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The Innovation Output Indicator 2018 Methodology Report

INNOVA MEASURE III D3.1

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Joint Research Centre

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Abstract / Executive Summary

This report presents the 2018 update of the Innovation Output Indicator (IOI), which is a composite indicator published by the European Commission since 2013 aiming to quantify the extent to which ideas for new products and services carry an economic added value and are capable of reaching the market.

The report presents the latest figures for the underlying indicators and composite index for 40 countries. The four components of the IOI benchmark countries in terms of technological innovation by patents, the share of highly skilled labor force feeding into the economic structure of a country, the competitiveness of knowledge-intensive goods and services, as well as employment in fast-growing enterprises in innovative sectors. The methodology is unchanged with respect to the refinements introduced in the 2017 editions.

Composite results show that the EU is outperformed by the US, while both are trailing Israel and Japan. There is no evidence of convergence, the gap between the EU with respect to the US as well as Japan has persisted over time. When comparing European countries, we notice that Ireland, Sweden, and the UK are among the leaders, whereas we find Lithuania, Croatia and Romania at the end of the ranking. Multivariate statistical analysis shows that it is important to benchmark a country’s performance not only according to its composite scores, but also according to the various components. Most notably, the component measuring employment in fast-growing enterprises in innovative sectors shows a weak, positive association with the rest of the components. This may be interpreted as two aspects of Schumpeterian dynamics, where knowledge- and R&D-based and entrepreneurship-based innovation may require specific, dedicated policies.

1 Introduction

The 2018 Innovation Output Indicator (IOI) report presents the most recent data for each of its components alongside country performance in the overall index. The IOI was introduced in the 2013 Communication and Staff Working Document (European Commission, 2013) and further refined in the 2014 and 2016 Methodology Reports[1]. The aim of the indicator is to support policy-makers by offering an output-oriented measure of innovation performance at the country and EU levels and measure countries' capacity to derive economic benefits from innovation, capture the dynamism of innovative entrepreneurial activities. Such an indicator aims to complement other benchmarking tools, such as the R&D spending targets and the European Innovation Scoreboard. The aim of this report is to serve as the methodological background for the latest update of the indicator and its components, rather than offer a detailed analysis of country performance. It thus focuses on presenting data and results alongside the relevant statistical analyses.

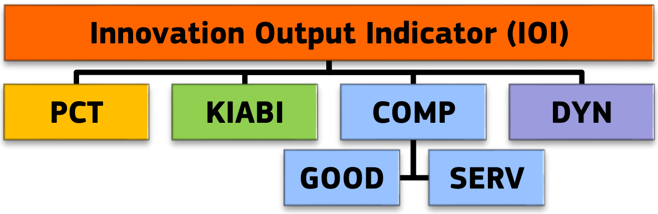


Figure 1 The Innovation Output Indicator framework

As elaborated in earlier reports (see in particular European Commission, 2013), the component indicators aim to quantify the extent to which ideas for new products and services carry an economic added value and are capable of reaching the market. Therefore, it can be captured by more than one measure. The IOI has four components, see **Figure 1** for an overview of the framework.

The first component, referred to as 'PCT', measures **technological innovation** by PCT patent applications, which account for the ability of the economy to transform knowledge into technology. The number of PCT patent applications per billion GDP is used as a measure of the marketability of innovations.[2] (See further details on how the computation of each component in section 2 of this report.) The second component, 'KIABI' measures the number of persons employed in knowledge-intensive business industry within total employment. It focuses on how a highly skilled labor force feeds into the **economic structure** of a country. Investing in people is one of the main challenges for Europe in the years ahead, as education and training provide workers with the skills for generating innovations. This component also captures the structural orientation of the business economy towards knowledge-intensive activities. Thirdly, the 'COMP' component aims to capture the **competitiveness of knowledge-intensive goods and services** in the export markets.[3] This is a fundamental dimension of a well-functioning economy, given the close link between growth, innovation

[1] See Vertesy and Tarantola, 2014; Vertesy and Deiss, 2016.

[2] Patent indicators are known to have drawbacks when it comes to measuring technological innovation. On the one hand, many patented inventions will not become innovation due to practices of strategic patenting. On the other hand, patents are sector specific (and even within manufacturing industries where patenting is more pervasive, firms may have alternative ways for protecting intellectual property, i.e. through secrecy or lead-time); see Griliches, 1990, 1998; Pavitt, 1985. At the same time, patents were found to be reliable proxies for knowledge production and innovation (Acs et al., 2002; Hall et al., 1986). Furthermore, while the number of granted patents may be a more accurate measure of marketable innovations, this suffers even more from timeliness issues than applications data, nevertheless, the two correlate highly at the country level. PCT applications are used to as a good compromise between allowing a global comparison and relatively more timely (although with at least 2 years lag) data.

[3] We note that the measurement of competitiveness has a long literature offering many alternative ways of measurement, including unit labour costs, price, market share, etc. for a recent discussion of potential alternatives, see i.e. Castellani and Koch (2015).

and internationalization. Competitiveness-enhancing measures and innovation strategies can be mutually reinforcing for the growth of employment, export shares and turnover at the firm level. This component is built integrating in equal weights the share of high-tech and medium-tech product exports to the total product exports (GOOD), and knowledge-intensive service exports as a share of the total services exports of a country (SERV). It reflects the ability of an economy, notably resulting from innovation, to export goods and services with high levels of value added, and successfully take part in knowledge-intensive global value chains. Finally, the last component, referred to as 'DYN', measures the **employment dynamism in fast-growing[4] enterprises in innovative sectors**. It compares countries in terms of the share of their employment in sectors that scored above-average applying sector-specific innovation coefficients. The component reflects the innovativeness of successful entrepreneurial activities. The specific target of fostering the development of high-growth enterprises in innovative sectors is an integral part of modern R&D and innovation policy.

The definition of the DYN component has been simplified in this 2017 edition in contrast to previous definitions, in order to make it more easily decomposable and easier to interpret. A dedicated section will discuss the details of the changes. The revision of the DYN component has been carried out jointly with the update of the European Innovation Scoreboard (EIS) and the revision of the respective component, so the IOI and EIS remain closely associated. All the IOI indicators form part of the Scoreboard. The set of indicators used for the IOI is, however, more narrowly focused on output, and using a different set of indicators than those within the 'impacts' dimension of the EIS. Further differences arise from the fact that data used for the two reports were frozen at different points in time (the IOI 2017 being more recent, with data collection reflecting the state of June 2017), and from using different methods to treat missing values, perform data normalization, as well as from the weighting and aggregation procedures applied to obtain the composite scores.[5]

[4] High-growth is defined by an annual average employment growth of 10% over a three-year period.
[5] For further comparison between EIS and IOI outcomes, see section 5 of this report.

2 Definition of components

In this section, we present the definition of each component and country performance in the most recent years available, in the previous year, as well five years prior to the most recent year available. We note that data were collected in August 2018; the year with most recent data for most components was 2017, so we indicate year lags for each component with respect to 2017.

2.1 PCT: PCT Patent applications per billion GDP (PPS)

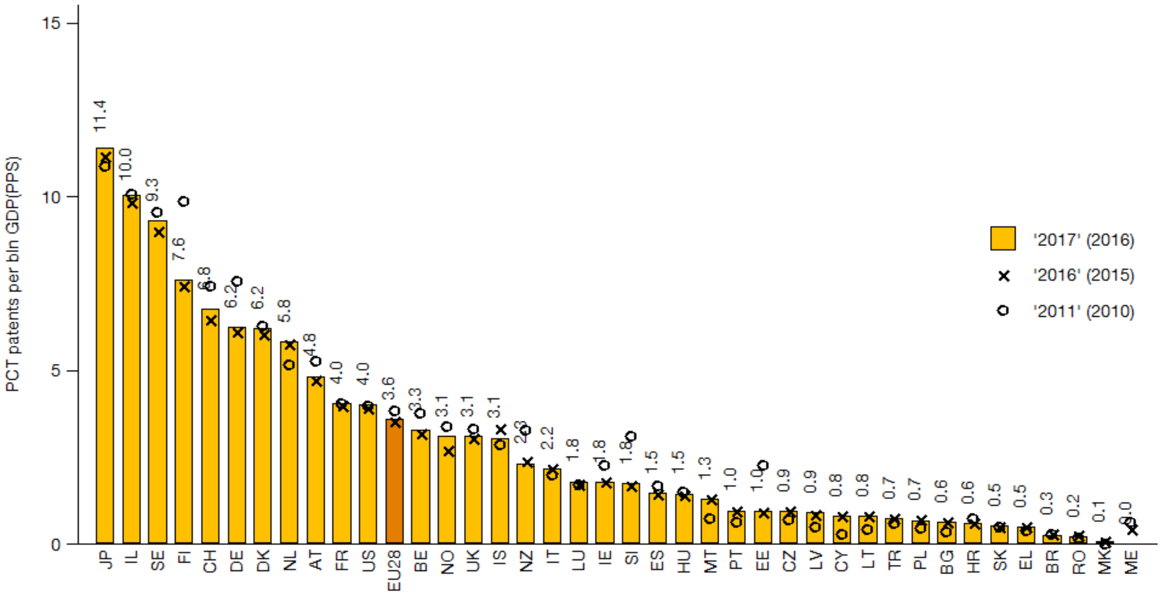
The purpose of the PCT component is to measure the ability of the economy to transform knowledge into marketable innovations. Although it is understood that patents are better indicators of successful inventions than innovations as they say little about how novelties will perform on the market, we consider patents filed under the Patent Cooperation Treaty (PCT)[6] to carry the information that its filing company expects it to have a higher market impact. The PCT component of the IOI is identical to indicator 3.3.1 of the most recent European Innovation Scoreboard and counts the number of PCT patent applications per billion GDP (PPP). The numerator is defined as the number of patent applications filed, in international phase, which name the European Patent Office (EPO) as designated office under the PCT. Patent counts are based on the priority date, the inventor's country of residence and fractional counts to account for patents with multiple attributions. The denominator is the GDP in Euro-based purchasing power parities, according to ESA2010. Due to the two-stage procedure in the PCT application process (see footnote 6), there may be a lag of almost 2.5 years between the priority date and the date when PCT applications enter the national or regional phase (where the actual decision is made about approval or rejection of a patent), posing a considerable constraint to timeliness (OECD, 2009). For a summary of key parameters, see **Table 1**.

Table 1 Key parameters of the PCT Component

	Numerator	Denominator
Definition	Number of PCT patent applications	GDP PPS
Source	OECD MSTI if available, OECD PATSTAT otherwise.	Eurostat nama_10_gdp (CP_MPPS) naida_10_gdp + OECD PPP, ESA2010
Notes	Indicator is flagged unreliable if PCT count is less than 10 per year	Release: t+9 months
Most recent year used [Nr. years lag vs. 2017]	2016 [1]	
Corresponding EIS indicator	3.3.1 PCT patent applications per billion GDP (in PPS €)	

Country performance in PCT in the most recent years, as well as evolution over 1 and 5 years are shown in **Figure 2**. The top performing EU Member States in PCT – Sweden, Finland and Germany –, are trailing the global leader Japan and Israel. PCT scores have markedly dropped over the past 5 years for a number of countries, including Finland, Israel, Germany, Norway as well as Latvia, while increased for a few countries, including Malta.

6 PCT is an international patent law treaty concluded in 1970, unifying procedures for filing patent applications. An application filed under PCT is called an "international application". An international patent is subject to two phases. The first one is the "international phase" (protection pends under a single application filed with the patent office of a contracting state of the PCT). The second one is the "national and regional phase" in which rights are continued by filing documents with the patent offices of the various PCT states.



Source: See Table 1. *Notes:* Years in quotation marks indicate 1-year shift relative to patent priority years (i.e., "2017" refers to data from 2016).

