



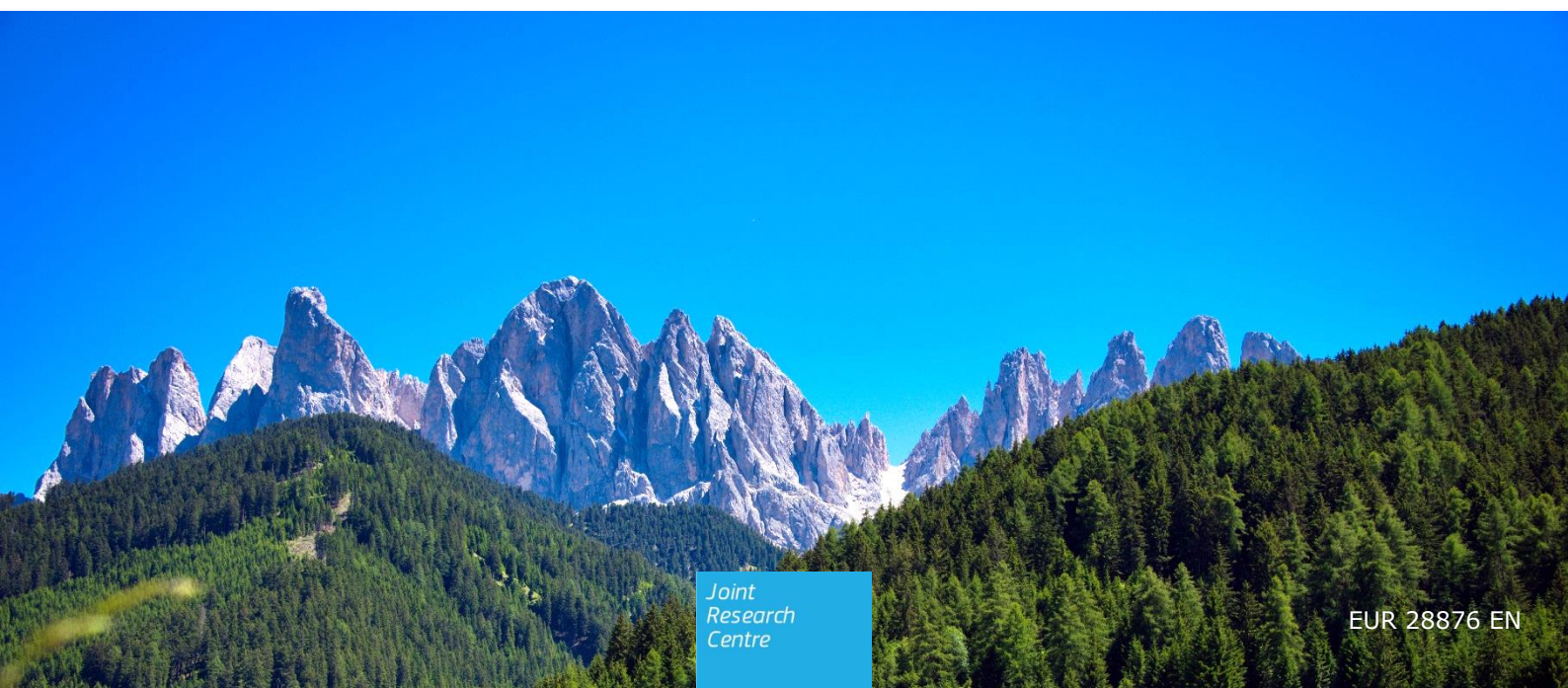
JRC TECHNICAL REPORTS

The Innovation Output Indicator 2017

Methodology Report

Vértesy, D

2017



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JRC108942

EUR 28876 EN

PDF ISBN 978-92-79-76474-5 ISSN 1831-9424 doi:10.2760/971852

Luxembourg: Publications Office of the European Union, 2017

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How to cite this report: Vertesy, D., *The Innovation Output Indicator 2017. Methodology Report*, EUR 28876 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-76474-5, doi:10.2760/971852, JRC108942

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Contents

Acknowledgements	4
Abstract / Executive Summary	5
1 Introduction	6
2 Definition of components	8
2.1 PCT: PCT Patent applications per billion GDP (PPS)	8
2.2 KIABI: Share of employment in knowledge-intensive business industries	11
2.3 The COMP Component	13
2.3.1 GOOD: The share of medium- and high-tech products in total exports	13
2.3.2 SERV: Knowledge-intensive services exports as % of total service exports	15
2.4 DYN: Employment share in fast-growing enterprises in innovative sectors	17
2.4.1 The revision of the DYN component	19
3 Multi-variate analysis	23
3.1 The IOI2017 dataset	23
3.2 Normalization and aggregation	24
4 Country Performance in composite scores	27
4.1 European comparison	27
4.2 International comparison	31
5 Conclusion: robustness of ranks and validation of results	34
5.1 Robustness of country ranks	34
5.2 Validation of results	35

Acknowledgements

This report benefitted substantially from suggestions and feedback from Richard Deiss and colleagues in the Competence Centre on Composite Indicators and Scoreboards at the JRC, in particular, Giacomo Damioli, Maria Del Sorbo, Claudia Ghisetti and Michaela Saisana.

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Abstract / Executive Summary

This report presents the 2017 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.

Beyond offering the latest figures for the underlying indicators and composite index, this current edition discusses the revision of the component that measures employment dynamism in fast-growing enterprises in innovative sectors. The new definition aims to simplify the interpretation of the indicator, which now compares countries' performance in terms of the share of employment in fast-growing enterprises in innovative sectors, rather than weighting sectoral innovation coefficients with sectoral shares of employment in high-growth enterprises. The report also discusses in details how changes in the definition of this component affect the outcomes. The rest of the components, measuring technological innovation by patents, the share of highly skilled labor force feeding into the economic structure of a country, as well as the competitiveness of knowledge-intensive goods and services, remain unchanged with regards to previous editions.

Composite results show that the EU is slightly 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, the UK and the Netherlands are among the leaders, whereas we find Croatia, Romania and Lithuania 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 R&D-based and entrepreneurship-based innovation may require specific, dedicated policies.

1 Introduction

The 2017 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 Reports¹. 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.

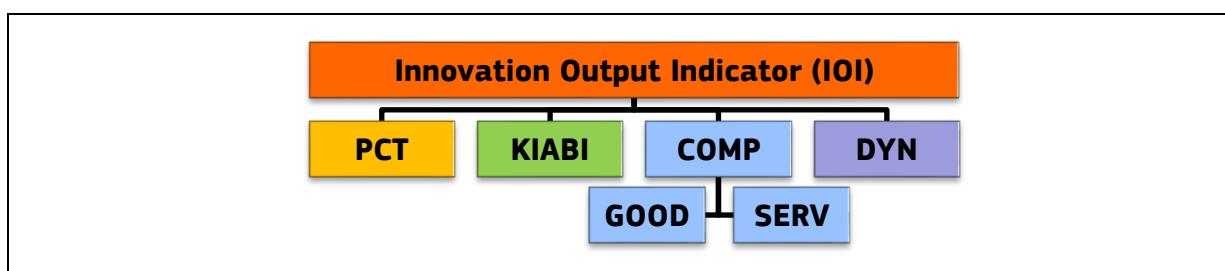


Figure 1 The Innovation Output Indicator framework

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

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).

the close link between growth, innovation 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-growing⁴ 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 June 2017; the year with most recent data for most components was 2016, so we indicate year lags for each component with respect to 2016.

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. 2016]	2014 [2]	
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.

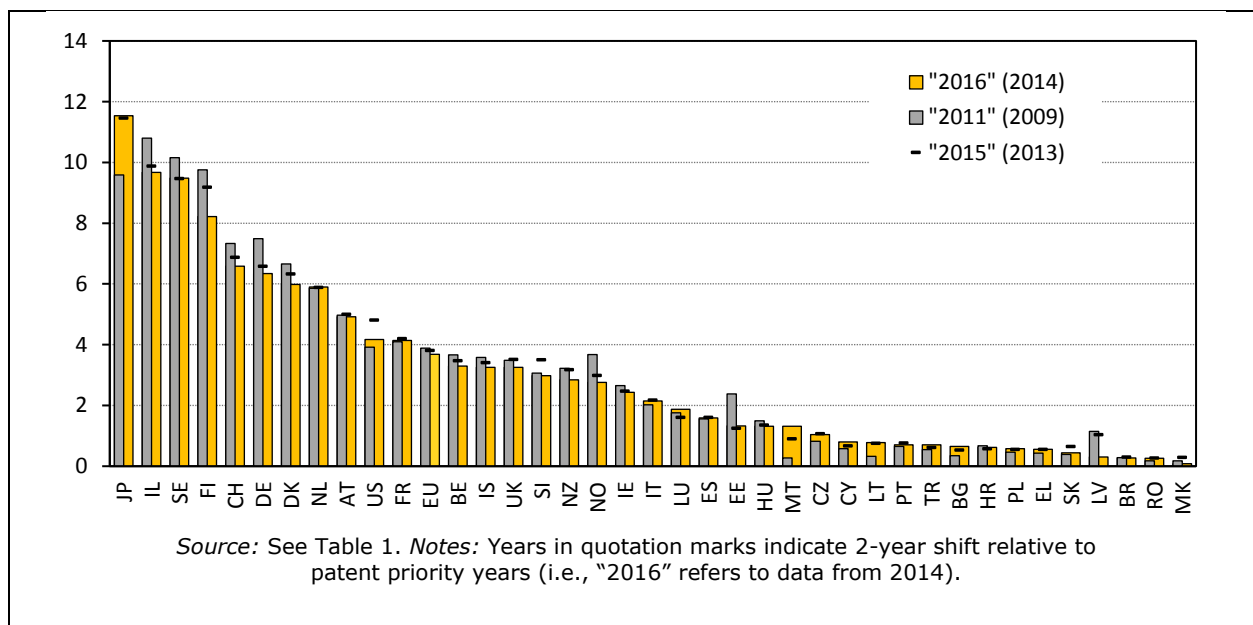


Figure 2 PCT patent applications per billion GDP (in PPS)

Box 1 An alternative denominator to PCT

In order to make the performance of countries of different size comparable, the number of patent applications are divided by GDP, which is an established measure of the size of the economy. Alternatively, it could be argued that size is better measured by population. The scatter plot in Figure 3 graphically illustrates how differently countries may score if the denominator was million population, rather than GDP (PPS) – while keeping PCT applications as the numerator. Although in general, the denominator has little impact on country scores (Pearson correlation $r = 0.96$), a few countries with higher GDP per capita rates, such as Luxembourg and Switzerland, or the US would benefit most from such a change.

