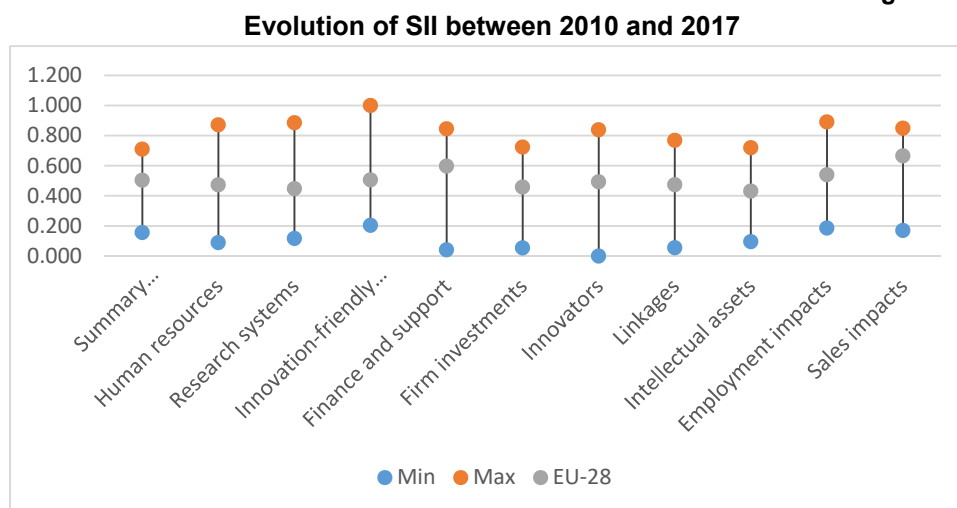
SD – standard deviation;

Cv – coefficient of variation.

In 2017, the highest level of the Summary Innovation Index was recorded for Sweden (0.710 points), being 40.8% higher than the EU-28 average, and the lowest level recorded was for Romania (0.157 points), representing 31.1% of the EU-28 average. The difference between the two extreme values exceeds the average level of the SII so that the relative amplitude of the variation is more than 100%. The standard deviation is high, and the coefficient of variation is more than 30%, which shows a high degree of spreading of the Summary Innovation Index, the 28 European countries being heterogeneous in terms of innovation.

The disparities identified at the Summary Innovation Index level are also kept at the level of its 10 dimensions. The graphical representation of the minimum and maximum values, as well as the EU-28 average for each of the 10 dimensions of innovation, is shown in the figure below:

Figure no. 2



Source: Authors' own work after EIS 2018

We identify the existence of large variation intervals for the scores granted to each dimension of innovation. Thus, the minimum values of each of the 10 innovation dimensions range from 0 (Innovators) and 0.204 (Innovation-friendly environment), while maximum values range from 0.720 (Intellectual assets) to 1.000 (Innovation-friendly environment). The range of score scores is high, with a maximum of 0.838 points (Innovators), representing 170% of the average score for this category, confirming the existence of significant gaps in innovation activities across the 28 EU Member States. The standard deviation and the coefficient of variation, calculated for each dimension of the innovation in part, records high values, being more than 30% in all cases.

The analysis of the gaps between the EU countries in their innovative activities continues on the basis of the Herfindahl - Hirschman and Gini - Struck concentration / diversification coefficients. Their level was calculated on the basis of the data provided by EIS 2018, for each year of the analyzed period, according to previous methodological specifications. The results obtained are presented in the following tables:

Table 2

Herfindahl - Hirschman Concentration / Dedication Coefficient for the Summary Innovation Index and Its Components

Indicators	2010	2011	2012	2013	2014	2015	2016	2017
Summary Innovation Index	0.0395	0.0396	0.0402	0.0400	0.0401	0.0399	0.0399	0.0398
Human resources	0.0427	0.0447	0.0425	0.0419	0.0424	0.0427	0.0421	0.0423
Research systems	0.0479	0.0480	0.0479	0.0476	0.0478	0.0470	0.0459	0.0450
Innovation-friendly environment	0.0434	0.0444	0.0447	0.0454	0.0445	0.0436	0.0432	0.0417
Finance and support	0.0452	0.0464	0.0447	0.0444	0.0435	0.0436	0.0426	0.0455
Firm investments	0.0399	0.0397	0.0415	0.0413	0.0416	0.0410	0.0417	0.0415
Innovators	0.0432	0.0432	0.0437	0.0437	0.0447	0.0447	0.0470	0.0470
Linkages	0.0416	0.0417	0.0419	0.0420	0.0425	0.0428	0.0429	0.0432
Intellectual assets	0.0477	0.0469	0.0465	0.0461	0.0453	0.0448	0.0451	0.0444
Employment impacts	0.0415	0.0413	0.0410	0.0407	0.0405	0.0402	0.0403	0.0395
Sales impacts	0.0381	0.0380	0.0392	0.0390	0.0398	0.0395	0.0401	0.0402