Figure 2 PCT patent applications per billion GDP (in PPS)

Table 2 PCT: PCT Applications per billion GDP (PPS)

Time Point (Actual year)	'2011' (2010)	'2012' (2011)	'2013' (2012)	'2014' (2013)	'2015' (2014)	'2016' (2015)	'2017' (2016)
JP	10.9	12.1	12.1	11.4	11.6	11.1	11.4
IL	10.1	10.0	10.6	9.9	10.0	9.8	10.0
SE	9.5	9.1	9.7	9.5	9.5	9.0	9.3
FI	9.9	9.4	9.9	9.2	8.3	7.4	7.6
CH	7.4	7.5	7.5	6.8	6.5	6.4	6.8
DE	7.5	7.2	6.8	6.6	6.3	6.1	6.2
DK	6.3	6.7	6.1	6.3	6.0	6.0	6.2
NL	5.1	6.0	5.8	5.8	5.9	5.8	5.8
AT	5.3	5.1	4.8	5.0	4.9	4.7	4.8
FR	4.0	4.2	4.1	4.2	4.2	4.0	4.0
US	4.0	4.2	4.3	4.8	4.2	3.9	4.0
EU28	3.8	3.9	3.7	3.8	3.7	3.5	3.6
BE	3.8	3.7	3.4	3.5	3.3	3.2	3.3
NO	3.4	3.0	2.9	3.0	2.8	2.7	3.1
UK	3.3	3.3	3.2	3.5	3.3	3.0	3.1
IS	2.9	3.4	3.4	3.5	3.4	3.3	3.1
NZ	3.3	3.1	3.1	3.1	3.0	2.4	2.3
IT	2.0	2.0	2.0	2.2	2.2	2.2	2.2
LU	1.7	1.9	1.9	1.6	1.9	1.7	1.8
IE	2.2	2.7	2.3	2.5	2.4	1.8	1.8
SI	3.1	3.0	2.8	3.5	3.0	1.7	1.8
ES	1.7	1.6	1.5	1.6	1.6	1.5	1.5
HU	1.5	1.6	1.4	1.4	1.4	1.4	1.5
MT	0.7	0.2	0.8	0.9	1.3	1.3	1.3
PT	0.6	0.7	0.7	0.8	0.7	0.9	1.0
EE	2.3	1.7	0.7	1.2	1.3	0.9	1.0
CZ	0.7	0.8	0.9	1.1	1.1	0.9	0.9
LV	0.5	0.8	1.0	1.0	0.4	0.9	0.9
CY	0.3	0.5	0.4	0.7	0.8	0.8	0.8
LT	0.4	0.4	0.8	0.8	0.8	0.8	0.8
TR	0.6	0.5	0.6	0.6	0.7	0.7	0.7
PL	0.5	0.4	0.5	0.5	0.6	0.7	0.7
BG	0.3	0.5	0.6	0.5	0.6	0.6	0.6
HR	0.7	0.7	0.7	0.6	0.6	0.6	0.6
SK	0.5	0.5	0.4	0.6	0.4	0.5	0.5
EL	0.4	0.4	0.5	0.6	0.6	0.5	0.5
BR	0.3	0.3	0.3	0.3	0.3	0.3	0.3
RO	0.2	0.2	0.2	0.3	0.3	0.2	0.2
MK	0.0	0.1	0.0	0.3	0.1	0.1	0.1
ME	0.6	0.0	0.2	0.4	0.1	0.4	0.0

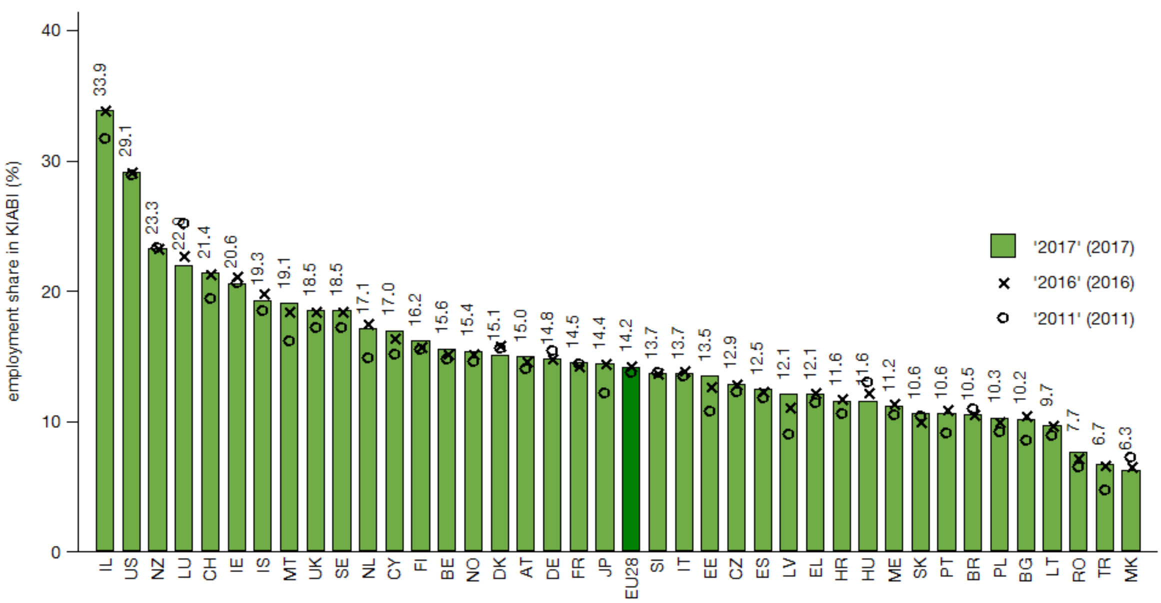
Source: see Table 1; *Note:* Actual figures are lagged by 1 years (thus, 2017 refers to 2016).

2.2 KIABI: Share of employment in knowledge-intensive business industries

The KIABI component aims at measuring how the supply of skills feeds into the economic structure. It is identical to indicator 4.1.1 of the European Innovation Scoreboard and measures the number of employed persons in knowledge-intensive activities (KIA) in business industries [KIABI] as a percentage of total employment. Knowledge-intensive activities provide products and services directly to consumers, such as telecommunications, and provide inputs to the innovative activities of other firms in all sectors of the economy. The KIABI component is calculated from EU Labour Force Survey data, as all NACE Rev.2 industries at 2-digit level, where at least 33% of employment has a tertiary degree. For a summary of key parameters, see **Table 3**.

Table 3 Key parameters of the KIABI component

	Numerator	Denominator
Definition	Employment in knowledge-intensive business industries	Total employment
Source	Eurostat, htec_kia_emp2 OECD, SSIS_BSC_ISIC4	
Notes	US, JP: not available anymore from Eurostat, used historic data	
Most recent year used [Nr. years lag vs. 2017]	2017 [0]	
Corresponding EIS indicator	4.1.1 Employment in knowledge-intensive activities as percentage of total employment	



Source: see Table 3. *Notes:* Years in quotation marks are identical to actual year of data.

Figure 3 Share of employment in knowledge-intensive activities in business industries (in %)

Table 4 KIABI: Share of employment in knowledge-intensive activities in business industries (%)

Time Point (Actual year)	'2011' (2011)	'2012' (2012)	'2013' (2013)	'2014' (2014)	'2015' (2015)	'2016' (2016)	'2017' (2017)
IL	31.7	31.7	31.0	33.9	33.9	33.9	33.9
US	28.9	28.8	29.2	29.2	29.1	29.1	29.1
NZ	23.3	23.4	23.5	23.3	23.3	23.3	23.3
LU	25.2	25.5	26.2	27.5	22.9	22.7	22.0
CH	19.4	20.1	20.2	20.8	20.7	21.3	21.4
IE	20.6	21.0	21.1	21.3	21.2	21.1	20.6
IS	18.5	17.5	17.2	18.2	18.6	19.8	19.3
MT	16.2	16.7	17.4	18.3	18.6	18.4	19.1
UK	17.2	17.6	17.8	18.0	18.3	18.4	18.5
SE	17.2	17.6	17.7	17.9	18.2	18.4	18.5
NL	14.9	15.3	17.1	17.3	17.4	17.5	17.1
CY	15.1	16.9	17.2	17.2	16.2	16.4	17.0
FI	15.5	15.5	15.7	15.8	16.1	15.7	16.2
BE	14.8	15.2	15.3	15.4	15.5	15.2	15.6
NO	14.6	15.3	15.9	16.3	15.8	15.2	15.4
DK	15.6	15.5	15.2	15.4	15.6	15.8	15.1
AT	14.0	14.2	14.6	14.7	14.5	14.6	15.0
DE	15.4	15.3	14.7	14.6	14.6	14.8	14.8
FR	14.4	14.3	14.0	14.0	14.3	14.2	14.5
JP	12.1	14.4	14.4	14.4	14.4	14.4	14.4
EU28	13.7	13.8	13.9	13.9	14.1	14.2	14.2
SI	13.7	14.1	14.0	14.0	14.1	13.7	13.7
IT	13.5	13.3	13.5	13.6	13.7	13.9	13.7
EE	10.8	11.0	11.9	11.4	12.4	12.7	13.5
CZ	12.3	12.7	13.0	12.7	12.4	12.8	12.9
ES	11.8	12.2	12.4	12.3	12.4	12.3	12.5
LV	9.0	10.3	10.8	10.9	11.2	11.1	12.1
EL	11.4	12.4	12.5	12.2	12.0	12.2	12.1
HR	10.6	10.5	10.6	10.7	11.0	11.7	11.6
HU	13.0	12.5	12.9	12.3	12.0	12.2	11.6
ME	10.5	10.2	11.0	10.7	11.7	11.4	11.2
SK	10.4	10.1	9.6	9.9	9.6	10.0	10.6
PT	9.1	9.0	9.4	10.3	10.7	10.9	10.6
BR	10.9	10.8	11.0	10.5	10.5	10.5	10.5
PL	9.2	9.7	9.6	9.9	10.0	10.0	10.3
BG	8.5	8.6	9.0	9.4	10.1	10.4	10.2
LT	8.9	9.1	9.0	8.8	9.3	9.7	9.7
RO	6.5	6.5	6.6	6.9	7.0	7.2	7.7
TR	4.7	5.0	5.3	5.7	6.2	6.6	6.7
MK	7.2	7.0	6.2	6.3	6.3	6.5	6.3

Source: see Table 3.

2.3 The COMP Component

Increasing competitiveness is an intended consequence of innovative activities. The COMP component aims to capture international competitiveness in knowledge-intensive sectors, and is defined as the arithmetic average (with equal weights) of two indicators: GOOD and SERV. GOOD measures the share of high-tech and medium-tech products in a country's exports and is identical to indicator 4.2.1 of the European Innovation Scoreboard. SERV, identical to indicator 4.2.2 of the European Innovation Scoreboard measures the share of knowledge-intensive services exports to the total services exports of a country.

2.3.1 GOOD: The share of medium- and high-tech products in total exports

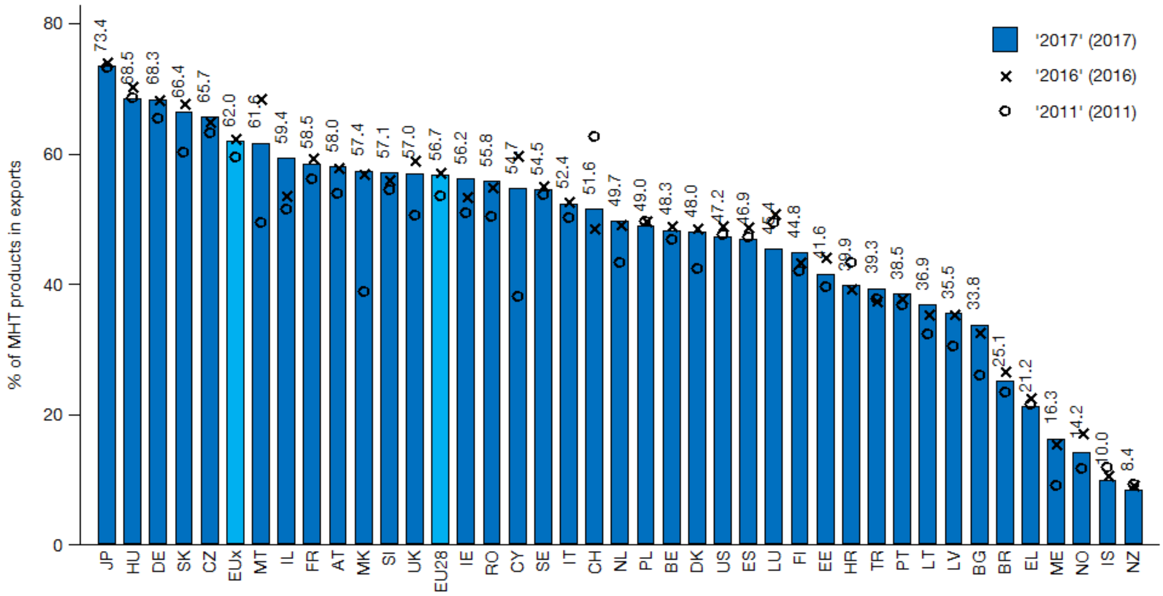
As highlighted by the European Innovation Scoreboard, this indicator measures the technological competitiveness of countries, in other words, their ability to commercialize the results of research and development (R&D) and innovation in international markets. It also reflects product specialization. Creating, exploiting, and commercializing new technologies are vital for the competitiveness of a country. Medium- and high-technology products are key drivers of economic growth, productivity and welfare, and are generally a source of high value added and well-paid employment.

The numerator of GOOD is the total value of exports of a country in Standard International Trade Classification (SITC) Rev.4 classes: 266, 267, 512, 513, 525, 533, 54, 553, 554, 562, 57, 58, 591, 593, 597, 598, 629, 653, 671, 672, 679, 71, 72, 731, 733, 737, 74, 751, 752, 759, 76, 77, 78, 79, 812, 87, 88 and 891. The denominator is the total value of product exports of a country. The data source for GOOD is the Eurostat COMEXT database for EU Member States and EFTA countries, and UN Comtrade for all others (OECD and BRIC countries), as described in **Table 5**.

For the EU28, two different GOOD scores were computed. In order to compare the EU on the whole in global trade with other countries (i.e. the US or Japan), only extra-EU trade should be considered, so that the EU, just like its partners, is considered as a single entity (i.e., interstate trade is not considered for the US). However, in order to compare the average EU performance against that of the Member States, intra-European trade (or dispatches) has to be considered as well as extra-EU trade. Therefore, for global comparison, the 'EUx' score measures only extra-EU product exports, while for a European comparison, the 'EU' score was computed by including both intra- and extra-EU product exports.