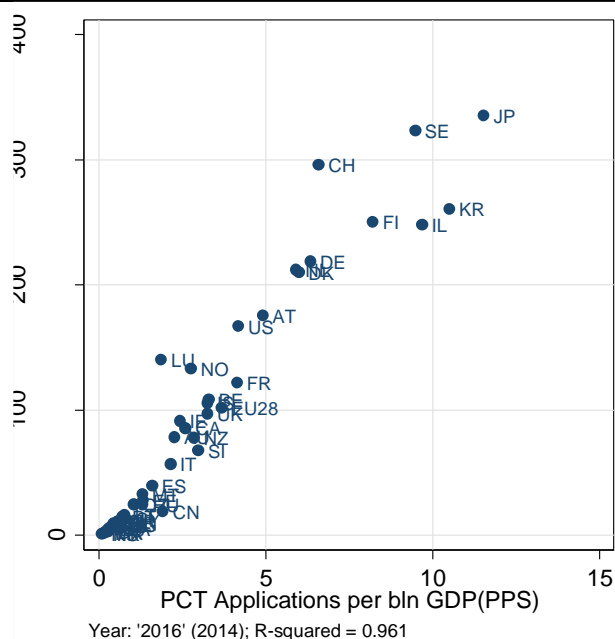


Figure 3 Comparison of GDP and Population as denominators for PCT

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

Time Point	"2011"	"2012"	"2013"	"2014"	"2015"	"2016"
Actual year	2009	2010	2011	2012	2013	2014
EU	3.9	3.9	3.9	3.8	3.8	3.7
AT	5.0	5.3	5.2	4.8	5.0	4.9
BE	3.7	3.7	3.7	3.4	3.5	3.3
BG	0.3	0.3	0.5	0.6	0.5	0.7
CY	0.6	0.3	0.5	0.4	0.7	0.8
CZ	0.8	0.7	0.8	0.9	1.1	1.0
DE	7.5	7.5	7.2	6.8	6.6	6.3
DK	6.7	6.3	6.7	6.1	6.3	6.0
EE	2.4	2.3	1.7	0.7	1.2	1.3
EL	0.4	0.4	0.4	0.6	0.5	0.6
ES	1.6	1.7	1.6	1.5	1.6	1.6
FI	9.8	9.9	9.4	10.0	9.2	8.2
FR	4.1	4.0	4.2	4.1	4.2	4.1
HR	0.7	0.7	0.7	0.7	0.6	0.6
HU	1.5	1.5	1.6	1.4	1.4	1.3
IE	2.7	2.3	2.7	2.3	2.5	2.4
IT	2.0	2.0	2.0	2.0	2.2	2.1
LT	0.3	0.4	0.4	0.8	0.7	0.8
LU	1.8	1.7	1.9	1.9	1.6	1.9
LV	1.1	0.5	0.8	1.0	1.0	0.3
MT	0.3	0.7	0.2	0.8	0.9	1.3
NL	5.9	5.2	6.1	5.9	5.9	5.9
PL	0.5	0.5	0.4	0.5	0.5	0.6
PT	0.7	0.6	0.7	0.7	0.8	0.7
RO	0.2	0.2	0.2	0.2	0.3	0.3
SE	10.2	9.5	9.1	9.8	9.5	9.5
SI	3.1	3.1	3.0	2.8	3.5	3.0
SK	0.4	0.5	0.5	0.4	0.6	0.4
UK	3.5	3.4	3.3	3.2	3.5	3.3
CH	7.3	7.5	7.5	7.5	6.9	6.6
IS	3.6	2.9	3.4	3.4	3.4	3.3
NO	3.7	3.4	3.0	2.9	3.0	2.8
IL	10.8	10.1	10.0	10.6	9.9	9.7
JP	9.6	10.9	12.1	12.1	11.4	11.5
NZ	3.2	3.3	3.1	3.1	3.2	2.8
US	3.9	4.0	4.2	4.3	4.8	4.2
MK	0.2	0.0	0.1	0.0	0.3	0.1
TR	0.5	0.6	0.5	0.6	0.6	0.7
BR	0.3	0.3	0.3	0.3	0.3	0.3

Source: see Table 1; Note: Actual figures are lagged by 2 years (thus, 2016 refers to 2014).

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. 2016]	2016 [0]	
Corresponding EIS indicator	4.1.1 Employment in knowledge-intensive activities as percentage of total employment	

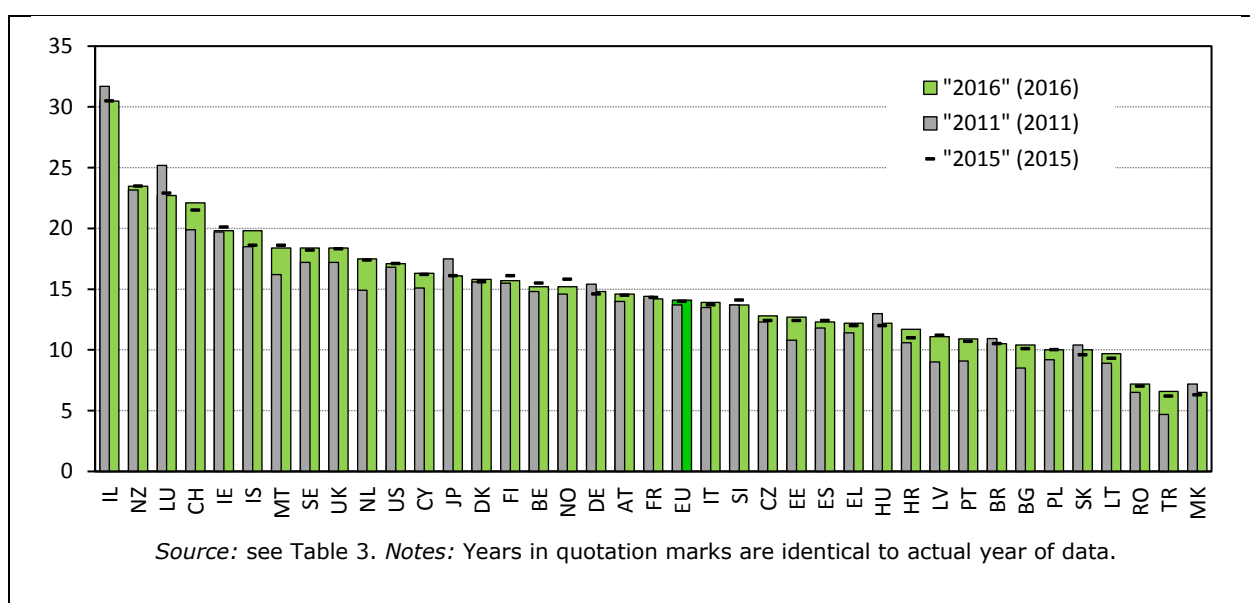


Figure 4 Share of employment in knowledge-intensive activities in business industries (in %)

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

Time point	"2011"	"2012"	"2013"	"2014"	"2015"	"2016"
Actual year	2011	2012	2013	2014	2015	2016
EU	13.7	13.8	13.8	13.9	14.0	14.1
AT	14.0	14.2	14.6	14.7	14.5	14.6
BE	14.8	15.2	15.3	15.4	15.5	15.2
BG	8.5	8.6	9.0	9.4	10.1	10.4
CY	15.1	16.9	17.2	17.2	16.2	16.3
CZ	12.3	12.7	13.0	12.7	12.4	12.8
DE	15.4	15.3	14.7	14.6	14.6	14.8
DK	15.6	15.5	15.2	15.4	15.6	15.8
EE	10.8	11.0	11.9	11.4	12.4	12.7
EL	11.4	12.4	12.5	12.2	12.0	12.2
ES	11.8	12.2	12.4	12.3	12.4	12.3
FI	15.5	15.5	15.7	15.8	16.1	15.7
FR	14.4	14.3	14.0	14.0	14.3	14.2
HR	10.6	10.5	10.6	10.7	11.0	11.7
HU	13.0	12.5	12.9	12.3	12.0	12.2
IE	19.7	20.1	20.1	20.2	20.1	19.8
IT	13.5	13.3	13.5	13.6	13.7	13.9
LT	8.9	9.1	9.0	8.8	9.3	9.7
LU	25.2	25.5	26.2	27.5	22.9	22.7
LV	9.0	10.3	10.8	10.9	11.2	11.1
MT	16.2	16.7	17.4	18.3	18.6	18.4
NL	14.9	15.3	17.1	17.3	17.4	17.5
PL	9.2	9.7	9.6	9.9	10.0	10.0
PT	9.1	9.0	9.4	10.3	10.7	10.9
RO	6.5	6.5	6.6	6.9	7.0	7.2
SE	17.2	17.6	17.7	17.9	18.2	18.4
SI	13.7	14.1	14.0	14.0	14.1	13.7
SK	10.4	10.1	9.6	9.9	9.6	10.0
UK	17.2	17.6	17.8	18.0	18.3	18.4
CH	19.9	20.5	20.7	21.4	21.5	22.1
IS	18.5	17.5	17.2	18.2	18.6	19.8
NO	14.6	15.3	15.9	16.3	15.8	15.2
IL	31.7	31.1	30.5	30.5	30.5	30.5
JP	17.5	17.2	16.1	16.1	16.1	16.1
NZ	23.2	23.3	23.4	23.5	23.5	23.5
US	16.8	17.1	17.2	17.1	17.1	17.1
MK	7.2	7.0	6.2	6.3	6.3	6.5
TR	4.7	5.0	5.3	5.7	6.2	6.6
BR	10.9	10.8	11.0	10.5	10.5	10.5

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: Eurostat, Comext 'DS-043227'; others: UN Comtrade	
Most recent year used [Nr. years lag vs. 2016]	2016 [0]	
Corresponding EIS indicator	4.2.1 Exports of medium and high technology products as a share of total product exports	