Source: Authors' own work after EIS 2018

Table 3

The Gini-Struck concentration / diversification factor for the Summary Innovation Index and its components

Indicators	2010	2011	2012	2013	2014	2015	2016	2017
Summary Innovation Index	0.0630	0.0638	0.0685	0.0669	0.0677	0.0657	0.0657	0.0647
Human resources	0.0849	0.0837	0.0841	0.0799	0.0836	0.0851	0.0813	0.0823
Research systems	0.1126	0.1127	0.1125	0.1109	0.1121	0.1079	0.1029	0.0979
Innovation-friendly environment	0.0893	0.0893	0.0964	0.1003	0.0953	0.0906	0.0879	0.0785
Finance and support	0.0993	0.1051	0.0964	0.0948	0.0896	0.0903	0.0844	0.1005
Firm investments	0.0660	0.0645	0.0773	0.0761	0.0781	0.0740	0.0787	0.0774
Innovators	0.0882	0.0882	0.0909	0.0909	0.0965	0.0965	0.1083	0.1083
Linkages	0.0782	0.0789	0.0802	0.0805	0.0841	0.0855	0.0864	0.0880
Intellectual assets	0.1114	0.1077	0.1060	0.1038	0.0995	0.0970	0.0985	0.0947
Employment impacts	0.0774	0.0762	0.0743	0.0716	0.0703	0.0681	0.0691	0.0625
Sales impacts	0.0493	0.0487	0.0598	0.0584	0.0654	0.0628	0.0671	0.0679

Source: Authors' own work after EIS 2018

The two concentration / diversification coefficients (H-H and GS) tended to grow in 2011 and 2012, signifying an increase in innovation gaps between EU Member States. Following the fluctuations in 2013 and 2014, in the period between 2015 and 2017 the two coefficients tended to decline, which means that countries with moderate or modest innovation activities have recovered some of the gaps in innovation leaders. Although in the last three years the evolution of the two indicators was favorable, in 2017 the H-H and GS values were higher compared to 2010, signifying the maintenance and even increasing of the gaps between the EU countries.

An analysis of the degree of concentration on the 10 dimensions of innovation highlights different stages of development. Thus, the highest values for HH and GS were recorded for

the sizes of Innovators (GS = 0.1083) and Finance and support (GS = 0.1500), which means that for these dimensions the gaps between EU Member States are the highest. At the same time, for the size of Innovators, the growth rate of the GS coefficient value is the highest (22.8%) signifying the increase in the gaps identified for this dimension. The lowest values for H-H and GS were recorded for the size of the Employment impact, decreasing compared to 2010 by almost 20%, signifying the narrowing of the gap in this category. In fact, out of the 10 dimensions of innovation, in the 2010-2017 period, 5 dimensions saw an increase in the values of the HH and GS coefficients, signifying the increase in the gap between the Member States, while in the other 5 dimensions the concentration coefficients recorded decreasing values, meaning reducing gaps.

The disparities between the EU Member States in terms of their innovation activities led to their grouping in four relatively homogeneous categories. According to EIS 2018, they are as follows:

- *Innovation Leaders*: Sweden, Denmark, Finland, Netherlands, United Kingdom, Luxembourg;
- *Strong Innovators*: Germany, Belgium, Ireland, Austria, France, Slovenia;
- *Moderate Innovators*: Czech Republic, Portugal, Malta, Estonia, Spain, Cyprus, Italy, Lithuania, Hungary, Greece, Slovakia, Latvia, Poland, Croatia;
- *Modest Innovators*: Bulgaria, Romania.

Depending on the values for the countries in each category, we calculated the average score for each group as well as the proportion in relation to the EU-28 average. The results obtained are presented in the following table:

Table 4

Dynamic Summary Innovation Index by group of states

		2010	2011	2012	2013	2014	2015	2016	2017
SII Values	EU-28	0.477	0.478	0.471	0.476	0.476	0.485	0.498	0.504
	Leaders	0.614	0.618	0.629	0.632	0.624	0.636	0.647	0.650
	Strong	0.535	0.542	0.537	0.538	0.536	0.540	0.560	0.563
	Moderate	0.337	0.338	0.330	0.339	0.330	0.344	0.345	0.352
	Modest	0.230	0.224	0.190	0.196	0.182	0.181	0.190	0.193
% EU-28	EU-28	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Leaders	128.7%	129.2%	133.5%	132.8%	131.3%	131.1%	129.7%	128.8%
	Strong	112.3%	113.3%	114.0%	113.0%	112.6%	111.3%	112.3%	111.5%
	Moderate	70.7%	70.7%	70.1%	71.1%	69.4%	70.8%	69.2%	69.9%
	Modest	48.2%	46.9%	40.2%	41.1%	38.2%	37.3%	38.2%	38.3%

Source: Authors' own work after EIS 2018

In 2011 and 2012, the Innovation Leaders and Strong Innovators group of states increased their innovation performance at a higher pace than the EU-28 level, in 2012 the SII level for Innovation Leaders being 33.5% higher than that for the EU-28, and for Strong Innovators 14% higher. After 2013, the pace of innovation performance growth for Innovation Leaders states has slowed, so in 2017 the SII for them was 28.8% higher than the European average. The situation was similar in the case of Strong Innovators.