Table 5 Key parameters of the GOOD component

	Numerator	Denominator
Definition	Total value of exports of a country in Standard International Trade Classification (SITC) Rev.4 classes: 266, 267, 512, 513, 525, 533, 54, 553, 554, 562, 57, 58, 591, 593, 597, 598, 629, 653, 671, 672, 679, 71, 72, 731, 733, 737, 74, 751, 752, 759, 76, 77, 78, 79, 812, 87, 88 and 891	Total value of exports
Source	EU Member States: Eurostat, Comext 'DS-018995'; EFTA countries and others: UN Comtrade	
Most recent year used [Nr. years lag vs. 2017]	2017 [0]	
Corresponding EIS indicator	4.2.1 Exports of medium and high technology products as a share of total product exports	



Source: see Table 5. *Notes:* The EU28 aggregate is represented by two values: 'EU' refers to intra- plus extra-EU trade; 'EUx' refers to Extra-EU trade only. For MS both intra- and extra-EU trade are included. Years in quotation marks indicate actual year of data

Figure 4 The share of medium- and high-tech products in total exports (in %)

Table 6 GOOD: The share of medium- and high-tech products in total exports

Time Point (Actual year)	'2011' (2011)	'2012' (2012)	'2013' (2013)	'2014' (2014)	'2015' (2015)	'2016' (2016)	'2017' (2017)
JP	73.1	74.4	72.6	72.9	73.2	74.0	73.4
HU	68.5	66.2	66.3	67.6	69.6	70.3	68.5
DE	65.4	66.0	66.2	66.5	67.6	68.2	68.3
SK	60.3	61.7	63.6	64.9	66.5	67.6	66.4
CZ	63.1	62.5	62.5	63.9	64.1	64.9	65.7
EUx	59.4	59.7	58.2	59.7	61.2	62.2	62.0
MT	49.4	51.3	55.6	62.5	57.7	68.4	61.6
IL	51.4	51.8	52.3	51.5	54.9	53.6	59.4
FR	56.2	57.1	57.2	57.4	58.6	59.2	58.5
AT	53.9	55.1	56.6	57.0	57.6	57.8	58.0
MK	38.8	41.1	45.6	52.1	56.0	57.0	57.4
SI	54.3	53.3	54.6	55.4	56.0	56.0	57.1
UK	50.5	53.8	47.9	52.9	54.8	59.0	57.0
EU28	53.5	53.5	53.1	54.3	56.2	57.1	56.7
IE	50.8	48.8	48.1	48.7	52.6	53.3	56.2
RO	50.4	50.2	50.7	50.9	52.8	54.9	55.8
CY	38.1	36.0	43.2	65.7	67.9	59.7	54.7
SE	53.6	51.3	52.4	52.2	54.7	55.1	54.5
IT	50.1	49.3	50.4	51.4	52.1	52.6	52.4
CH	62.5	45.5	41.3	49.8	49.7	48.6	51.6
NL	43.2	42.8	42.1	44.3	48.6	49.1	49.7
PL	49.5	48.2	48.7	48.9	49.4	49.6	49.0
BE	46.7	46.7	45.9	46.6	48.3	48.9	48.3
DK	42.3	42.9	43.5	46.0	47.8	48.5	48.0
US	47.5	47.7	46.9	47.3	49.2	48.9	47.2
ES	47.2	44.3	46.0	45.5	47.8	48.8	46.9
LU	49.3	51.5	49.4	48.7	52.5	50.7	45.4
FI	42.0	40.4	38.7	40.6	44.6	43.4	44.8
EE	39.6	40.9	42.8	42.2	42.7	44.0	41.6
HR	43.3	39.4	37.6	35.1	38.0	39.3	39.9
TR	37.7	34.1	36.7	36.6	36.3	37.5	39.3
PT	36.8	36.5	35.2	35.9	36.8	37.9	38.5
LT	32.4	31.9	31.1	34.7	34.5	35.3	36.9
LV	30.4	29.0	30.3	32.4	34.7	35.3	35.5
BG	25.9	25.7	26.8	29.1	31.0	32.5	33.8
BR	23.3	24.1	25.7	23.0	24.9	26.7	25.1
EL	21.5	18.7	18.2	19.5	22.7	22.5	21.2
ME	9.0	12.6	10.3	11.3	14.7	15.4	16.3
NO	11.8	11.5	12.4	13.5	16.6	17.1	14.2
IS	11.9	11.8	10.0	11.5	9.6	10.6	10.0
NZ	9.3	9.6	8.7	8.1	9.2	9.1	8.4

Source: see Table 5.

2.3.2 SERV: Knowledge-intensive services exports as percentage of total service exports

SERV is the second component of COMP and measures the share of knowledge-intensive services in total services exports. It measures the competitiveness of the knowledge-intensive services sector. The indicator reflects the ability of an economy, notably resulting from innovation, to export services with high levels of value added, and successfully take part in knowledge-intensive global value chains. As described in **Table 7**, SERV is defined as the sum of credits in EBOPS 2010 (Extended Balance of Payments Services Classification) items SC1, SC2, SC3A, SF, SG, SH, SI, SJ and SK1. The denominator is the total value of services exports (S). In comparison to the previous year's edition, the Charges for the use of intellectual property (SH) was added. The indicator is identical to the EIS indicator 4.2.2 Knowledge-intensive services exports as percentage of total services exports.

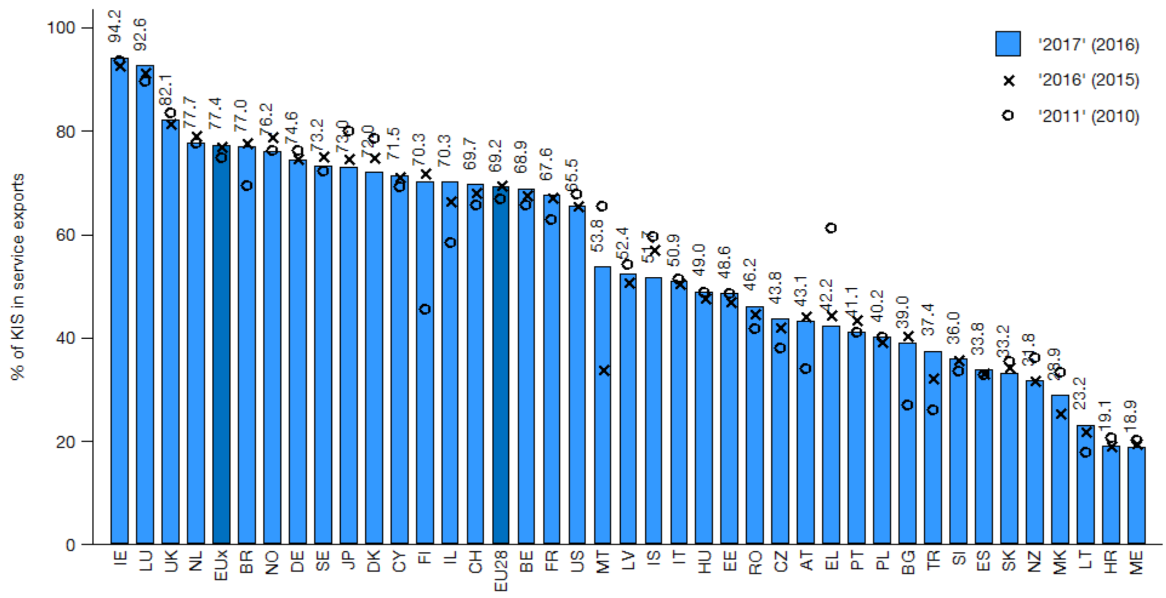
The effect of the change in the Balance of Payments (BPM) classification and due to confidentiality reasons, many EBOPS service posts are still missing in data published by Eurostat or OECD in some or all years. In a few cases, we relied on Eurostat special

tabulations. In most other cases, we referred to estimates reported by the International Trade Centre (ITC). This data originates from the IMF or is an estimate of the ITC. In cases where data were missing for a certain year, following the practice of the European Innovation Scoreboards, figures were taken from the nearest available year.

As in the case of GOOD, two different SERV scores were computed for the EU28 aggregate to accommodate both European and global comparisons. For the global comparison, only extra-EU service exports were considered, resulting in the score for 'EUx'. For a European comparison, the 'EU' weighted average score was computed by including both intra- and extra-EU service exports.

Table 7 Key parameters of the SERV component

	Numerator	Denominator
Definition	Total value of exports in EBOPS 2010 items SC1, SC2, SC3A, SF, SG, SH, SI, SJ and SK1	Total value of service exports (EBOPS 2010 item S)
Source	Eurostat, bop_its6_det series for EU Member States; OECD TISP_EBOPS2010 data for other OECD countries; ITC (based on IMF) for all others	
Most recent year used [Nr. years lag vs. 2017]	2016 [1]	
Corresponding EIS indicator	4.2.2 Knowledge-intensive services exports as percentage of total services exports	



Source: see Table 7; Notes: 'EUx' refers to Extra-EU 28 trade only, 'EU' refers to both intra- and extra-EU trade for EU28 aggregate. Years in quotation marks refer to a 1-year shift relative to actual (i.e., "2017" refers to 2016 data).

Figure 5 Knowledge-intensive services exports as percentage of total services exports (in %)

Table 8 SERV: Knowledge-intensive services exports as percentage of total services exports (in %)

Time Point (Actual year)	'2011' (2010)	'2012' (2011)	'2013' (2012)	'2014' (2013)	'2015' (2014)	'2016' (2015)	'2017' (2016)
IE	93.5	93.5	93.5	93.2	93.8	92.7	94.2
LU	89.5	89.5	88.9	89.4	89.8	91.3	92.6
UK	83.4	83.6	83.3	81.9	81.1	81.4	82.1
NL	77.7	77.7	77.7	77.7	77.7	79.1	77.7
EUx	74.9	75.7	75.5	74.8	75.8	76.9	77.4
BR	69.4	70.7	71.1	70.6	77.2	77.7	77.0
NO	76.1	71.5	78.8	78.8	79.8	78.8	76.2
DE	76.2	76.3	76.9	74.9	73.6	74.6	74.6
SE	72.3	73.7	73.8	75.4	75.1	75.2	73.2
JP	79.8	81.9	78.1	79.1	77.4	74.6	73.0
DK	78.5	78.1	79.3	78.2	78.0	74.7	72.0
CY	69.2	72.2	69.3	67.3	69.2	71.0	71.5
FI	45.4	51.2	54.0	52.8	61.8	71.9	70.3
IL	58.3	61.0	61.4	64.0	64.8	66.4	70.3
CH	65.6	65.6	66.5	65.9	66.2	68.1	69.7
EU28	66.8	67.2	67.9	67.4	68.4	69.4	69.2
BE	65.6	65.6	66.1	67.7	67.1	67.6	68.9
FR	62.9	62.9	63.7	63.8	64.7	67.0	67.6
US	67.8	68.1	67.6	67.4	67.2	65.4	65.5
MT	65.4	22.7	33.6	34.6	57.9	33.9	53.8
LV	54.1	50.4	49.7	50.1	47.2	50.7	52.4
IS	59.4	59.4	59.4	59.4	59.5	57.1	51.7
IT	51.2	51.8	52.7	51.4	51.0	50.4	50.9
HU	48.7	49.4	48.3	47.7	48.4	47.7	49.0
EE	48.6	46.1	46.1	45.3	45.3	47.0	48.6
RO	41.7	40.2	44.0	45.3	45.1	44.7	46.2
CZ	37.9	40.0	40.7	42.7	42.7	42.1	43.8
AT	33.9	36.6	45.1	44.8	44.6	44.0	43.1
EL	61.2	56.8	56.0	52.0	51.4	44.4	42.2
PT	41.0	43.3	42.8	43.6	43.8	43.5	41.1
PL	40.0	38.4	38.5	37.5	38.1	39.2	40.2
BG	26.9	30.2	32.5	31.9	37.2	40.4	39.0
TR	26.0	27.0	29.0	30.3	30.9	32.2	37.4
SI	33.4	34.8	34.1	33.7	34.7	35.7	36.0
ES	32.8	32.8	32.8	30.8	32.3	33.2	33.8
SK	35.4	35.4	35.4	35.4	35.3	34.4	33.2
NZ	36.1	36.6	37.0	36.7	34.5	31.7	31.8
MK	33.3	25.8	26.4	26.7	24.9	25.3	28.9
LT	17.8	18.0	17.7	18.8	21.0	22.0	23.2
HR	20.7	20.7	20.4	17.9	19.1	19.0	19.1
ME	20.2	19.5	20.0	19.9	19.2	19.6	18.9

Source: see Table 7.