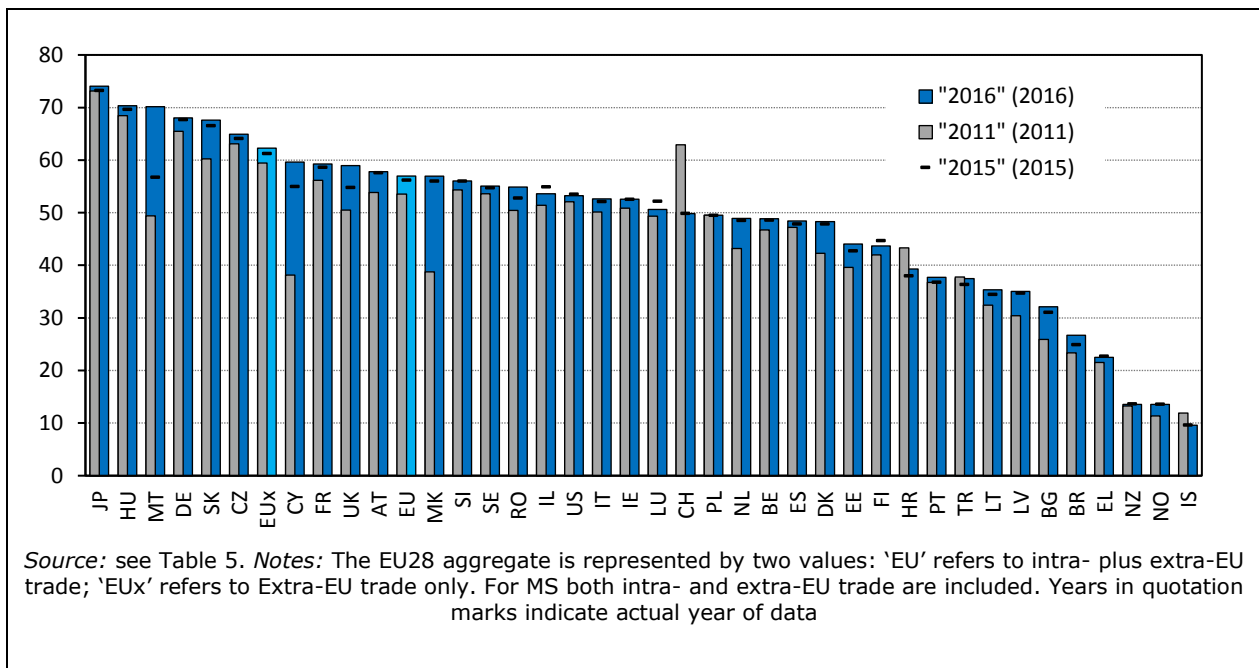


Figure 5 The share of medium- and high-tech products in total exports (in %)

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

Time point	"2011"	"2012"	"2013"	"2014"	"2015"	"2016"
Actual Year	2011	2012	2013	2014	2015	2016
EUx	59.4	59.7	58.2	59.8	61.2	62.3
EU	53.5	53.5	53.1	54.3	56.2	57.0
AT	53.9	55.1	56.6	57.0	57.6	57.8
BE	46.7	46.7	45.9	46.9	48.5	48.8
BG	25.9	25.7	26.8	29.1	31.0	32.1
CY	38.1	36.0	43.2	55.5	55.0	59.6
CZ	63.1	62.5	62.5	63.9	64.1	64.9
DE	65.4	66.0	66.2	66.5	67.6	68.0
DK	42.3	42.9	43.5	46.0	47.8	48.3
EE	39.6	40.9	42.8	42.2	42.7	44.0
EL	21.5	18.7	18.2	19.5	22.7	22.5
ES	47.2	44.3	46.0	45.5	47.8	48.4
FI	42.0	40.4	38.7	40.6	44.6	43.7
FR	56.2	57.1	57.1	57.4	58.6	59.2
HR	43.3	39.4	37.6	35.1	38.0	39.3
HU	68.5	66.2	66.3	67.6	69.6	70.3
IE	50.8	48.8	48.0	48.6	52.5	52.6
IT	50.1	49.3	50.4	51.4	52.1	52.6
LT	32.4	31.9	31.1	34.7	34.5	35.3
LU	49.3	52.5	49.4	48.4	52.2	50.6
LV	30.4	29.0	30.3	32.4	34.7	35.1
MT	49.4	51.3	55.6	62.5	56.7	70.1
NL	43.2	42.8	42.1	44.3	48.5	48.9
PL	49.5	48.2	48.7	48.9	49.4	49.6
PT	36.8	36.5	35.2	35.9	36.7	37.7
RO	50.4	50.2	50.7	50.9	52.8	54.9
SE	53.6	51.3	52.4	52.2	54.7	55.1
SI	54.3	53.3	54.6	55.4	56.0	56.1
SK	60.3	61.7	63.6	64.9	66.5	67.6
UK	50.5	53.8	47.9	52.9	54.8	59.0
CH	62.9	45.6	41.3	49.9	49.8	49.8
IS	11.9	11.8	10.0	11.5	9.6	9.6
NO	11.4	11.5	12.5	13.5	13.5	13.5
IL	51.4	51.8	52.3	51.5	54.9	53.6
JP	73.1	74.4	72.6	72.9	73.2	74.0
NZ	13.2	13.1	11.6	11.1	13.6	13.5
US	52.1	52.2	51.5	51.6	53.5	53.3
MK	38.8	41.1	45.6	52.1	56.0	57.0
TR	37.7	34.1	36.7	36.6	36.3	37.5
BR	23.3	24.1	25.7	23.0	24.9	26.7

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. 2016]	2015 [1]	
Corresponding EIS indicator	4.2.2 Knowledge-intensive services exports as percentage of total services exports	

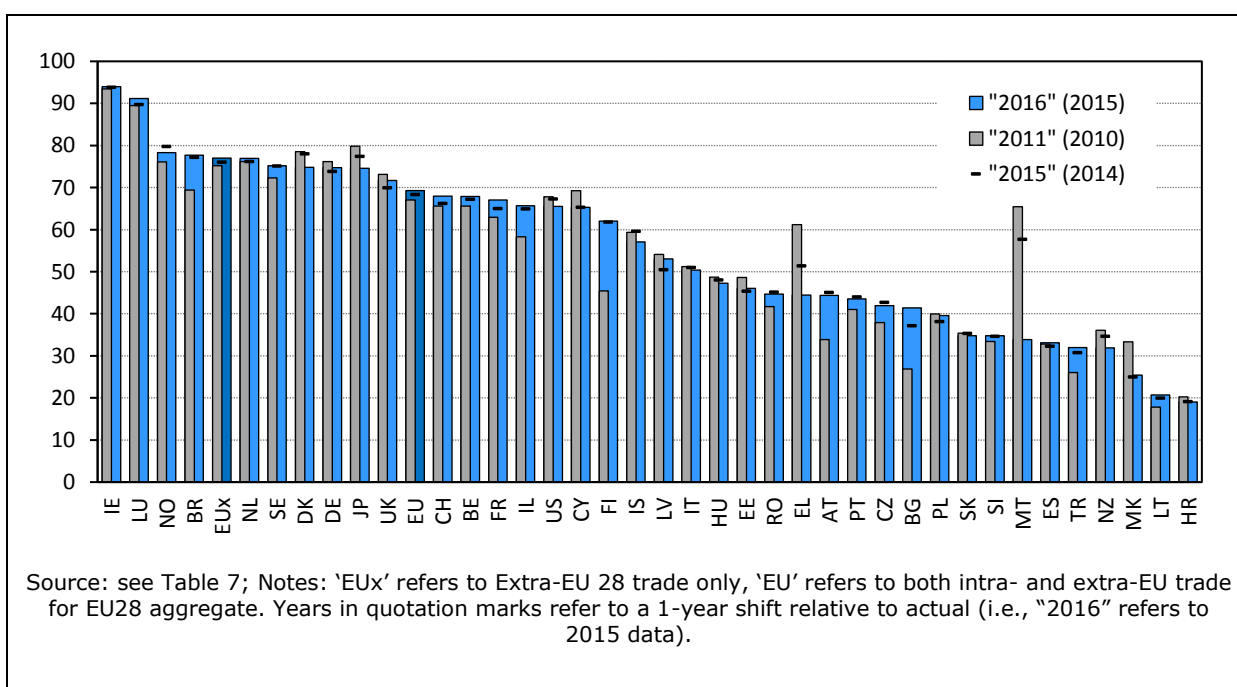


Figure 6 Knowledge-intensive services exports as percentage of total services exports (in %)

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

Time Point	"2011"	"2012"	"2013"	"2014"	"2015"	"2016"
Actual Year	2010	2011	2012	2013	2014	2015
EUx	75.2	75.8	75.5	74.8	76.0	77.0
EU	67.0	67.4	68.0	67.4	68.3	69.3
AT	33.9	36.6	45.1	44.8	45.1	44.4
BE	65.6	65.6	66.1	67.7	67.2	67.9
BG	26.9	30.2	32.5	31.9	37.2	41.4
CY	69.2	72.2	69.3	67.3	65.3	65.3
CZ	37.9	40.0	40.7	42.7	42.7	42.0
DE	76.2	76.3	76.9	74.9	73.8	74.7
DK	78.5	78.1	79.3	78.2	78.0	74.8
EE	48.6	46.1	46.1	44.0	45.4	46.1
EL	61.2	56.8	56.0	52.0	51.4	44.4
ES	32.8	32.8	32.8	30.8	32.3	33.1
FI	45.4	51.2	54.0	52.8	61.8	62.0
FR	62.9	62.9	63.7	63.8	65.0	67.0
HR	20.3	20.3	20.4	17.9	19.1	19.0
HU	48.7	49.4	48.3	47.7	48.0	47.3
IE	93.5	93.5	93.5	93.2	93.8	94.0
IT	51.2	51.8	52.7	51.4	51.0	50.4
LT	17.8	18.0	17.7	17.7	19.9	20.7
LU	89.5	89.5	88.9	89.3	89.7	91.2
LV	54.1	50.4	49.7	50.1	50.4	53.1
MT	65.4	22.7	33.6	34.6	57.7	33.9
NL	76.1	76.1	76.1	76.1	76.1	76.9
PL	39.9	38.5	38.4	37.4	38.1	39.6
PT	41.0	43.3	42.8	43.6	44.0	43.5
RO	41.7	40.2	44.0	45.3	45.1	44.7
SE	72.3	73.7	73.8	75.4	75.1	75.2
SI	33.4	34.8	34.1	33.7	34.7	34.8
SK	35.4	35.4	35.4	35.4	35.3	34.8
UK	73.1	72.9	72.2	71.1	70.0	71.7
CH	65.6	65.7	66.5	66.0	66.2	68.0
IS	59.3	59.3	59.3	59.3	59.6	57.1
NO	76.1	71.5	78.8	78.8	79.8	78.3
IL	58.3	61.0	63.4	64.3	64.9	65.7
JP	79.8	81.9	78.1	79.1	77.4	74.6
NZ	36.1	36.6	37.0	36.7	34.6	31.9
US	67.8	68.1	67.6	67.4	67.3	65.5
MK	33.3	25.8	26.4	26.7	24.9	25.5
TR	26.0	27.0	29.0	30.3	30.8	31.9
BR	69.4	70.7	71.1	70.7	77.2	77.7

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.

This indicator has undergone a significant revision since the last edition of the IOI.