The states in Moderate Innovators category recorded shifts in the Summary Innovation Index, growth years alternating with deflation years (2012 and 2014). The level recorded in 2017 was higher than in 2010, but compared to the EU-28 average it fell by almost 1%.

The Modest Innovators category recorded a reduction in the average score from 0.230 points in 2010 to 0.193 in 2017. Relative to the EU-28 average, in 2017 there was a reduction of nearly 10% from 48.2% (2010) to 38.3% (2017). The obtained results confirm the slight increase in the gaps between EU Member States in terms of innovation, gaps which can influence the pace of economic growth and may constitute barriers to real convergence and reduction of economic and social disparities at EU level.

5. Conclusions

The Summary Innovation Index evolution in the period 2010-2017 confirms the improvement of innovative performance at EU-28 level. The analysis carried out at the level of the 10 components of the SII highlighted the upward trend for 9 of them, with the weaknesses in the record of intellectual property rights for the results of the innovative activities. However, the situation has not been confirmed at the level of all EU Member States. While in some countries the IIS level increased significantly over the period under review, there were also countries for which it remained constant or even diminished. The different pace of evolution of the IIS and its components has led to the appearance and intensification of gaps between EU Member States.

The values of the descriptive statistics indicators (variance amplitude, standard deviation, variance coefficient) and the Herfindahl - Hirschman and Gini - Struck concentration / diversification coefficients confirm the existence of significant innovation gaps between Innovation Leaders, located in the north and west Europe, and Moderate respectively Modest Innovators, located predominantly in Central and Eastern Europe, with potential consequences for their growth rate.

In order to reduce the gaps between the EU Member States in the field of innovation, at the level of the states from the Moderate and Modest Innovators categories, a series of measures are needed to drive innovatory activities and support smart, sustainable and inclusive growth.

The starting point for this approach should be to support national education systems by increasing public funding allocated to education funding; increasing the attractiveness of the curriculum and adapting it to the requirements of the labor market; developing the relationships between the university environment and the economic and social environment with which it interacts; internationalization of study programs and increasing international mobility of pupils, students and teachers; supporting doctoral students' access to archives, libraries, publications, databases and other sources of information, Etc.;

The development of scientific research activities by increasing public and private funds to finance them, ensuring unrestricted access of all researchers to the top publications in their field of activity, setting up a system of awarding top results, simplifying registration procedures for intellectual property rights, etc., could be another direction for action to boost innovation activities.

Another measure could be to stimulate SMEs activity that introduces product or process innovation, marketing or organizational innovation, or conducts internal innovation activities, through tax incentives or financial support in the form of state aid.

Such recommendations, however, implemented in a coordinated system at European level to capitalize on the competitive advantages of each state, have the role of boosting innovation activities at EU level, reducing gaps between Member States and contributing to supporting economic development.

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Appendix

Annex 1

Dynamic Summary Innovation Index and its components at EU-28 level

Indicators	2010	2011	2012	2013	2014	2015	2016	2017	Index 2017/2010
Summary Innovation Index	0.477	0.478	0.471	0.476	0.476	0.485	0.498	0.504	1.058
Human resources	0.396	0.396	0.396	0.429	0.446	0.451	0.464	0.473	1.193
Research systems	0.394	0.402	0.414	0.428	0.423	0.432	0.443	0.448	1.136
Innovation-friendly environment	0.378	0.390	0.388	0.387	0.375	0.404	0.447	0.506	1.338
Finance and support	0.555	0.527	0.496	0.475	0.497	0.535	0.578	0.598	1.077
Firm investments	0.410	0.410	0.391	0.395	0.439	0.451	0.467	0.458	1.118
Innovators	0.573	0.573	0.571	0.571	0.498	0.498	0.493	0.493	0.860
Linkages	0.470	0.484	0.438	0.440	0.464	0.465	0.484	0.475	1.010
Intellectual assets	0.427	0.435	0.440	0.444	0.439	0.433	0.430	0.431	1.009
Employment impacts	0.537	0.540	0.546	0.549	0.552	0.560	0.530	0.540	1.006
Sales impacts	0.639	0.632	0.636	0.636	0.622	0.638	0.669	0.665	1.041

Source: EIS 2018