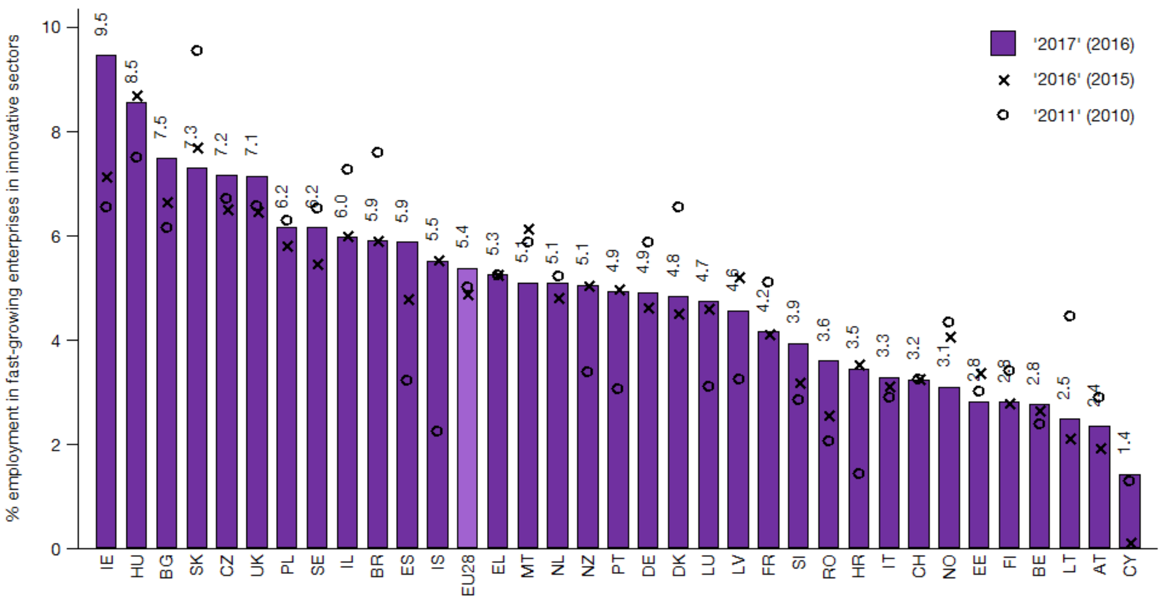
2.4 DYN: Employment share in fast-growing enterprises in innovative sectors

This indicator provides an indication of the dynamism of fast-growing firms in innovative sectors as compared to all fast-growing business activities. It captures the capacity of a country to rapidly transform its economy to respond to new needs and to take advantage of emerging demand. While DYN continues to represent a bottleneck for international comparison (information is unavailable for non-European countries that either lack comparable business demography statistics), we notice some improvement in data availability for European countries, including Greece, Iceland and Switzerland. For a detailed explanation of the establishment of the methodology to compute DYN, the identification of

the most innovative sectors, the reader is kindly referred to the IOI 2017 Methodology Report (Vertesy, 2017).

Table 9 Key parameters of the DYN component

	Numerator	Denominator
Definition	Number of employees in high growth enterprises measured in employment (growth by 10% or more) in the top 50% most innovative sectors, defined according to CIS*KIA scores	Number of employees in the population of active enterprises in t (in the Business economy except activities of holding companies, with 10 employees or more)
Source	Eurostat, bd_9pm_r2 [indic_sb: V16961, selected NACE sectors: B06, B09, C11, C12, C19, C20, C21, C26, C27, C28, C29, C30, C32, D35, E39, G46, H51, J, K, L, M, N79]	Eurostat bd_9bd_sz_cl_r2 [indic_sb: V16911; sizeclass: GE10: nace_r2: B-N_X_K642]
Notes	EU28 2012, 2013: numerator computed as sum of available countries. ME, MK, TR, JP, US data not available.	EU28: 2015, 2016 denominator computed using available countries
Most recent year used [Nr. years lag vs. 2017]	2016 [1]	
Notes on time coverage	Data not available prior to 2012, except for BR and NZ.	
Corresponding EIS indicator	4.1.2 Employment in fast-growing enterprises (percentage of total employment)	



Source: see Table 9. *Notes:* Years in quotation marks refer to a 1-year shift relative to actual (i.e., "2017" refers to 2014 data); note that figures are only available for the actual years 2012-16, thus aggregations use 2011 data for time points preceding 2010, with the exception of New Zealand and Brazil. Countries with missing data (CH, IS, ME, MK, TR, JP, US) are not shown on the graph.

Figure 6 Employment in fast-growing enterprises in the top 50% most innovative sectors as a percentage of total employment (in %)

Table 10 DYN: Employment in fast-growing enterprises in the top 50% most innovative sectors as a percentage of total employment (in %)

Time Point (Actual year)	**'2011' (2010)**	**'2012' (2011)**	**'2013' (2012)**	**'2014' (2013)**	**'2015' (2014)**	**'2016' (2015)**	**'2017' (2016)**
IE	n.a.	n.a.	n.a.	6.6	8.8	7.1	9.5
HU	n.a.	n.a.	7.5	7.7	7.6	8.7	8.5
BG	n.a.	n.a.	6.2	6.3	6.1	6.6	7.5
SK	n.a.	n.a.	9.6	9.3	7.4	7.7	7.3
CZ	n.a.	n.a.	6.7	7.3	4.9	6.5	7.2
UK	n.a.	n.a.	6.6	7.4	6.9	6.5	7.1
PL	n.a.	n.a.	6.3	5.2	5.5	5.8	6.2
SE	n.a.	n.a.	6.5	7.2	6.0	5.5	6.2
IL	n.a.	7.3	7.9	6.9	6.5	6.0	n.a.
BR	7.6	8.0	7.4	6.6	5.9	n.a.	n.a.
ES	n.a.	n.a.	3.2	3.1	3.5	4.8	5.9
IS	n.a.	2.2	3.9	3.8	3.5	5.5	5.5
EU28	n.a.	n.a.	5.0	5.3	4.6	4.9	5.4
EL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5.3
MT	n.a.	n.a.	5.9	5.8	7.3	6.1	5.1
NL	n.a.	n.a.	5.2	5.7	5.5	4.8	5.1
NZ	3.4	3.6	4.9	4.7	5.0	5.1	n.a.
PT	n.a.	n.a.	3.1	3.3	3.7	5.0	4.9
DE	n.a.	n.a.	5.9	5.7	4.5	4.6	4.9
DK	n.a.	n.a.	6.5	4.5	4.3	4.5	4.8
LU	n.a.	n.a.	3.1	3.9	4.2	4.6	4.7
LV	n.a.	n.a.	3.2	4.4	4.8	5.2	4.6
FR	n.a.	n.a.	5.1	4.9	4.3	4.1	4.2
SI	n.a.	n.a.	2.9	2.7	2.9	3.2	3.9
RO	n.a.	n.a.	2.1	2.2	2.8	2.6	3.6
HR	n.a.	n.a.	1.4	3.0	2.8	3.5	3.5
IT	n.a.	n.a.	2.9	3.2	2.6	3.1	3.3
CH	n.a.	n.a.	3.2	3.2	3.2	3.2	3.2
NO	n.a.	n.a.	4.3	5.0	4.8	4.1	3.1
EE	n.a.	n.a.	3.0	4.8	3.4	3.4	2.8
FI	n.a.	n.a.	3.4	3.4	2.8	2.8	2.8
BE	n.a.	n.a.	2.4	2.6	2.4	2.7	2.8
LT	n.a.	n.a.	4.5	4.5	4.0	2.1	2.5
AT	n.a.	n.a.	2.9	3.1	2.4	1.9	2.4
CY	n.a.	n.a.	1.3	0.6	0.8	0.1	1.4

Source: see Table 9. *Note:* a) Data for time points up to "2013" was in some cases partly available from the OECD, but not from Eurostat. Thus, for subsequent calculations for the composite indicator, we followed the practice of the European Innovation Scoreboard to replicate the closest available data for years with missing data.

3 Multi-variate analysis

3.1 The IOI2018 dataset

The multi-variate analysis and aggregation of the IOI 2018 indicators were carried out on a dataset that consisted of 240 observations (data were collected for 40 countries, including EU total, for 6 consecutive years) and 5 variables: PCT, KIABI, GOOD, SERV and DYN. As explained above, two alternative vectors were considered for GOOD and SERV, depending on whether the EU28 is compared in a global benchmark (_INT) or with European Member States (_EUR).

Data availability: We noted that in a few cases, data were missing for some of the years in the time range considered. In these cases, similarly to the established practice of the European Innovation Scoreboard, data from the nearest available year was used.

Imputation: Data for DYN was unavailable from official statistics for a range of countries, including FYR Macedonia, Montenegro and Turkey, as well as Japan and the US for any of the time points.[7] In accordance with the established IOI methodology, missing data for these countries was imputed using the Expectation-Maximization method.

Descriptive Statistics for the [non-normalized] IOI 2017 dataset are shown in the upper part of **Table 11**. (In the table, for distinction purposes, the imputed DYN series are denoted as DYN_{imp}). When compared with previous editions of the IOI, the current dataset is by far the largest, shown by the number of observations: in fact, last year's IOI 2017 dataset was expanded here by an additional year and an additional country, Montenegro (thus increased from 234 to 280 country-year observations). We note that none of the distribution shows excessive skewness or kurtosis.

Table 11 Descriptive statistics and correlation for the IOI variables (all 6 years)

	PCT	KIABI	$GOOD_{EUR}$	$GOOD_{INT}$	$SERV_{EUR}$	$SERV_{INT}$	DYN	DYN_{imp}
N. Obs.	280	280	280	280	280	280	245	280
Min	0.0	4.7	8.1	8.1	17.7	17.7	0.1	0.1
Max	12.1	33.9	74.4	74.4	94.2	94.2	9.6	9.6
Mean	3.0	14.8	45.0	45.2	54.3	54.5	4.7	4.7
Std. Dev.	3.0	5.7	16.1	16.2	20.4	20.5	1.9	1.8
Skewness	1.3	1.2	-0.6	-0.6	0.0	0.0	0.2	0.3
Kurtosis	3.7	4.7	2.8	2.8	1.9	1.9	2.6	2.8
Correlation								
PCT	1							
KIABI	0.597	1						
$GOOD_{EUR}$	0.181	(0.017)	1					
$GOOD_{INT}$	0.182	(0.015)	0.998	1				
$SERV_{EUR}$	0.429	0.498	0.098	0.104	1			
$SERV_{INT}$	0.428	0.491	(0.104)	0.114	0.998	1		
DYN	(0.042)	(0.101)	0.183	0.184	0.151	0.151	1	
$DYN_{imp.}$	(0.042)	(0.101)	0.183	0.184	0.151	0.151	1.000	1

Note: Pearson correlation coefficients in brackets are not significant at 10%.

We further observe that the Pearson **correlation** between the IOI 2017 variables (shown in the lower part of **Table 11**) is positive and significant in all cases but that of the KIABI and GOOD indicator pairs. The highest ratios are found between KIABI and PCT (0.597) and KIABI and the SERV indicators (0.498 for SERV_EUR). There is little if any association between GOOD and SERV, or between DYN and most of the indicators. Low but positive correlation between indicators implies that each of the indicators provide complementary

[7] This is due to the fact that the publication of business demographic statistics on high-growth firms is a relatively recent development in European statistics. The issue is also on the agenda of the OECD Entrepreneurship Indicators Programme, however, its data for the US is published according to a 20%, rather than 10% growth threshold. As shown by Vertesy et al (2017) using CIS data, the two thresholds not only result in very different country rankings, but capture a significantly different share of firms.

information about countries' innovation output. It is therefore important that alongside aggregate IOI scores, country performance is compared using data for the individual components.

3.2 Normalization and aggregation

In the z-score **normalization** procedure, each country-year score was transformed by subtracting the mean and dividing by the standard deviation for the pooled country-year combinations for the selected indicator. The z-scores thus obtained were re-scaled using the following formula: z*1.5+5, to obtain a roughly positive, 0-10 range for the indicators, in line with previous IOI methodology (see Vertesy and Tarantola, 2014). COMP (_EUR and _INT) scores were next obtained as the average of the normalized, respective GOOD and SERV scores. The descriptive statistics for and the correlation between the normalized IOI variables are shown in **Table 12**. The combination of GOOD and SERV into COMP[8] leads to stronger correlation coefficients with respect to PCT as well as KIABI (0.528 and 0.530, respectively), but still relatively lower with respect to DYN (0.257). As DYN remains the most "distinct" indicator in the normalized dataset from a statistical point of view, there is reason to expect that the information it contains is bound to be underrepresented unless weights (as scaling coefficients) are applied in its favor when data are aggregated into composite scores. **Figure 7** offers a visual representation of the relationship between indicator pairs for the latest time point. The matrix of scatterplots shows all possible two-way combinations of the IOI components, helping to understand how countries perform with relation to one another according to two selected dimensions. The matrix also helps understand visually the association between the components.

Table 12 Descriptive statistics and pairwise Pearson correlation for the normalized components (6 years, pooled dataset)

	PCT	**KIABI**	**$COMP_{EUR}$**	**DYN_{imp}**
N.Obs.	280	280	280	280
Min	3.5	2.3	2.1	1.2
Max	9.5	10.1	7.4	9.1
Mean	5.0	5.0	5.0	5.0
Std. Dev.	1.5	1.5	1.2	1.5
Skewness	1.3	1.2	-0.3	0.3
Kurtosis	3.7	4.7	2.5	2.8
Correlation				
PCT	1			
KIABI	0.530	1		
$COMP_{EUR}$	0.528	0.384	1	
$DYN_{imp.}$	0.090	0.133	0.257	1

[8] To avoid redundancy, we only show here statistics for COMP_EUR, as it is virtually identical to COMP_INT.