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;	EU28: 2014 denominator computed using available countries; BE 2014: used 2013 denominator
Most recent year used [Nr. years lag vs. 2016]	2014 [2]	
Notes on time coverage	Data not available prior to 2012, except for BR, IL, NZ.	
Corresponding EIS indicator	4.1.2 Employment in fast-growing enterprises (percentage of total employment)	

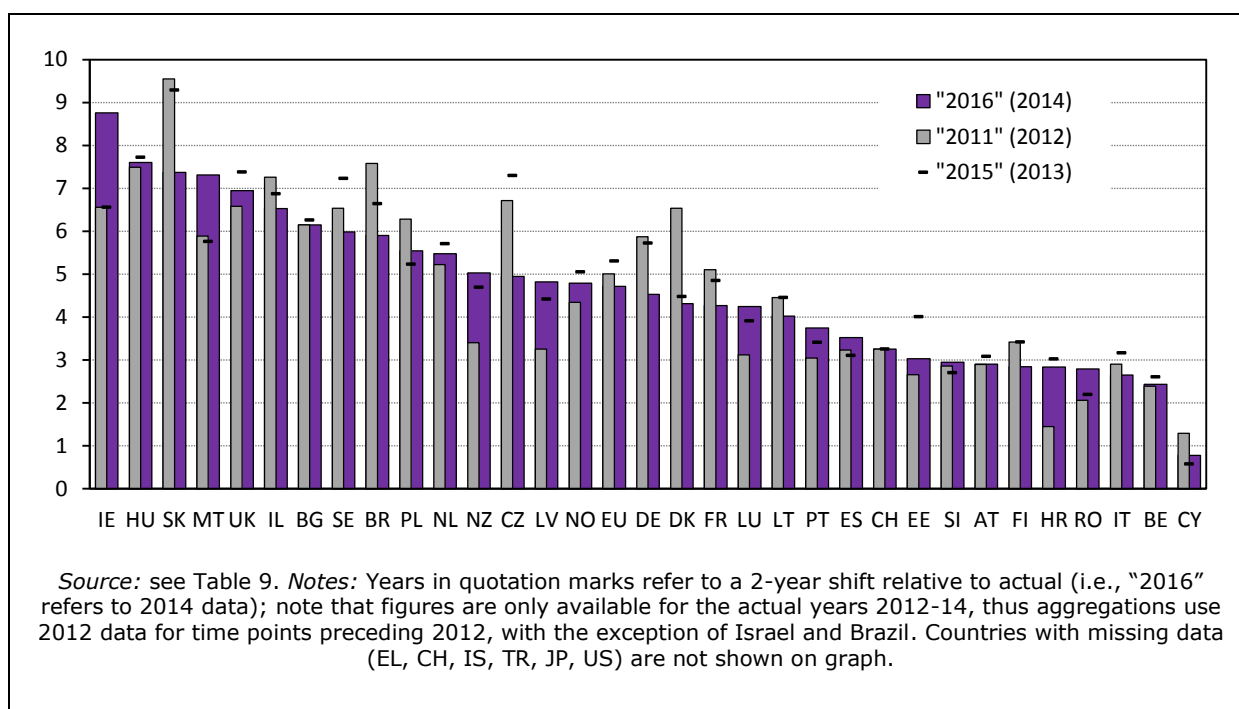
**Figure 7** Employment in fast-growing enterprises in the top 50% most innovative sectors as a percentage of total employment (in %)

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

Time Point	"2011"	"2012"	"2013"	"2014"	"2015"	"2016"
Actual year	2012 ^a	2012 ^a	2012 ^a	2012	2013	2014
EUx	n.a.	n.a.	n.a.	5.0	5.3	4.7
EU	n.a.	n.a.	n.a.	5.0	5.3	4.7
AT	n.a.	n.a.	n.a.	2.9	3.1	2.9
BE	n.a.	n.a.	n.a.	2.4	2.6	2.4
BG	n.a.	n.a.	n.a.	6.2	6.3	6.1
CY	n.a.	n.a.	n.a.	1.3	0.6	0.8
CZ	n.a.	n.a.	n.a.	6.7	7.3	4.9
DE	n.a.	n.a.	n.a.	5.9	5.7	4.5
DK	n.a.	n.a.	n.a.	6.5	4.5	4.3
EE	n.a.	n.a.	n.a.	2.7	4.0	3.0
EL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
ES	n.a.	n.a.	n.a.	3.2	3.1	3.5
FI	n.a.	n.a.	n.a.	3.4	3.4	2.8
FR	n.a.	n.a.	n.a.	5.1	4.9	4.3
HR	n.a.	n.a.	n.a.	1.4	3.0	2.8
HU	n.a.	n.a.	n.a.	7.5	7.7	7.6
IE	n.a.	n.a.	n.a.	6.6	6.6	8.8
IT	n.a.	n.a.	n.a.	2.9	3.2	2.6
LT	n.a.	n.a.	n.a.	4.5	4.5	4.0
LU	n.a.	n.a.	n.a.	3.1	3.9	4.2
LV	n.a.	n.a.	n.a.	3.2	4.4	4.8
MT	n.a.	n.a.	n.a.	5.9	5.8	7.3
NL	n.a.	n.a.	n.a.	5.2	5.7	5.5
PL	n.a.	n.a.	n.a.	6.3	5.2	5.5
PT	n.a.	n.a.	n.a.	3.0	3.4	3.7
RO	n.a.	n.a.	n.a.	2.1	2.2	2.8
SE	n.a.	n.a.	n.a.	6.5	7.2	6.0
SI	n.a.	n.a.	n.a.	2.9	2.7	2.9
SK	n.a.	n.a.	n.a.	9.6	9.3	7.4
UK	n.a.	n.a.	n.a.	6.6	7.4	6.9
CH	n.a.	n.a.	n.a.	3.2	3.2	3.2
IS	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NO	n.a.	n.a.	n.a.	4.3	5.0	4.8
IL	n.a.	n.a.	7.3	7.9	6.9	6.5
JP	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NZ	n.a.	3.4	3.6	4.9	4.7	5.0
US	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
MK	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
TR	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
BR	n.a.	7.6	8.0	7.4	6.6	5.9

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.

2.4.1 The revision of the DYN component

The DYN component was a rather complex indicator in previous versions of the IOI⁷. It combined sectoral innovativeness coefficients and employment data at the fine-grained, 3-digit sectoral level. While it rendered intuitive results for cross-country comparison at a given point in time, the interpretation of changes over time was less intuitive. Moreover, it was not possible to decompose country scores as these relied on confidential data. In response to suggestions by users, the indicator has been simplified in a way to maintain its purpose to measure business dynamism in fast-growing, innovative enterprises.

Feedback from users of the indicator showed preference for a revised indicator that would measure employment in high-growth, innovative sectors as a share of total employment. However, it is not straight forward how to distinguish innovative high-growth firms from

⁷ See specification i.e. in Vertesy and Deiss (2016), section 3.4.

non-innovative ones using official statistics. Forced by data availability, the revision of the indicator followed a sector-based approach (in this respect, similarly to the previous version), rather than a firm-level approach⁸. Sectoral- and country-level data have become available on employment in high-growth firms for Europe in recent years, using such data lies on the assumption that innovation performance varies more between than within sectors.

For the sectoral approach, the main challenge is identifying the innovative sectors, while offering a fair coverage of both manufacturing and service industries. Measures such as R&D intensity has a shortcoming that it is most informative for manufacturing industries. Skills-based measures, such as the share of tertiary graduates among the labour force is more informative for service sectors, but is a rather distant proxy. The OECD developed an experimental taxonomy to help better measure innovativeness of manufacturing and service sectors, combining two coefficients, based on innovation and knowledge intensity. The “*cis*” coefficients were obtained from aggregating firm-level innovation performance data at the 2- and 3-digit sectoral level using pooled European Community Innovation Survey microdata. Sectoral “*kia*” coefficients were obtained from the share of employees with tertiary degree, helping better gauge knowledge-intensive service activities. As the report OECD DSTI/EAS/IND/WPIA(2011)5 shows, the combination of sectoral *cis* and *kia* scores offers rather intuitive sectoral rankings.⁹ *Cis*kia* scores can both be used as sectoral weights (as in the case of the previous definition of the DYN component), or as thresholds that can be applied to select a set of industries (as in the case of the current definition). While the results may be coarser, the method is simpler to communicate, and is to a large extent coherent with other sectoral classifications used in the EIS and IOI, i.e. the knowledge-intensive business industries (KIABI) or Medium-high-tech product exports and knowledge-intensive service exports. This, however, brings up the problem of where to establish the threshold. Some sectors are more sensitive than other to the business cycle (i.e., real estate, construction, retail, employment agencies, etc.). For this reason, we tested the impact of selecting the top 50%, 40%, 33%, 25% most innovative sectors based on *cis*kia* scores and also addressed the sensitivity to update of CIS*KIA coefficients. For the tests, calculations were based on CIS2008 and CIS2010-based *cis* scores, and respective European Labour Force Survey (LFS) data for *kia*. While striking a balance between the level of details and data availability, we opted to use 2-digit sectoral classification offering less detailed information, but significantly improving data availability in contrast with the 3-digit level.

Table 11 shows whether a given 2-digit NACE Rev.2 sector is included or not among the most innovative sectors depending on whether a more restrictive selection criterion (top 25%) or a broader selection criterion (top 50%) is applied, using the CIS2008 and CIS2010-based *cis*kia* coefficients. Clearly, a more restrictive threshold would mostly filter manufacturing industries but include many service sectors (hence a difference in contrast with R&D-intensity-based measures and a greater alignment with KIABI), while broader definitions enrich the picture by adding a broader range of manufacturing as well as mining and quarrying related activities, or supply and utilities sectors. Any definition is arbitrary, and the choice in this case to include the 50% most innovative sectors was motivated by the idea that a broader definition accommodates better the diverse specialization of countries. **Figure 8** decomposes the proposed DYN component by showing employment share in the top 5 best performing sector (among the top 50% most innovative ones) for each country. While it reveals that knowledge-intensive, intuitively innovative sectors (i.e., machinery and automobile industries (C28 & C29), computer programming (J62), professional, scientific and technical activities (M)) feature among the top 5 for each country, wholesale trade (G46) is among the strongest source of high-growth employment across Europe. Yet, this sector, which enters in the top 50% threshold

⁸ There is, at the moment, no publicly available data of sufficient quality that would allow to measure innovativeness and growth to allow cross-country and cross-time comparison. Community Innovation Survey microdata offers a sophisticated measure of innovativeness, but employment data at best for two time points – however, firm growth was not a sampling criteria for firms, and microdata is not available for all EU Member States, not to mention other benchmark countries. Other company data, including commercial datasets, offer very limited amount of information on innovation performance.