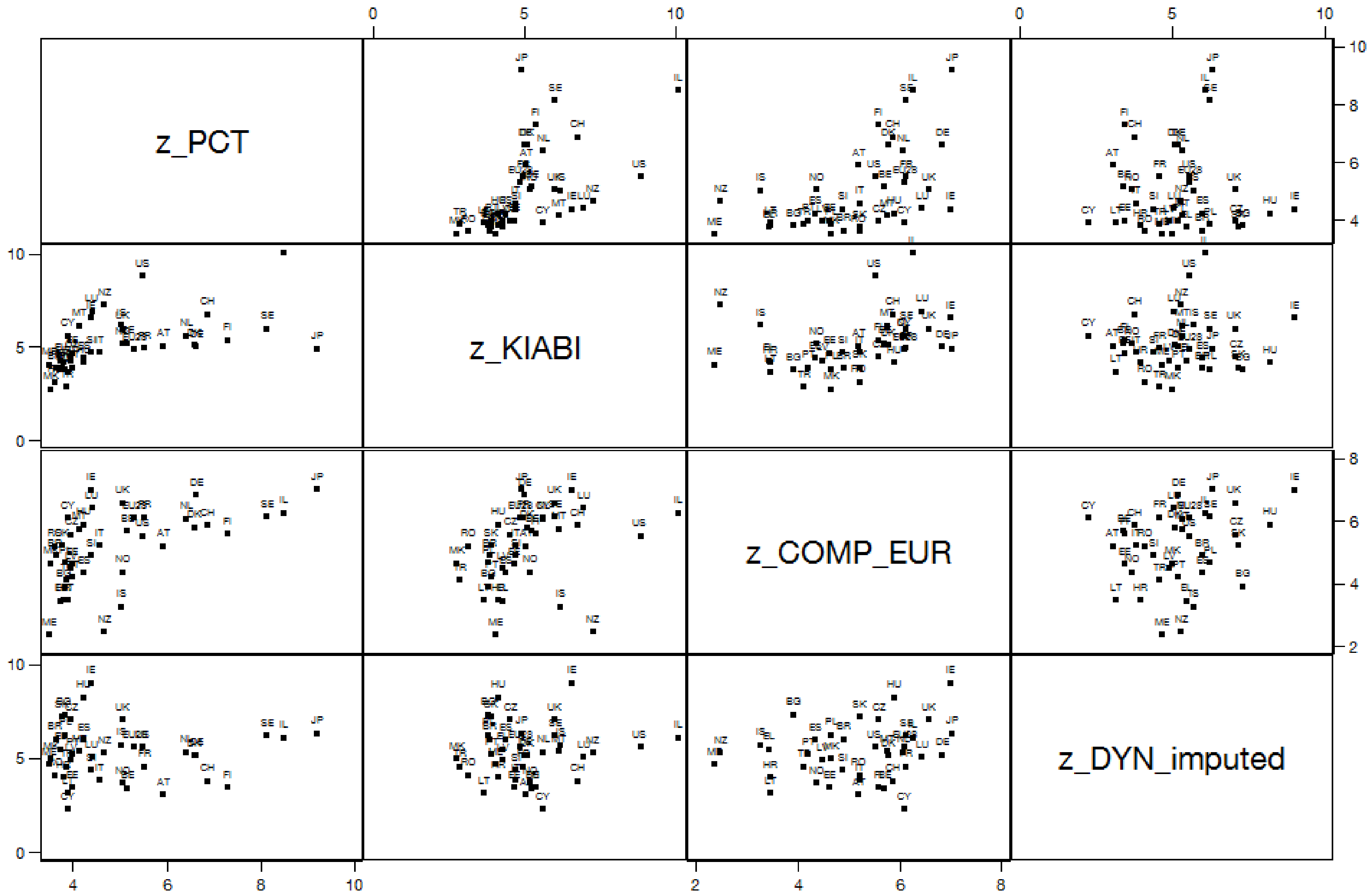


Figure 7 Scatterplot matrix for normalized IOI component scores, most recent year

Next, IOI scores are obtained by **aggregating** the z-score normalized component scores in two steps. First, a weighted average of the normalized data is computed according to the formula $I = w_1 PCT + w_2 KIABI + w_3 COMP + w_4 DYN$, where w_1, w_2, w_3, w_4 are the weights (or rather, scaling coefficients) of the component indicators (.22, .22, .20, .36), that were obtained in such a way that the IOI is statistically equally balanced in its underlying components. This procedure aims to avoid that the variables are equally important in nominal terms but that, statistically, the IOI depends more on some variables (namely, PCT, KIABI and COMP) and less on the others (namely, DYN).[9] We note that the scaling factors are defined by the correlation structure of the pooled country-year dataset. As this may change when data from additional years or countries are added, any new update will imply a re-adjustments of the weights or scaling coefficients.

In a final step, the obtained scores are re-normalized to EU2011 = 100, for ease of communication. The obtained results are reported in the next section.

The aggregation is carried out for two datasets. The first one aims at comparing EU Member States with one another as well as with selected international benchmark countries (a dataset which includes intra- plus extra-EU scores for the EU-28 (labelled 'EU'), and referred to as EU Member States' comparison). The other dataset ('EU's worldwide comparison') which aims to compare the EU aggregate with selected international benchmark countries (in which only extra-EU scores are used, for a more valid comparison[10].) Given the difference in the level of EU scores and the second normalization step which relates scores to EU2011=100, composite scores obtained from the two datasets are not directly comparable with one another.

9 Paruolo et al (2013) and Becker et al (2017) show that the relative importance of variables are variance based, hence they are ratios of quadratic forms of nominal weights, while target relative importance are often deduced as ratios of nominal weights. A correction of the 'scaling coefficients' can be made to achieve component indicators with the desired relative target importance.

10 Considering that export values for the US similarly exclude trade between the various States.

4 Country Performance in composite scores

IOI composite score results are presented in this section separately for the two aggregations described above. The first benchmark – referred to as the "European comparison" – shall be used to compare EU Member States with one another, with the EU average, with as well as with the available non-EU Member States (i.e., OECD, BRICS countries). The second benchmark is offered for the main reason to compare the scores of the EU as a single entity (EUx) with those of non EU-Member States (nevertheless, other comparisons are also possible, with the exception of EU MSs vs. the EUx). Country scores obtained from the two rankings will differ due to the fact that a) different country figures for the EU imply different distribution of the underlying dataset, which affects the normalized scores and in turn, the resulting composite scores, and finally, the EU 2011 = 100 benchmark. In the end, apart from the different EU benchmark level, the main difference is the range of composite scores, and only a slight impact on rank positions (i.e., the order of neighboring country pairs IS – CZ and LT – MK changes; this suggests that ranks should be seen as). **Table 13** aims to help readers select the appropriate source for a given comparison.

Table 13 Which source to use for different comparisons?

Which ranking to use to compare…	European comparison	International comparison
an EU Member State (MS) with another EU MS (i.e., DE vs NL)?	•	•
an EU MS with the EU [weighted] average (i.e., DE vs EU28)?	•	
an EU MS with a non-EU MS (i.e., DE vs. US)?	•	•
a non-EU MS with another non-EU Member State (i.e., US vs IL)?	•	•
a non-EU MS with the EU [weighted] average (i.e., US vs EU28)?		•

4.1 European comparison

This section reports the IOI 2017 scores obtained from the aggregation. Overall performance of countries is shown in **Figure 8** and in **Table 14** for the European comparison.

Israel is a clear leader among the countries in the sample, even if its performed has declined over the past few years. Among EU Member States, Ireland, Sweden, the UK and the Netherlands stand out as top performers.

To compare trends over time, users are advised to consider country performance for different years as observed in the different year's values reported in the **current edition**. Comparing results across different editions of the IOI would not be valid given the differences in dataset (country and year range), definition changes (i.e., DYN), all of which affect normalization, weighting and aggregation procedure, and thus, final scores and ranking of countries.[11]

Looking at the trends, we observe that the following countries have changed their performance most significantly in recent years: Ireland's position increased due to the increasing performance in DYN; Malta's performance increased due to improvements in PCT, DYN, GOOD, all offsetting a decline in SERV. At the same time, Germany's score declined due to a weaker performance in DYN, and a slight fall in PCT, while the scores for both Slovakia and the Czech Republic declined due to DYN.

[11] Nevertheless, in section 5, we make a rough attempt at simulating the impact of changing the definition of DYN to the IOI scores.

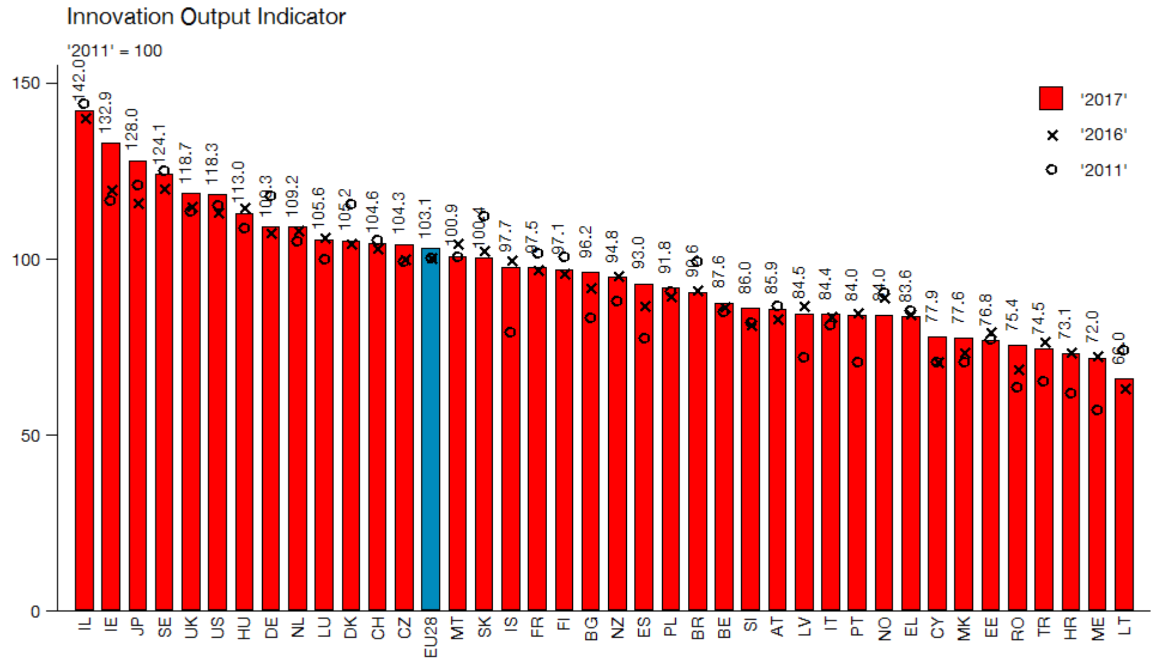


Figure 8 IOI composite scores (EUR) by country and across time

The "subway chart" in **Error! Reference source not found.** offers a representation of IOI omposite (bars) scores together with component (dots) scores for the latest time point, "2016" (where the right vertical axis shows the normalized component scores and raw composite scores, while the left vertical axis measures the re-normalized /EU2011=100/ scores). The aim of the graph is to "deconstruct" composite scores and help understand the relative strengths and weaknesses of each country. For instance, it uncovers that a relatively similar performance of Ireland and Sweden is accompanied by a diagonally different performance in PCT and DYN, whereas the two countries perform rather similarly in terms of GOOD and KIA. In other words, there is a diversity of ways to achieve good innovation output scores, and that there is no country that ranks best (or worst) in all dimensions.

It is especially **important to look at performance by components one by one** as weaker association between DYN and the rest of the indicators implies a potential loss of information on country variation in the aggregation. Such an analysis is offered in section 4.2. It is also important to keep in mind that in some cases, it is difficult to distinguish country rankings with a high certainty given the viability of alternative modelling choices in the development of the composite indicator. Readers are therefore advised to consider the range of possible alternative country ranks as shown in section 5.1.

Table 14 Innovation Output Indicator scores by country: European countries' comparison

Country	2011	2012	2013	2014	2015	2016	2017
IL	143.9	144.2	148.5	144.5	143.4	140.2	142.0
IE	116.3	117.4	116.5	117.2	130.2	119.5	132.9
JP	120.7	125.7	127.3	122.1	122.7	115.9	128.0
SE	125.1	124.4	126.0	129.8	123.5	119.9	124.1
UK	113.5	114.4	113.3	119.4	117.1	114.8	118.7
US	115.1	123.5	118.3	113.8	119.7	113.3	118.3
HU	108.6	107.9	107.8	108.5	108.0	114.6	113.0
DE	117.8	117.1	115.7	114.1	106.8	107.4	109.3
NL	104.9	107.0	108.6	111.9	111.7	108.0	109.2
LU	99.9	101.0	101.4	106.7	104.8	106.0	105.6
DK	115.4	116.3	115.0	104.2	103.1	104.3	105.2
CH	105.1	103.0	102.5	103.3	102.5	103.1	104.6
CZ	99.3	100.3	100.9	104.6	90.9	100.1	104.3
EU28	100.0	100.2	100.1	102.0	98.8	100.1	103.1
MT	100.4	94.3	98.5	100.3	112.7	104.4	100.9
SK	112.0	112.0	111.6	111.1	99.8	102.3	100.4
IS	79.2	79.1	88.0	88.8	86.9	99.7	97.7
FR	101.6	102.0	101.7	100.4	97.7	96.8	97.5
FI	100.4	99.9	101.3	100.0	97.1	96.0	97.1
BG	83.1	84.0	85.2	86.3	87.8	91.7	96.2
NZ	88.1	89.3	96.6	95.0	96.6	95.1	94.8
ES	77.4	77.3	77.6	76.5	79.6	86.8	93.0
PL	90.8	90.9	91.1	85.4	87.5	89.5	91.8
BR	99.2	101.8	98.9	93.6	90.6	91.0	90.6
BE	84.7	85.0	84.4	86.3	85.4	86.3	87.6
SI	81.7	81.9	81.6	82.1	83.0	81.4	86.0
AT	86.7	87.3	88.4	90.0	86.0	82.9	85.9
LV	72.0	73.4	74.5	81.7	82.9	86.7	84.5
IT	81.2	81.0	81.6	83.4	80.7	83.6	84.4
PT	70.7	71.1	71.2	74.1	76.8	84.7	84.0
NO	90.2	89.5	91.0	95.9	94.1	89.2	84.0
EL	85.3	85.4	85.6	84.9	85.2	84.3	83.6
CY	70.7	73.2	74.1	74.3	75.3	70.7	77.9
MK	70.8	71.9	66.0	74.2	73.7	73.4	77.6
EE	77.2	76.1	75.4	85.9	79.5	79.1	76.8
RO	63.6	63.5	64.2	65.7	69.5	68.6	75.4
TR	65.2	71.7	71.4	72.6	72.1	76.6	74.5
HR	61.7	60.7	60.5	68.6	68.6	73.6	73.1
ME	57.2	66.8	66.1	71.8	73.6	72.3	72.0
LT	73.9	74.0	74.6	75.1	73.5	63.4	66.0

Source: author's calculations. *Note:* countries ranked according to 2017 scores; EU 2011 = 100

4.2 International comparison

The EU28 can be benchmarked against non-European countries with the use of a slightly modified index, which – as explained earlier – uses GOOD and SERV figures that characterize the external trade of the EU as a block.

It is important to keep in mind that performance scores for non-European countries should be read with caution. Differences in industrial classification and coverage may imply that KIABI scores are not fully comparable. As for DYN, in some cases, scores may lack comparability due to differences in the industrial breakdown (as in the case of Israel, New Zealand and Brazil), in other cases, due to imputations (namely, US, Japan, but also Greece, Iceland, FYRO Macedonia and Turkey).[12]

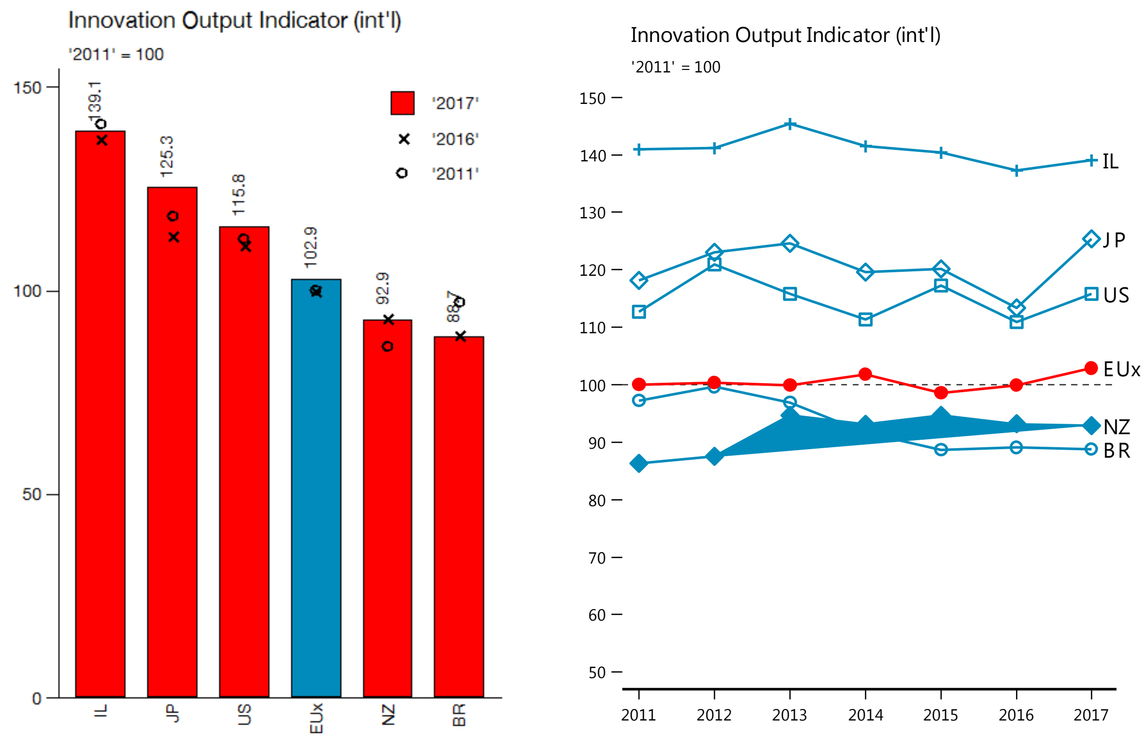


Figure 9 The innovation Output Indicator 2018: EU28 in a global comparison and trends over time

The global benchmark scores of the latest time point and trends over time are presented above in two figures, followed by a table of scores. **Figure 9** aims to offer an instantaneous comparison of current and past EU [EUx in the charts] performance with the United States and Japan, as well as selected countries from different continents for which sufficient data were available: Israel, New Zealand and Brazil. Actual composite scores are reported in **Table 15**. Country performance in the component indicators are provide further below which help understand the source of differences in IOI performance.

Both the US and the EU are trailing Israel and Japan in terms of the composite measure of innovation output, and despite a short drop between the 2015 and 2016 time points, on the long run, the US retains a lead over the EU28. Interesting to note that the US performance in its four dimensions (PCT, KIABI, GOOD and SERV) show very little variance, making its score rather robust, while the EU28's scores are more widespread: the EU leads in GOOD and SERV, but is outperformed by the US in the other dimensions.

[12] See data source tables in Section 2 for eventual specific details and notes on data for non-EU MSs.

Table 15 Innovation Output Indicator scores by country: International Comparison

Country	2011	2012	2013	2014	2015	2016	2017
IL	140.9	141.2	145.4	141.5	140.4	137.2	139.1
IE	113.9	114.9	114.0	114.7	127.5	117.0	130.1
JP	118.2	123.1	124.6	119.6	120.2	113.4	125.3
SE	122.5	121.8	123.4	127.1	120.9	117.4	121.5
UK	111.1	112.0	110.9	116.9	114.6	112.4	116.2
US	112.7	120.9	115.8	111.4	117.2	110.9	115.8
HU	106.3	105.6	105.6	106.3	105.8	112.2	110.7
DE	115.3	114.6	113.2	111.7	104.6	105.1	106.9
NL	102.7	104.8	106.3	109.5	109.3	105.8	106.9
LU	97.7	98.9	99.2	104.4	102.6	103.8	103.3
DK	113.0	113.9	112.6	102.0	100.9	102.1	103.0
EUx	100.0	100.3	99.9	101.8	98.6	99.9	102.9
CH	102.9	100.8	100.4	101.1	100.3	100.9	102.4
CZ	97.2	98.2	98.8	102.5	89.0	98.0	102.1
MT	98.3	92.3	96.5	98.2	110.4	102.2	98.8
SK	109.7	109.7	109.3	108.8	97.7	100.2	98.3
IS	77.6	77.5	86.2	87.0	85.2	97.6	95.7
FR	99.5	99.8	99.5	98.3	95.6	94.8	95.4
FI	98.3	97.8	99.2	97.9	95.1	94.0	95.0
BG	81.4	82.3	83.5	84.6	86.0	89.8	94.3
NZ	86.3	87.5	94.7	93.1	94.7	93.2	92.9
ES	75.8	75.7	76.0	75.0	78.0	85.0	91.1
PL	89.0	89.0	89.2	83.6	85.7	87.6	89.9
BR	97.2	99.7	96.9	91.6	88.7	89.1	88.7
BE	83.0	83.2	82.6	84.5	83.6	84.5	85.7
SI	80.0	80.2	79.9	80.4	81.3	79.7	84.2
AT	84.9	85.5	86.5	88.2	84.2	81.2	84.1
LV	70.5	71.9	72.9	80.0	81.2	84.9	82.7
IT	79.5	79.3	79.9	81.7	79.0	81.9	82.6
PT	69.3	69.6	69.7	72.5	75.3	83.0	82.3
NO	88.3	87.6	89.1	93.9	92.2	87.4	82.2
EL	83.5	83.6	83.8	83.2	83.5	82.5	81.9
CY	69.2	71.6	72.5	72.7	73.7	69.2	76.3
MK	69.3	70.5	64.7	72.7	72.2	71.8	76.0
EE	75.6	74.5	73.8	84.1	77.8	77.5	75.2
RO	62.3	62.2	62.9	64.3	68.0	67.2	73.9
TR	63.9	70.2	69.9	71.1	70.7	75.0	73.0
HR	60.4	59.5	59.3	67.2	67.2	72.1	71.6
ME	56.0	65.4	64.8	70.4	72.1	70.9	70.6
LT	72.4	72.5	73.1	73.6	72.1	62.1	64.7

Source: author's calculations. *Note:* countries ranked according to 2017 scores; EUx 2011 = 100

4.3 Analysis by components

The IOI scores serve as an entry point to examine the performance and trends at the level of indicators. In the following, we provide an overview table of the component-by-component performance of the 40 countries in our sample, assessing the latest results and ranks, as well as the change over the 2011 to 2017 period, between the first and last available data points. In addition, we highlight the strengths and weaknesses of each country in each of the five components, measured in terms of their performance relative to others. Whether a country ranks among the top or bottom 20% of the 40 countries in terms of an indicator not only helps better understand a given its IOI rank, but also strengths and weaknesses of the innovation output that policies may leverage on.