⁹ JRC calculations using more recent CIS2010 and new KIA microdata (scores that were also used in recent editions of the IUS / IOI) show that sectoral coefficients hardly fluctuate over time.

but not in the top 40%, turns out to be similarly high across the various EU Member States to the extent that the correlation between DYN scores obtained using the 40 and 50% thresholds are extremely strong and positive ($r=0.98$).

Table 11 Inclusion of 2-digit sectors among the top 25-50% most innovative ones

NACE2D	CISxKIA Top...				KIABI
	50%	40%	33%	25%	
B05					
B06	CIS10	CIS10	CIS10		
B07					
B08					
B09	CIS10	CIS10			X
C10					
C11	BOTH	CIS08			
C12	BOTH	BOTH	CIS08		
C13					
C14					
C15					
C16					
C17					
C18					
C19	BOTH	BOTH	BOTH	BOTH	X
C20	BOTH	BOTH	BOTH	CIS08	
C21	BOTH	BOTH	BOTH	BOTH	X
C22					
C23					
C24					
C25					
C26	BOTH	BOTH	BOTH	BOTH	X
C27	BOTH	CIS08	CIS08		
C28	BOTH	BOTH	CIS08		
C29	BOTH	BOTH	CIS08		
C30	BOTH	BOTH	BOTH		
C31					
C32	BOTH				
C33					
D35	BOTH	CIS10	CIS10		
E36	CIS08				
E37					
E38					
E39	CIS10				
F41					
F42					
F43					

NACE2D	CISxKIA Top...				KIABI
	50%	40%	33%	25%	
G45					
G46	BOTH				
G47					
H49					
H50					
H51	BOTH	BOTH	BOTH	BOTH	X
H52					
H53					
I55					
I56					
J58	BOTH	BOTH	BOTH	BOTH	X
J59	BOTH	BOTH	CIS10	CIS10	X
J60	BOTH	BOTH	BOTH	BOTH	X
J61	BOTH	BOTH	BOTH	BOTH	X
J62	BOTH	BOTH	BOTH	BOTH	X
J63	BOTH	BOTH	BOTH	BOTH	X
K64	BOTH	BOTH	BOTH	BOTH	X
K65	BOTH	BOTH	BOTH	BOTH	X
K66	BOTH	BOTH	CIS10		X
L68	BOTH				
M69	BOTH				X
M70	BOTH	BOTH	BOTH	BOTH	X
M71	BOTH	BOTH	BOTH	BOTH	X
M72	BOTH	BOTH	BOTH	BOTH	X
M73	BOTH	BOTH	BOTH	CIS10	X
M74	BOTH	BOTH	BOTH	BOTH	X
M75	BOTH	BOTH	BOTH	BOTH	X
N77					
N78					X
N79	BOTH	BOTH	BOTH		X
N80					
N81					
N82	CIS08				
S95					

Source: CISxKIA classifications following OECD (2011) and recomputed using CIS2010 and LFS 2010 data; KIABI defined in Eurostat *Knowledge Intensive Activities by NACE Rev.2* Note: 'CIS08' and 'CIS10' in the cells indicate sectors included based on CIS2008 and the recomputed CIS2010 data, respectively (and corresponding LFS data); 'BOTH' indicates sectors included based on both CIS waves data.

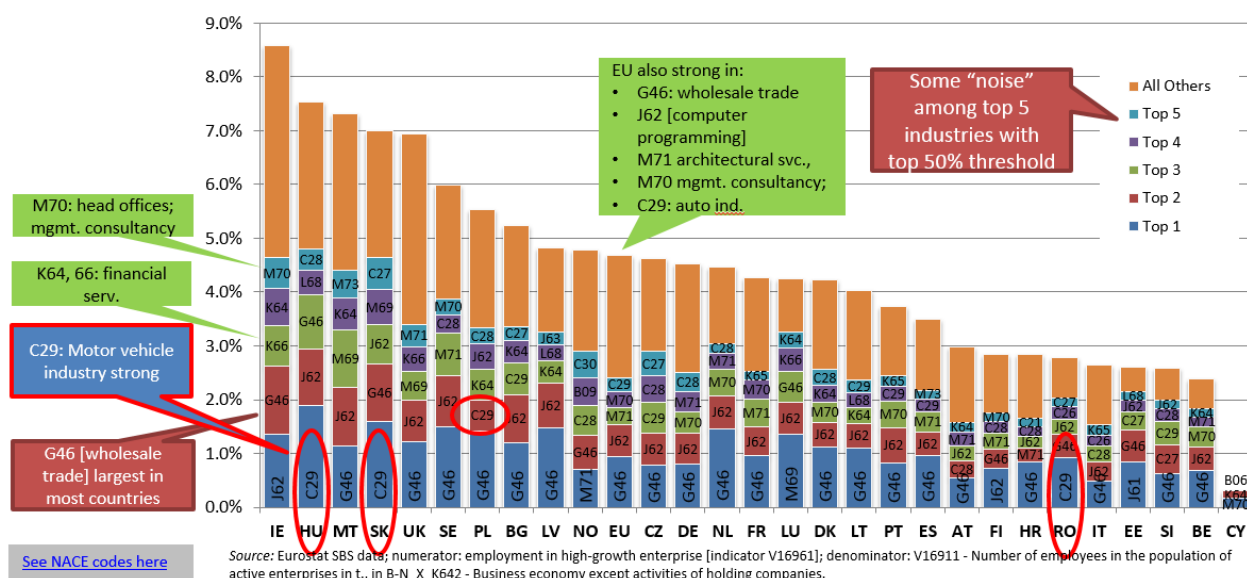
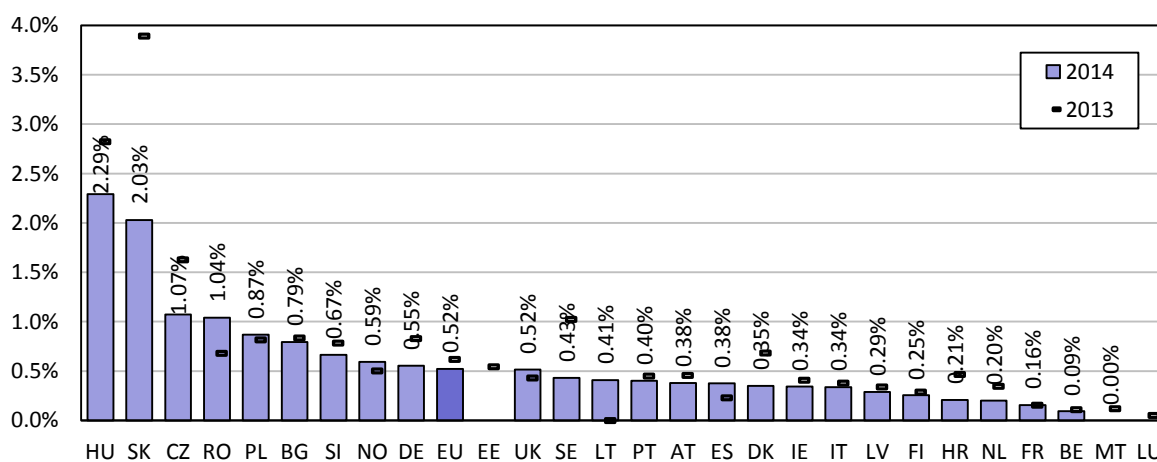


Figure 8 Business dynamics in fast growing enterprises in top 50% most innovative sectors: a structural composition by country, 2014

Further tests on the structural composition of countries in terms of high-growth firms flagged that the inclusion of the automobile and machinery industry, typically a medium-high-tech activity, accounted for in 2014 a significant share (above 1%, twice the EU average) in a few Central Eastern European Member States, including Hungary, Slovakia, the Czech Republic and Romania (**Figure 9**). The inclusion of these two sectors, which are among the 40% most innovative ones according to the *cis*kia* scores obtained using CIS 2008 and 2010, strongly lower correlation between DYN and other components of the IOI (and EIS). While there is little information available as to the innovativeness of the fast-growing companies in these countries, analysis using pooled European CIS 2014 microdata (Vertesy et al, 2017) also showed that the two sectors are above-average in terms of high innovativeness as well as high-growth, pointing to the direction that the strong performance is due to Central Eastern European economies. At the same time, a low correlation with other indicator is not a problem per se, as it shows that this indicator adds new information contained by other EIS and IOI indicators. Nonetheless, when developing aggregate summary measures, caution should be exercised as a low correlation implies a loss of information in aggregate measures.



Source: Eurostat; Notes: Sum of NACE Rev.2 codes C28 and C29.

Figure 9 Employment share in high-growth firms in the machinery and motor vehicles industries, 2013-2014

3 Multi-variate analysis

3.1 The IOI2017 dataset

The multi-variate analysis and aggregation of the IOI 2017 indicators was carried out on a dataset that consisted of 234 observations (data were collected for 39 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 Greece, Iceland, FYR Macedonia and Turkey, as well as Japan and the US for any of the time points.¹⁰ 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 12**. (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, the IOI 2016 dataset was expanded here by two additional years (and increase from 152 to 234 country-year observations). We note that none of the distribution shows excessive skewness or kurtosis.

Table 12 Descriptive statistics and correlation scores for the IOI variables (all 6 years)

	PCT	KIABI	GOOD _{EUR}	GOOD _{INT}	SERV _{EUR}	SERV _{INT}	DYN	DYN _{imp}
N. Obs.	234	234	234	234	234	234	198	234
Min	0.0	4.7	9.6	9.6	17.7	17.7	0.6	0.6
Max	12.1	31.7	74.4	74.4	94.0	94.0	9.6	9.6
Mean	3.1	14.5	45.7	45.8	54.6	54.8	4.7	4.7
Std. Dev.	3.1	5.1	15.2	15.3	19.6	19.8	2.0	1.8
Skewness	1.2	0.9	-0.6	-0.6	0.0	0.0	0.3	0.3
Kurtosis	0.5	1.4	0.0	0.0	-1.0	-1.0	-0.7	-0.4

Correlation								
PCT	1							
KIABI	0.583	1						
GOOD _{EUR}	0.290	(0.057)	1					
GOOD _{INT}	0.290	(0.056)	0.998	1				
SERV _{EUR}	0.498	0.566	0.131	0.136	1			
SERV _{INT}	0.496	0.560	0.136	0.144	0.998	1		
DYN	0.105	0.109	0.227	0.227	0.177	0.177	1	
DYN _{imp}	0.112	0.123	0.242	0.242	0.187	0.188	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 12**) 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 (0.583) and KIABI and the SERV indicators (0.566 for SERV_{EUR}). There is little if any association between GOOD and SERV, or between DYN and most of the indicators (ranging from 0.105 with PCT and 0.227 with GOOD). Low but positive correlation between indicators

¹⁰ 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.

implies that each of the indicators provide complementary 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: $z \cdot 1.5 + 5$, 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 13**. The combination of GOOD and SERV into COMP¹¹ leads to stronger correlation coefficients with respect to PCT as well as KIABI (0.524 and 0.414, respectively), but still relatively lower with respect to DYN (0.286). 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 10** 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 13 Descriptive statistics and pairwise Pearson correlation for the normalized components (6 years, pooled dataset)

	PCT	KIABI	COMP_{EUR}	DYN_{imp}
N.Obs.	234	234	234	234
Min	3.5	2.1	2.5	1.7
Max	9.4	10.1	7.5	9.0
Mean	5.0	5.0	5.0	5.0
Std. Dev.	1.5	1.5	1.1	1.5
Skewness	1.2	0.9	-0.1	0.3
Kurtosis	0.5	1.4	-0.7	-0.4
Correlation				
PCT	1.000			
KIABI	0.583	1.000		
COMP _{EUR}	0.524	0.414	1.000	
DYN _{imp.}	0.112	0.123	0.286	1.000

¹¹ To avoid redundancy, we only show here statistics for COMP_EUR, as it is virtually identical to COMP_INT.