Table 16 Country performance in the IOI components and change over time

group	geo	indicator	IOI	PCT	KIABI	GOOD	SERV	DYN
EU28	EU28	Value '2017'	**103.1**	3.6	14.2	56.7	69.2	5.4
		Rank	**14**	12	21	13	15	13
		% Change '2017'/'2011'	↑ ***3.1***	↓ *-6.3*	↑ *3.6*	↑ *5.9*	↑ *3.6*	↑ *7.5*
	EUx	Value '2017'	**102.9**	3.6	14.2	62.0 ●	77.4 ●	5.4
		Rank	**12**	12	21	6	5	13
		% Change '2017'/'2011'	↑ ***2.9***	↓ *-6.3*	↑ *3.6*	↑ *4.3*	↑ *3.3*	↑ *7.5*
	AT	Value '2017'	**85.9**	4.8	15.0	58.0	43.1	2.4 ○
		Rank	**27**	9	17	9	27	34
		% Change '2017'/'2011'	↓ ***-0.9***	↓ *-7.8*	↑ *7.1*	↑ *7.7*	↑ *27.3*	↓ *-18.7*
	BE	Value '2017'	**87.6**	3.3	15.6	48.3	68.9	2.8 ○
		Rank	**25**	13	14	22	16	32
		% Change '2017'/'2011'	↑ ***3.4***	↓ *-12.3*	↑ *5.4*	↑ *3.3*	↑ *5.1*	↑ *16.2*
	BG	Value '2017'	**96.2**	0.6 ○	10.2 ○	33.8 ○	39.0	7.5 ●
		Rank	**20**	33	36	34	31	3
		% Change '2017'/'2011'	↑ ***15.8***	↑ *84.5*	↑ *20.0*	↑ *30.2*	↑ *45.1*	↑ *21.6*
	CY	Value '2017'	**77.9**	0.8	17.0	54.7	71.5	1.4 ○
		Rank	**33**	29	12	16	11	35
		% Change '2017'/'2011'	↑ ***10.3***	↑ *186.4*	↑ *12.6*	↑ *43.6*	↑ *3.2*	↑ *11.3*
	CZ	Value '2017'	**104.3**	0.9	12.9	65.7 ●	43.8	7.2 ●
		Rank	**13**	27	25	5	26	5
		% Change '2017'/'2011'	↑ ***5.0***	↑ *37.2*	↑ *4.9*	↑ *4.1*	↑ *15.5*	↑ *6.5*
	DE	Value '2017'	**109.3**	6.2 ●	14.8	68.3 ●	74.6 ●	4.9
		Rank	**8**	6	18	3	7	19
		% Change '2017'/'2011'	↓ ***-7.3***	↓ *-17.2*	↓ *-3.9*	↑ *4.4*	↓ *-2.2*	↓ *-16.5*
	DK	Value '2017'	**105.2**	6.2 ●	15.1	48.0	72.0	4.8
		Rank	**11**	7	16	23	10	20
		% Change '2017'/'2011'	↓ ***-8.9***	↓ *-0.8*	↓ *-3.2*	↑ *13.5*	↓ *-8.2*	↓ *-26.1*
	EE	Value '2017'	**76.8**	1.0	13.5	41.6	48.6	2.8 ○
		Rank	**35**	26	24	28	24	30
		% Change '2017'/'2011'	↓ ***-0.6***	↓ *-57.4*	↑ *25.0*	↑ *5.0*	↓ *-0.1*	↓ *-6.2*
	EL	Value '2017'	**83.6**	0.5 ○	12.1	21.2 ○	42.2	5.3
		Rank	**32**	36	27.5	36	28	14
		% Change '2017'/'2011'	↓ ***-2.0***	↑ *31.4*	↑ *6.1*	↓ *-1.4*	↓ *-31.0*	⇨ *0.0*
	ES	Value '2017'	**93.0**	1.5	12.5	46.9	33.8 ○	5.9
		Rank	**22**	22	26	25	34	11
		% Change '2017'/'2011'	↑ ***20.1***	↓ *-11.4*	↑ *5.9*	↓ *-0.6*	↑ *3.0*	↑ *82.4*
	FI	Value '2017'	**97.1**	7.6 ●	16.2	44.8	70.3	2.8 ○
		Rank	**19**	4	13	27	12	31
		% Change '2017'/'2011'	↓ ***-3.3***	↓ *-22.9*	↑ *4.5*	↑ *6.8*	↑ *54.8*	↓ *-17.2*
	FR	Value '2017'	**97.5**	4.0	14.5	58.5	67.6	4.2
		Rank	**18**	10	19	8	17	23
		% Change '2017'/'2011'	↓ ***-4.0***	↑ *0.3*	↑ *0.7*	↑ *4.1*	↑ *7.4*	↓ *-18.3*
	HR	Value '2017'	**73.1**	0.6 ○	11.6	39.9	19.1 ○	3.5
		Rank	**38**	34	29.5	29	39	26
		% Change '2017'/'2011'	↑ ***18.5***	↓ *-17.6*	↑ *9.4*	↓ *-8.0*	↓ *-7.9*	↑ *139.0*
	HU	Value '2017'	**113.0**	1.5	11.6	68.5 ●	49.0	8.5 ●
		Rank	**7**	23	29.5	2	23	2
		% Change '2017'/'2011'	↑ ***4.1***	↓ *-1.8*	↓ *-10.8*	↑ *0.0*	↑ *0.5*	↑ *14.1*
	IE	Value '2017'	**132.9**	1.8	20.6 ●	56.2	94.2 ●	9.5 ●
		Rank	**2**	20	6	14	1	1
		% Change '2017'/'2011'	↑ ***14.3***	↓ *-20.4*	⇨ *0.0*	↑ *10.5*	↑ *0.8*	↑ *44.3*
	IT	Value '2017'	**84.4**	2.2	13.7	52.4	50.9	3.3
		Rank	**29**	18	22.5	18	22	27
		% Change '2017'/'2011'	↑ ***3.9***	↑ *9.3*	↑ *1.5*	↑ *4.5*	↓ *-0.7*	↑ *13.5*
	LT	Value '2017'	**66.0**	0.8	9.7 ○	36.9 ○	23.2 ○	2.5 ○
		Rank	**40**	30	37	32	38	33
		% Change '2017'/'2011'	↓ ***-10.7***	↑ *93.7*	↑ *9.0*	↑ *13.9*	↑ *29.8*	↓ *-44.1*
	LU	Value '2017'	**105.6**	1.8	22.0 ●	45.4	92.6 ●	4.7
		Rank	**10**	19	4	26	2	21
		% Change '2017'/'2011'	↑ ***5.7***	↑ *7.1*	↓ *-12.7*	↓ *-7.9*	↑ *3.5*	↑ *52.2*
	LV	Value '2017'	**84.5**	0.9	12.1	35.5 ○	52.4	4.6
		Rank	**28**	28	27.5	33	20	22
		% Change '2017'/'2011'	↑ ***17.3***	↑ *92.7*	↑ *34.4*	↑ *16.6*	↓ *-3.1*	↑ *40.5*
	MT	Value '2017'	**100.9**	1.3	19.1 ●	61.6 ●	53.8	5.1
		Rank	**15**	24	8	6	19	15
		% Change '2017'/'2011'	↑ ***0.5***	↑ *77.4*	↑ *17.9*	↑ *24.8*	↓ *-17.7*	↓ *-13.2*
	NL	Value '2017'	**109.2**	5.8 ●	17.1	49.7	77.7 ●	5.1
		Rank	**9**	8	11	20	4	16
		% Change '2017'/'2011'	↑ ***4.1***	↑ *13.5*	↑ *14.8*	↑ *15.0*	↓ *0.0*	↓ *-2.4*
	PL	Value '2017'	**91.8**	0.7	10.3 ○	49.0	40.2	6.2 ●
		Rank	**23**	32	35	21	30	7
		% Change '2017'/'2011'	↑ ***1.1***	↑ *52.4*	↑ *12.0*	↓ *-1.1*	↑ *0.4*	↓ *-1.8*
	PT	Value '2017'	**84.0**	1.0	10.6 ○	38.5	41.1	4.9
		Rank	**30**	25	32.5	31	29	18
		% Change '2017'/'2011'	↑ ***18.7***	↑ *58.1*	↑ *16.5*	↑ *4.7*	↑ *0.2*	↑ *60.4*
	RO	Value '2017'	**75.4**	0.2 ○	7.7 ○	55.8	46.2	3.6
		Rank	**36**	38	38	15	25	25
		% Change '2017'/'2011'	↑ ***18.5***	↑ *39.7*	↑ *18.5*	↑ *10.7*	↑ *10.6*	↑ *75.2*
	SE	Value '2017'	**124.1**	9.3 ●	18.5	54.5	73.2	6.2
		Rank	**4**	3	9.5	17	8	8
		% Change '2017'/'2011'	↓ ***-0.7***	↓ *-2.5*	↑ *7.6*	↑ *1.6*	↑ *1.2*	↓ *-5.8*
	SI	Value '2017'	**86.0**	1.8	13.7	57.1	36.0 ○	3.9
		Rank	**26**	21	22.5	11	33	24
		% Change '2017'/'2011'	↑ ***5.3***	↓ *-43.2*	⇨ *0.0*	↑ *5.0*	↑ *7.7*	↑ *38.4*
	SK	Value '2017'	**100.4**	0.5 ○	10.6 ○	66.4 ●	33.2 ○	7.3 ●
		Rank	**16**	35	32.5	4	35	4
		% Change '2017'/'2011'	↓ ***-10.4***	↑ *13.6*	↑ *1.9*	↑ *10.2*	↓ *-6.0*	↓ *-23.5*
	UK	Value '2017'	**118.7**	3.1	18.5	57.0	82.1 ●	7.1 ●
		Rank	**5**	15	9.5	12	3	6
		% Change '2017'/'2011'	↑ ***4.6***	↓ *-6.1*	↑ *7.6*	↑ *13.0*	↓ *-1.6*	↑ *8.6*

Table 16 (cont'd)

group	geo	indicator	IOI	PCT	KIABI	GOOD	SERV	DYN
EFTA	CH	Value '2017'	**104.6**	6.8 ●	21.4 ●	51.6	69.7	3.2
		Rank	**12**	5	5	19	14	28
		% Change '2017'/'2011'	↓ ***-0.5***	↓ *-8.7*	↑ *10.3*	↓ *-17.5*	↑ *6.2*	⇒ *0.0*
	IS	Value '2017'	**97.7**	3.1	19.3 ●	10.0 ○	51.7	5.5
		Rank	**17**	16	7	39	21	12
		% Change '2017'/'2011'	↑ ***23.4***	↑ *7.0*	↑ *4.3*	↓ *-16.0*	↓ *-12.9*	↑ *146.5*
	NO	Value '2017'	**84.0**	3.1	15.4	14.2 ○	76.2 ●	3.1 ○
		Rank	**31**	14	15	38	6	29
		% Change '2017'/'2011'	↓ ***-6.9***	↓ *-7.9*	↑ *5.5*	↑ *21.0*	↑ *0.1*	↓ *-28.4*
OECD	IL	Value '2017'	**142.0**	10.0 ●	33.9 ●	59.4 ●	70.3	6.0
		Rank	**1**	2	1	7	13	9
		% Change '2017'/'2011'	↓ ***-1.3***	↓ *-0.3*	↑ *6.8*	↑ *15.6*	↑ *20.4*	↓ *-17.6*
	JP	Value '2017'	**128.0**	11.4 ●	14.4	73.4 ●	73.0	
		Rank	**3**	1	20	1	9	
		% Change '2017'/'2011'	↑ ***6.0***	↑ *5.0*	↑ *19.0*	↑ *0.4*	↓ *-8.5*	
	NZ	Value '2017'	**94.8**	2.3	23.3 ●	8.4 ○	31.8 ○	5.1
		Rank	**21**	17	3	40	36	17
		% Change '2017'/'2011'	↑ ***7.7***	↓ *-28.9*	↓ *-0.1*	↓ *-9.7*	↓ *-11.9*	↑ *49.2*
	US	Value '2017'	**118.3**	4.0	29.1 ●	47.2	65.5	
		Rank	**6**	11	2	24	18	
		% Change '2017'/'2011'	↑ ***2.8***	↑ *1.7*	↑ *1.0*	↓ *-0.6*	↓ *-3.4*	
Candidates	ME	Value '2017'	**72.0**	0.0 ○	11.2	16.3 ○	18.9 ○	
		Rank	**39**	40	31	37	40	
		% Change '2017'/'2011'	↑ ***26.0***	↓ *-100.0*	↑ *6.7*	↑ *81.0*	↓ *-6.4*	
	MK	Value '2017'	**77.6**	0.1 ○	6.3 ○	57.4	28.9 ○	
		Rank	**34**	39	40	10	37	
		% Change '2017'/'2011'	↑ ***9.7***		↓ *-12.5*	↑ *48.0*	↓ *-13.2*	
	TR	Value '2017'	**74.5**	0.7	6.7 ○	39.3	37.4 ○	
		Rank	**37**	31	39	30	32	
		% Change '2017'/'2011'	↑ ***14.3***	↑ *27.5*	↑ *42.6*	↑ *4.2*	↑ *43.9*	
BRICS	BR	Value '2017'	**90.6**	0.3 ○	10.5 ○	25.1 ○	77.0 ●	5.9
		Rank	**24**	37	34	35	5	10
		% Change '2017'/'2011'	↓ ***-8.7***	↓ *-1.8*	↓ *-3.7*	↑ *7.7*	↑ *10.9*	↓ *-22.2*

Note: ● (or ○) indicates that the country is among the top (or bottom) 20% performers for a given indicator

5 Conclusion: robustness of ranks and validation of results

5.1 Robustness and sensitivity analysis

5.1.1 Robustness of country ranks to changing modelling assumptions

An important modelling choice in the development of the IOI was selecting weights as scaling coefficients so as to ensure that each component has an equal contribution to the variance of the final scores. Choices with regards to weights is one among a set of modelling choices that are made amidst uncertainty which, in theory, influences the robustness of actual country rank outcomes. We performed a robustness analysis to quantify the impact of the uncertainty in a) selecting the weights and b) selecting a fully compensatory vs. a non-fully-compensatory aggregation method on country rankings. By running 500 Monte-Carlo simulations in which the scaling coefficients of each component were perturbed by +/-35% with respect to those used to obtain effective equal contribution, and in which the geometric average was considered as an alternative to the fully compensatory arithmetic average, we obtained a distribution of possible country rankings with which we could contrast the baseline IOI rankings (see **Figure 10**).[13] Based on the outcomes of the uncertainty analysis, we can conclude the following. First, that the median rank obtained from the simulations is identical to the baseline ranking for 26 of the 40 countries, and deviates only 1 position for the rest of the countries. The IOI [baseline] ranks falls in all cases within the interquartile range (IQR) of possible ranks. In other words, this means that even if weights were adjusted by as much as 35% in favor of a given country, it is unlikely that it would significantly improve its rank position.

Second, while the results show a rather robust picture for the IOI, one should (as in the case of other aggregate indicators) not take ranks at face value, given that many neighboring country pairs show considerable overlap in their possible ranks (i.e., it is difficult to distinguish with certainty the performance of IE and JP, or HU, DE and NL, or the LU, DK, CH and CZ "cluster" of countries.) Countries showing the highest variation of their simulated ranks include FI, AT, CY, EL and SK (with 90% of simulated ranks ranging 8 or more positions), while the ranks of IL, IE, SE, UK and LT appear rather solid. Thirdly, we also plotted a hypothetical rank obtained by applying uniform weights (0.25) for all coefficients (thus, in effect, reducing the contribution of the DYN component). This results suggest that country most positively affected by such a choice are CH, FI and AT, while countries most negatively affected are HU, CZ and BG.

[13] We discuss ranks obtained from European comparison as the results obtained from the international comparison are highly similar.