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, .22, .34), 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).¹² 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 comparison¹³.) 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.

¹² 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.

¹³ 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 14** aims to help readers select the appropriate source for a given comparison.

Table 14 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 11** and in **Table 15** for the European comparison.

Israel is a clear leader among the countries in the sample, even if its performance 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.¹⁴

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.

¹⁴ Nevertheless, in section 5, we make a rough attempt at simulating the impact of changing the definition of DYN to the IOI scores.

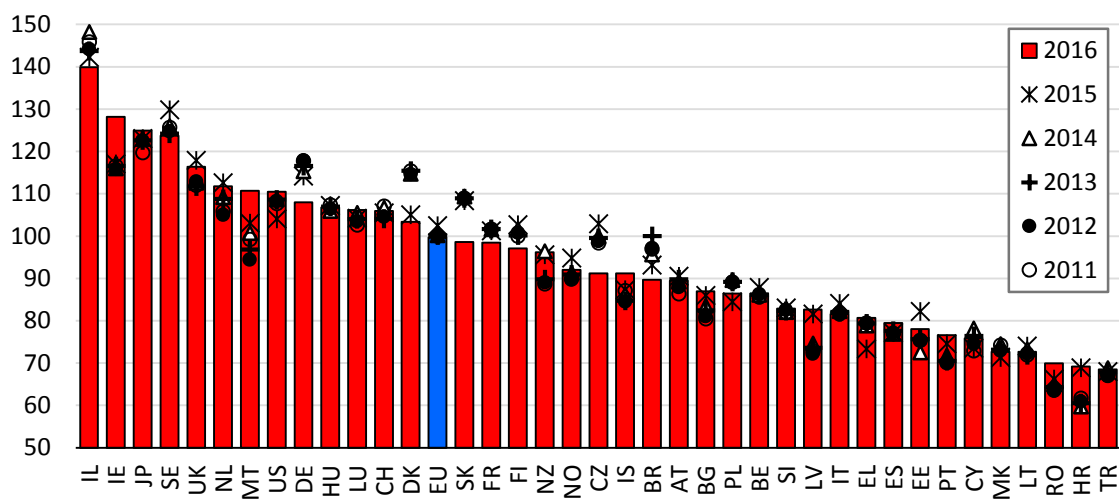


Figure 11 IOI composite scores (EUR) by country and across time

The “subway chart” in **Figure 12** offers a representation of IOI composite (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.

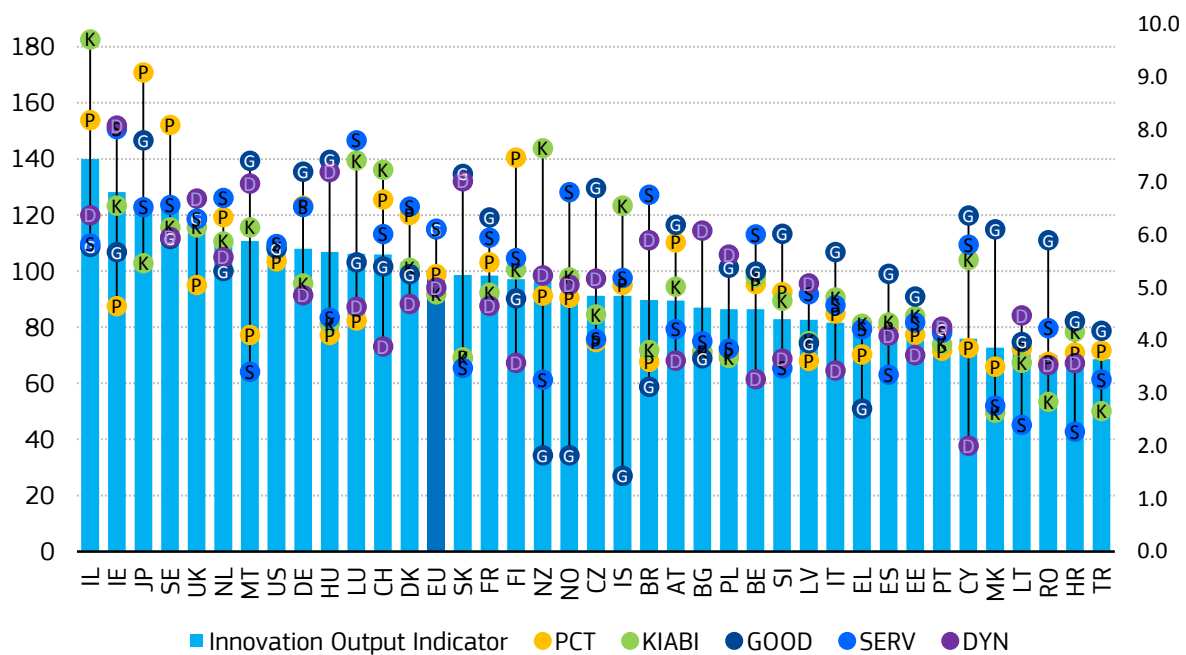


Figure 12 Innovation Output Indicator and component scores by country for the latest time point. Left vertical axis shows re-normalized scores (EU2011=100), right axis shows scores before re-normalization.

Table 15 Innovation Output Indicator scores by country: European countries' comparison

Country	2011	2012	2013	2014	2015	2016
IL	145.9	144.2	143.7	148.2	142.2	139.9
IE	116.6	115.8	116.6	116.0	117.1	128.2
JP	119.7	122.6	122.6	123.0	123.0	124.9
SE	125.7	124.7	124.2	126.0	129.9	123.7
UK	112.0	112.9	111.8	112.6	117.9	116.4
NL	105.9	105.0	108.8	109.2	112.6	111.8
MT	99.2	94.4	96.8	100.7	103.0	110.7
US	107.7	108.2	108.6	108.7	104.0	110.5
DE	117.7	117.9	116.6	115.3	114.2	108.0
HU	107.4	106.4	106.9	106.0	107.2	106.8
LU	102.6	103.5	104.0	105.5	104.2	106.2
CH	107.1	104.5	104.1	106.7	105.5	105.9
DK	115.4	114.6	115.4	114.7	105.0	103.3
EU	100.0	100.1	100.2	100.2	102.5	99.6
SK	108.9	109.0	108.9	109.3	108.4	98.6
FR	101.7	101.6	101.7	101.6	101.3	98.4
FI	100.0	100.8	100.1	101.6	102.7	97.1
NZ	88.7	89.0	89.8	96.4	95.6	96.2
NO	90.0	89.6	90.9	91.4	94.8	92.0
CZ	98.3	98.8	99.6	100.0	102.9	91.2
IS	87.1	84.5	84.7	86.2	87.3	91.2
BR	97.0	97.1	100.0	95.7	93.1	89.7
AT	86.4	87.9	89.8	89.2	90.5	89.5
BG	80.5	81.1	82.5	83.6	86.0	86.9
PL	89.1	89.2	89.2	89.6	84.5	86.4
BE	85.6	86.3	86.1	86.1	87.8	86.4
SI	82.0	82.5	82.3	82.1	83.0	82.8
LV	72.8	72.2	73.6	74.6	81.6	82.6
IT	81.8	81.4	82.1	82.3	84.1	81.6
EL	79.5	79.3	79.3	78.8	73.3	80.7
ES	77.0	77.1	77.6	76.9	77.2	79.5
EE	75.4	75.3	75.6	72.5	82.2	78.0
PT	70.1	70.2	70.5	71.9	74.6	76.6
CY	72.9	74.5	76.4	78.2	73.5	75.9
MK	74.2	72.9	73.2	74.5	71.3	72.7
LT	71.9	72.3	71.8	73.2	74.0	72.6
RO	63.7	63.4	64.3	64.9	66.2	69.9
HR	61.7	60.9	60.5	59.7	68.9	69.1
TR	67.1	66.9	67.9	68.8	68.0	68.5

Source: author's calculations. *Note:* countries ranked according to 2016 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 industrial breakdown (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).¹⁵

The global benchmark scores of 2017 and trends over time are presented below with the help of multiple figures, followed by a table of scores. The left panel of **Figure 13** 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. The right panel of **Figure 13** offers a picture of annual evolution of the IOI for the same set of countries. Country performance in the component indicators superimposed over the IOI (international) scores in **Figure 14** help understand the source of differences in IOI performance. Actual composite scores are reported in **Table 16**.

Both the US and the EU are trailing Israel and Japan in terms of the composite measure of innovation output, and despite a convergence in the 2015 time point, on the long run, the US retains a slight lead over the EU28. Interestingly, 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.

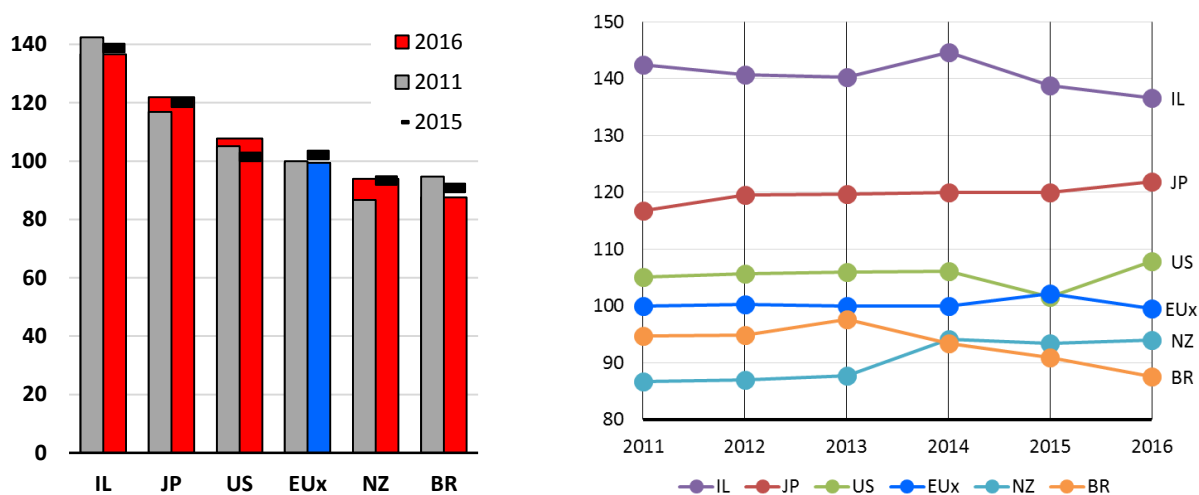


Figure 13 The innovation Output Indicator 2017: EU28 in a global comparison

¹⁵ See data source tables in Section 2 for eventual specific details and notes on data for non-EU MSs.

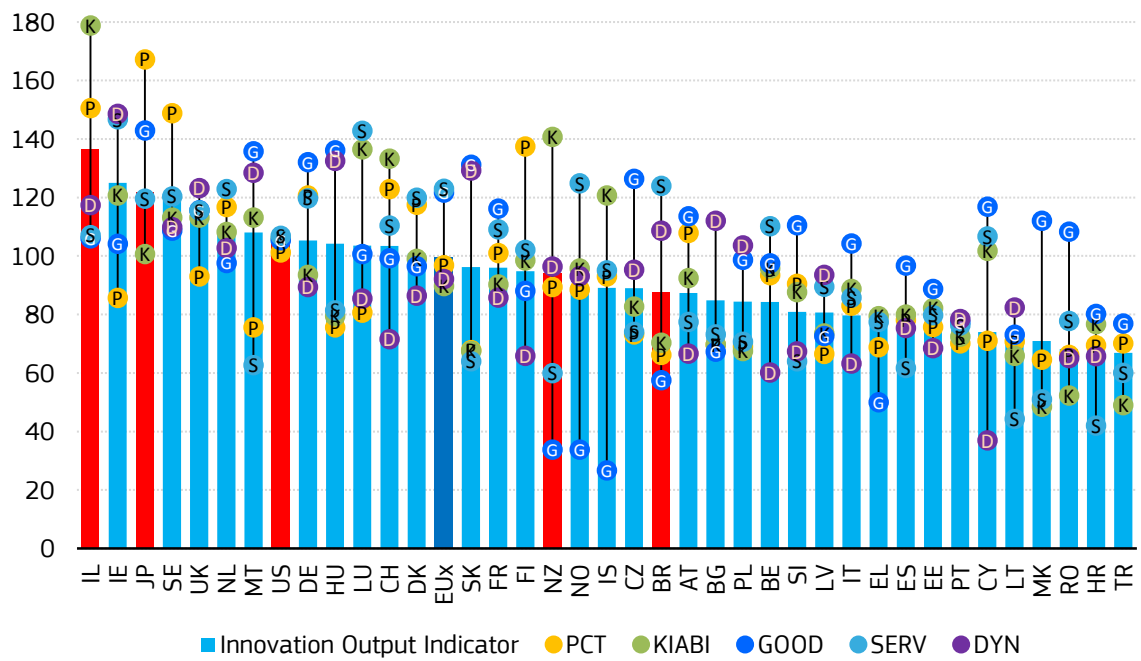


Figure 14 Innovation Output Indicator, global benchmark: country performance by components

Table 16 Innovation Output Indicator scores by country: International Comparison

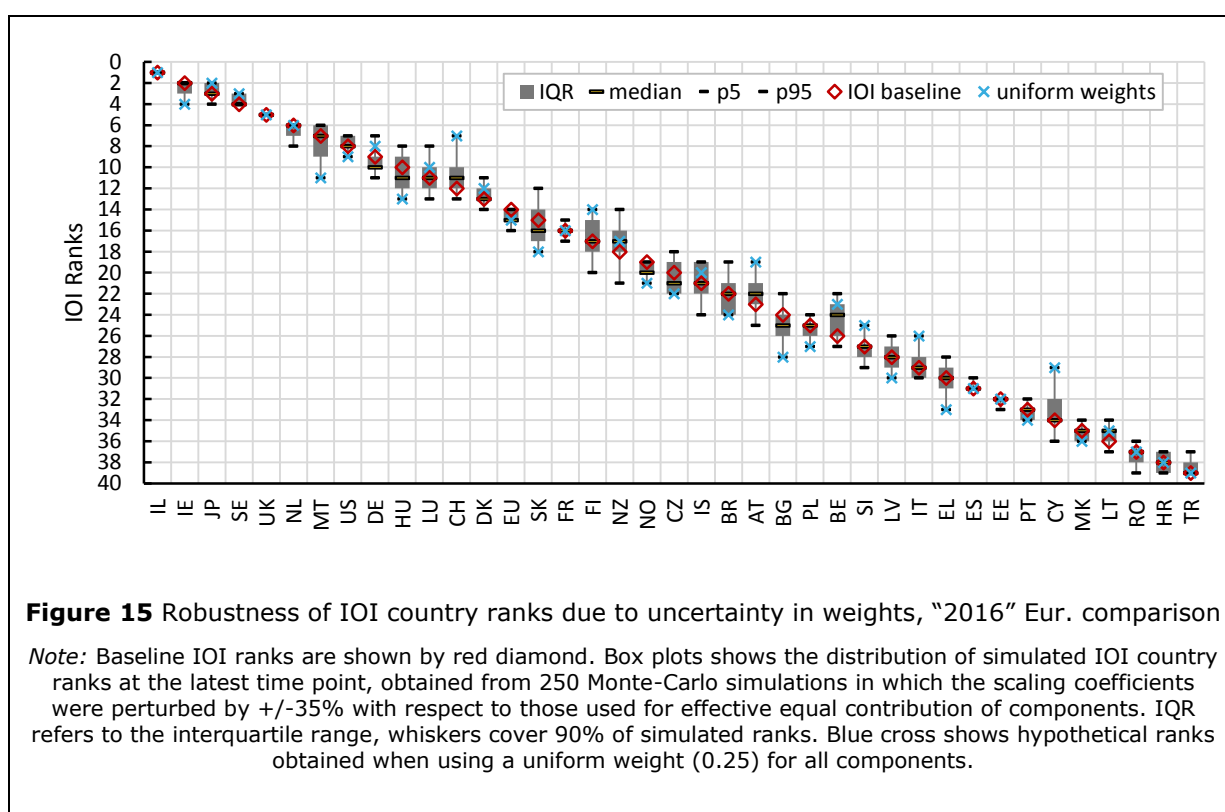
Country	2011	2012	2013	2014	2015	2016
IL	142.4	140.7	140.3	144.7	138.8	136.6
IE	113.7	113.0	113.7	113.2	114.2	125.0
JP	116.8	119.6	119.6	120.0	120.0	121.9
SE	122.7	121.7	121.2	123.0	126.7	120.7
UK	109.3	110.1	109.1	109.8	115.1	113.6
NL	103.3	102.4	106.2	106.6	109.9	109.1
MT	96.8	92.2	94.5	98.3	100.6	108.1
US	105.1	105.6	106.0	106.0	101.5	107.8
DE	114.9	115.0	113.7	112.5	111.4	105.3
HU	104.8	103.9	104.4	103.4	104.6	104.2
LU	100.1	101.0	101.5	102.9	101.7	103.6
CH	104.5	102.0	101.6	104.2	103.0	103.4
DK	112.6	111.8	112.6	112.0	102.5	100.8
EUx	100.0	100.2	99.9	100.0	102.2	99.4
SK	106.3	106.4	106.3	106.7	105.8	96.3
FR	99.2	99.1	99.2	99.2	98.8	96.0
FI	97.6	98.4	97.8	99.2	100.2	94.8
NZ	86.6	87.0	87.7	94.2	93.3	94.0
NO	87.9	87.5	88.8	89.2	92.5	89.8
IS	85.0	82.5	82.7	84.2	85.3	89.0
CZ	96.0	96.4	97.2	97.6	100.5	89.0
BR	94.6	94.8	97.6	93.4	90.9	87.5
AT	84.3	85.8	87.7	87.1	88.3	87.3
BG	78.6	79.2	80.6	81.6	84.0	84.9
PL	87.0	87.1	87.0	87.5	82.5	84.4
BE	83.5	84.2	84.0	84.1	85.7	84.3
SI	80.0	80.5	80.4	80.1	81.1	80.9
LV	71.1	70.4	71.9	72.8	79.7	80.7
IT	79.9	79.5	80.1	80.3	82.0	79.7
EL	77.6	77.5	77.5	77.0	71.6	78.8
ES	75.2	75.3	75.8	75.1	75.3	77.6
EE	73.6	73.5	73.8	70.8	80.3	76.2
PT	68.4	68.5	68.8	70.1	72.8	74.8
CY	71.1	72.7	74.5	76.3	71.7	74.0
LT	70.3	70.6	70.2	71.5	72.3	71.0
MK	72.5	71.2	71.4	72.7	69.6	70.9
RO	62.2	61.8	62.7	63.4	64.6	68.2
HR	60.2	59.5	59.1	58.4	67.3	67.5
TR	65.5	65.4	66.3	67.2	66.4	66.9

Source: author's calculations. *Note:* countries ranked according to 2016 scores; EUx 2011 = 100

5 Conclusion: robustness of ranks and validation of results

5.1 Robustness of country ranks

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. Considering that choices with regards to weights are made amidst a certain degree of uncertainty, this uncertainty in theory influences the robustness of actual country rank outcomes. We performed a robustness analysis to quantify the impact of the weights on country rankings. By running 250 Monte-Carlo simulations in which the scaling coefficients of each component were perturbed by $\pm 35\%$ with respect to those used to obtain effective equal contribution, we obtained a distribution of possible country rankings with which we could contrast the baseline IOI rankings (see **Figure 15**).¹⁶ Based on the outcomes of the uncertainty analysis, we can conclude the following. Firstly, the median rank obtained from the simulations is identical to the baseline ranking for 27 of the 39 countries, deviates 1 position for 11 countries and 2 positions in the single case of Belgium; nevertheless, the IOI baseline rank falls in all cases within the interquartile range (IQR) of possible ranks. In other words, this means that even if weights are adjusted by as much as 35% in favor of a given country, it is unlikely that it would significantly improve its rankings.