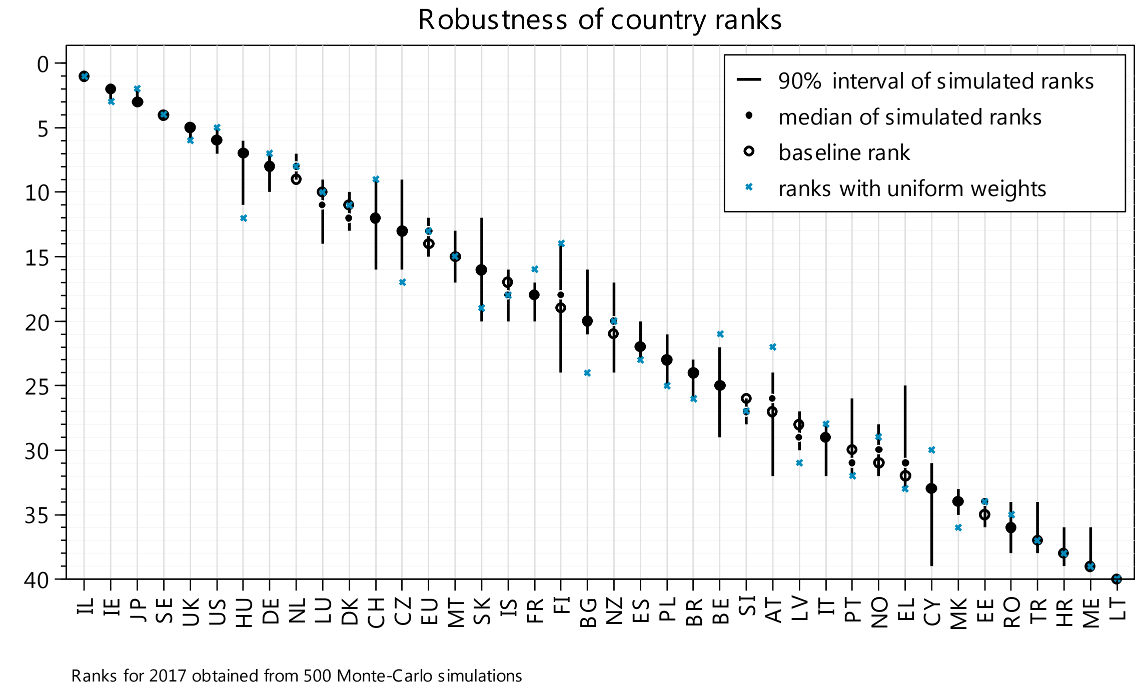


Figure 10 Robustness of IOI country ranks due to uncertainty in weights, "2017" Eur. comparison

Note: Baseline IOI ranks are shown by hollow circle. Box plots shows the distribution of simulated IOI country ranks at the latest time point, obtained from 500 Monte-Carlo simulations in which the scaling coefficients were perturbed by +/-35% with respect to those used for effective equal contribution of components, and alternative averages (the non-fully compensatory geometric vs arithmetic) were applied. Vertical lines show the distribution of 90% of the simulated ranks. Black dot shows the median rank across all the simulations. Blue cross shows hypothetical ranks obtained when using uniform weight (0.25) for all components.

5.1.2 Sensitivity of results to changes in components

In a "confirmatory" analysis, we computed sensitivity indices to reveal the contribution of each component to the total variance in IOI composite scores. This is a validation exercise, since by construction, the weights or scaling coefficients for each components were calibrated to achieve equal contribution. Nevertheless, we follow two methods: considering as Si sensitivity indices for each component using R^2 from Pearson correlation coefficients as well as a polynomial spline-fitting technique in order to also accommodate non-linearity. The results confirm that the S_i sensitivity indices r^2 scores are between 0.46-0.48 in the linear method, and 0.47-0.50 in the non-linear one, thus suggesting that (a) all components have an equal contribution, and (b) that the composite scores provide additional information about the latent phenomenon of innovation output compared with the individual components.

Table 17 Sensitivity indices for IOI components

Component	S_i Corr r^2	S_i Spline r^2
PCT	0.48	0.48
KIABI	0.46	0.47
COMP	0.47	0.50
DYN	0.47	0.47

5.2 Validation of results

IOI scores for '2017' reported in this editions are benchmarked against IOI scores obtained from the most recent edition of the IOI (IOI2017) as well as the Summary Innovation Index 2017, in order to validate results and better understand the impact of methodological changes on country scores.

There is no reason to expect IOI 2018 scores to be fully aligned with IOI 2017 scores, given the data updates affecting all components in a retroactive manner. As shown by **Figure 11**, there is a strong, positive correlation between IOI 2017's latest time point ("2016") and IOI 2018 scores, both considering the latest time point of IOI 2018 ("2016", left panel) and the time point corresponding to the latest time point of the IOI 2016, "2014" (right panel). Countries that score higher according to IOI 2017 than according to IOI 2016 are in the top left part of the scatterplots – such as Malta, Hungary, Slovakia, Bulgaria, the US or Brazil. The country that is most negatively affected by the methodology change is Cyprus, which ranked very high in terms of the previous DYN definition due to a small number of high growth firms. Other countries more moderately affected include Austria, Belgium, Finland and Romania. In the case of the former three, DYN proves to be a clear weakness in their profile, relative to the other components.

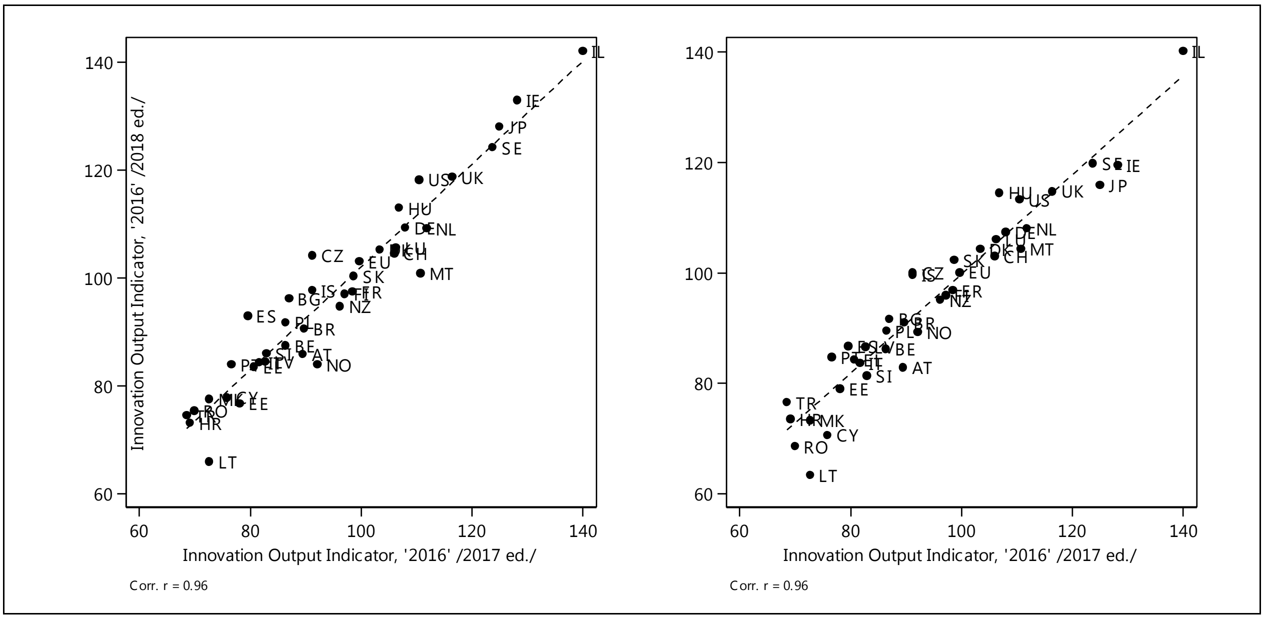


Figure 11 Comparison of IOI scores between the 2018 and 2017 editions. Left panel shows '2017' time point, right panel shows '2016' time point from the 2018 edition.

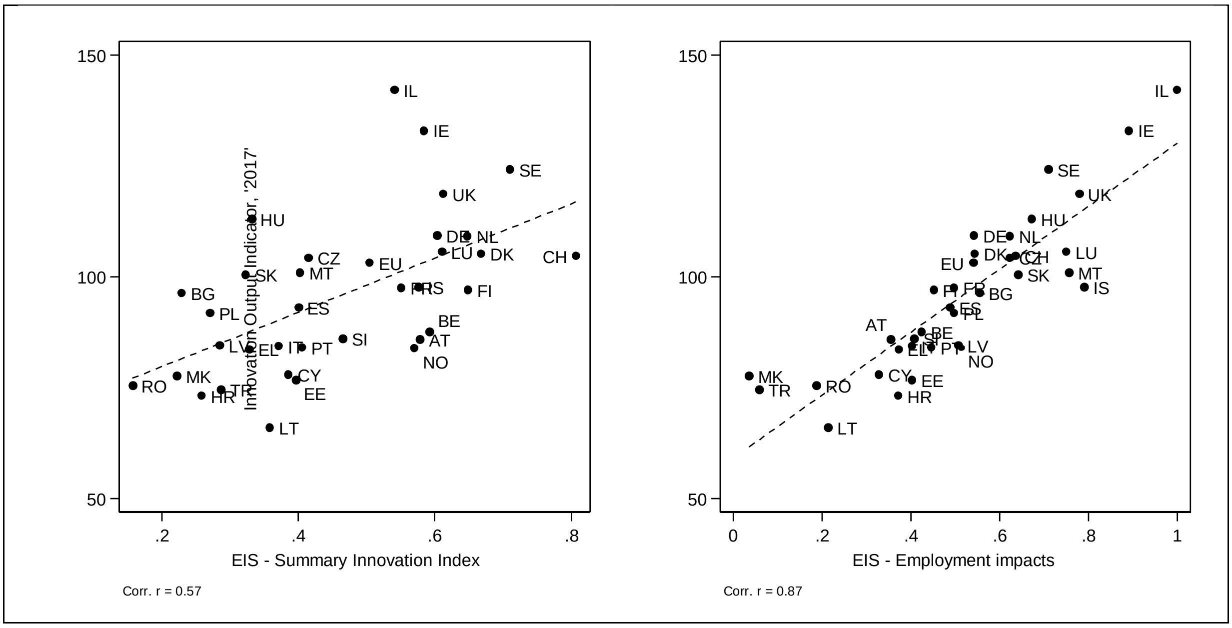


Figure 12 Comparison of country scores according to IOI, and the Summary Innovation Index as well as the EIS's Impacts: Employment (4.1) pillar

It is also interesting to compare the IOI with Summary Innovation Index, and other indices of the European Innovation Scoreboard (EIS) to understand similarities and differences across the two rankings. We observe that the IOI and overall SII offer a rather different picture of innovation performance of countries (left panel of **Figure 12**). While the two indices are positively correlated (Pearson r=0.57), we see that some countries, such as Belgium, the UK and the Netherlands and Israel, which have very similar scores according to the SII, are set widely apart by their IOI scores. The observed differences are not surprising, as the SII is an unweighted average of 27 variables, whereas the IOI is a weighted average of only 4 components (and five variables). It is therefore more informative to consider for comparison an aggregate of a smaller set of EIS indicators, which are more associated with impacts and outputs. The right panel of **Figure 12** therefore focuses on the Employment impacts dimension of the EIS (with which the IOI shows a Pearson correlation r=0.89), and accordingly, we see that the two scores are much more aligned – with the exception of Iceland.

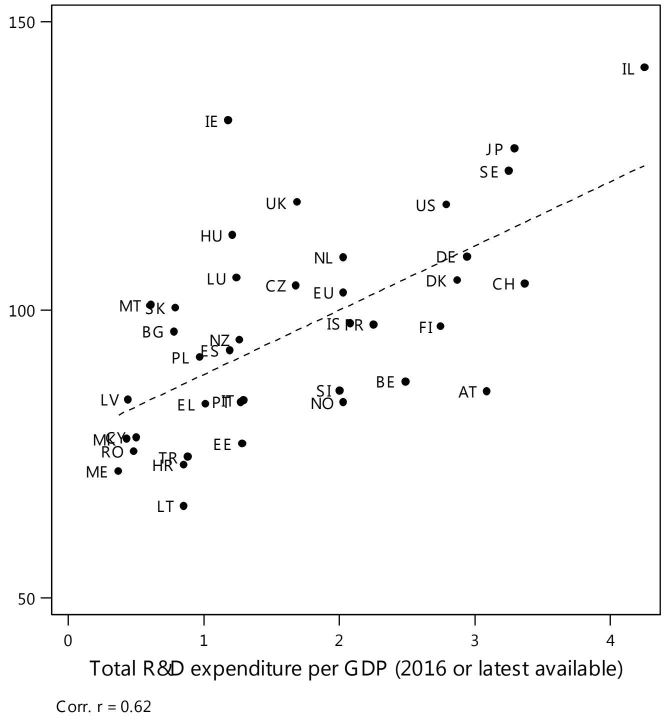


Figure 13 The relationship between Innovation Output and R&D expenditure

Countries' innovation output measured by the IOI scores correlates positively with their R&D intensity (gross R&D expenditure per GDP), as illustrated by **Figure 13**. Israel, which reports the highest R&D intensity is also the leader in innovation output. It is noteworthy that the innovation output score of a set of countries with an R&D intensity of about 2-2.2% may have very different output scores: see i.e. the scores of Slovenia, France or the Netherlands – and conversely, Finland, France and Slovakia achieve highly similar innovation output scores with very different R&D spending per GDP.

These findings reflect the fact that the IOI is relatively more sensitive to non-R&D, but entrepreneurship and trade-based measures (such as DYN and COMP, the latter driven also by SERV) in comparison with, for instance the Summary Innovation Index[14].

The relatively more modest association R&D and non-R&D (i.e., entrepreneurship-) based measures of innovation also points to a discussion – which exceeds the scope of this report – about how the design of innovation policies can best address this diversity to create the foundations for growth.

[14] The Pearson correlation between R&D and the SII is r=0.81, while it is r=0.65 in the case of the IOI.

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List of country abbreviations

Code	Country
AT	Austria
BE	Belgium
BG	Bulgaria
BR	Brazil
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
EL	Greece
ES	Spain
EU	EU28
EUx	Extra-EU28
FI	Finland
FR	France
HR	Croatia
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
TR	Turkey
UK	United Kingdom
US	United States

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