Secondly, while the results show a rather robust picture for the IOI "2016", 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, LU and CH, or the CZ, IS, BR and AT "cluster" of countries.) Countries showing the highest variance in simulated ranks include NZ, CY, as well as CH, SK, FI, AT, BG, while the lowest

¹⁶ We discuss ranks obtained from European comparison as the results obtained from the international comparison are highly similar.

variance is observed for IL, SE, UK, ES and EE. 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, CY and AT, while countries most negatively affected are MT, BG, HU, SK and EL.

5.2 Validation of results

IOI 2017 are benchmarked against IOI scores obtained from previous edition (IOI2016) 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 2016 scores to be fully aligned with IOI 2017 scores, given the rather substantial change in the definition of DYN, one of the four components. Furthermore, data updates are also affecting the other components in a retroactive manner. As shown by **Figure 17**, there is a strong, positive correlation between IOI 2016's latest time point ("2014") and IOI 2017 scores, both considering the latest time point of IOI 2017 ("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.

In an attempt to single out the impact of changing the definition of DYN on the IOI composite scores, we compared actual and simulated IOI scores, which were computed for the most recent time point using the DYN scores as used in the previous edition following to the old definition, alongside the latest data for PCT, KIABI and COMP. As the rank deviations show in **Figure 16**, the change has a rather significant impact on composite scores. The average of absolute rank changes is 4.7 positions for the 38 countries. 12 countries shift 7 or more positions and 6 countries shift 8 or more positions in absolute terms in the simulated scores. Among these latter we find Cyprus and France (which would improve 27 or 8 positions, respectively, if the old definition of DYN was used) as well as Brazil, Hungary, Malta and the Netherlands (which would fall back 12, 9, 8 and 8 positions, respectively, with the old definition). The impact of the change of the DYN definition should therefore be taken into consideration when interpreting composite scores.

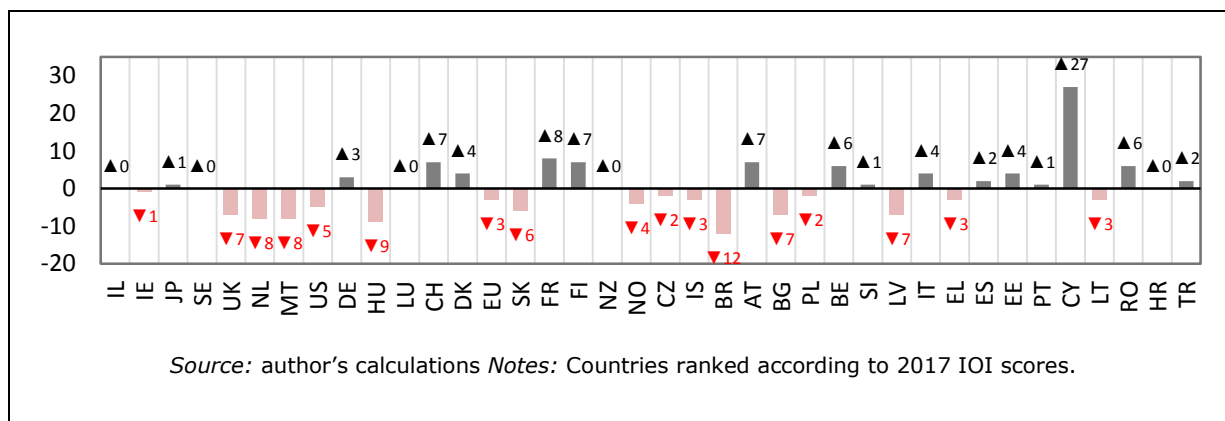


Figure 16 Deviation from baseline ranks in a scenario where old DYN scores (2013 figures) are used (in combination with the most recent data for the rest of the components)

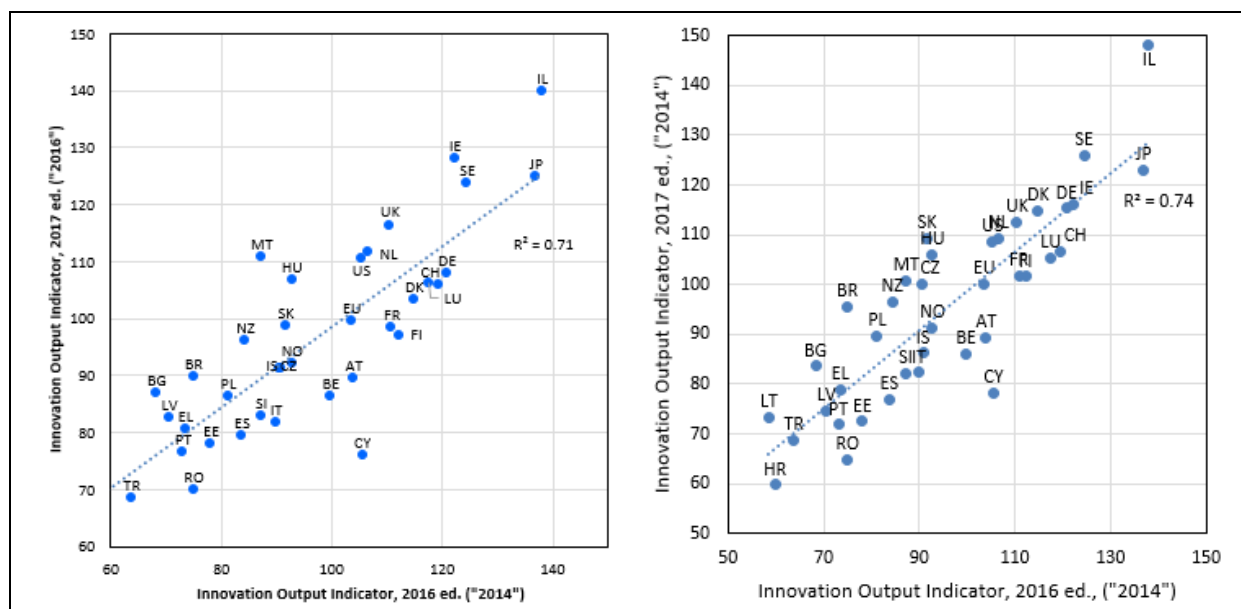


Figure 17 Comparison of IOI scores between the 2017 and 2016 editions. Left panel shows "2016" time point, right panel shows "2014" time point from the 2017 edition.

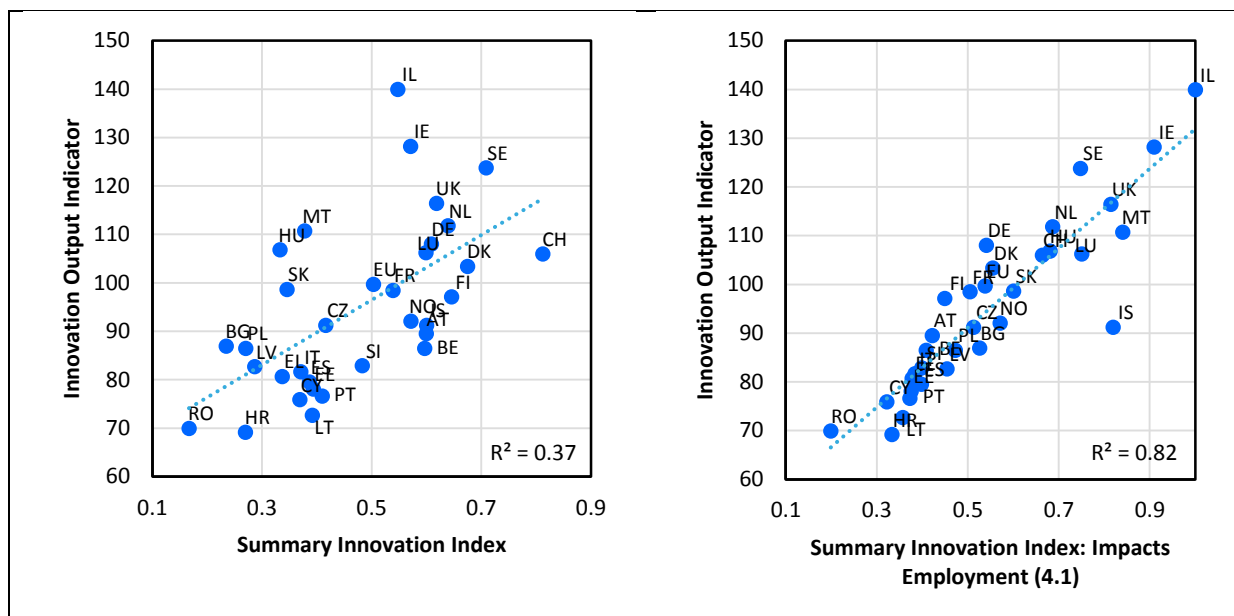


Figure 18 Comparison of country scores according to IOI, and the Summary Innovation Index as well as the EIS's Impacts: Employment (4.1) pillar

It is also interesting to compare the IOI with Summary Innovation Index, and other indices of the European Innovation Scoreboard (EIS). We observe that the IOI and SII offer a different picture of country performance (left panel of **Figure 18**). While the two indices are positively correlated (Pearson $r=0.64$), 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 18** 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.

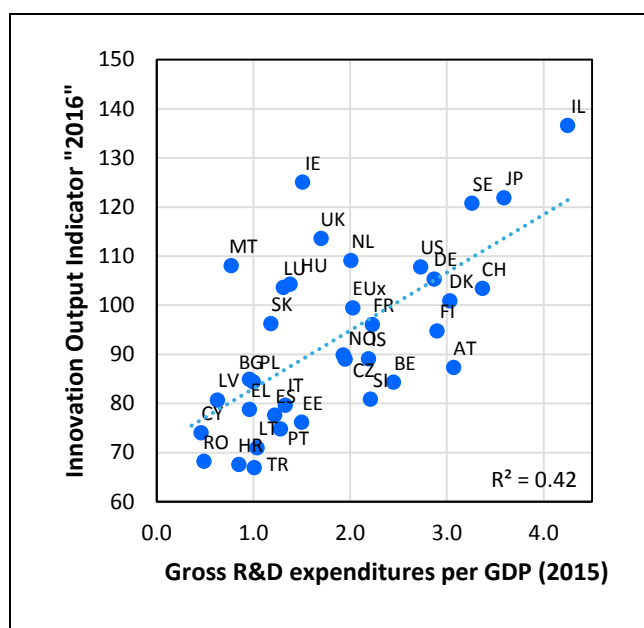


Figure 19 The relationship between Innovation Output and R&D expenditure

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 19**. 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) in comparison with, for instance the Summary Innovation Index¹⁷.

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.

¹⁷ 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

List of Figures

Figure 1 The Innovation Output Indicator framework	6
Figure 2 PCT patent applications per billion GDP (in PPS)	9
Figure 3 Comparison of GDP and Population as denominators for PCT	9
Figure 4 Share of employment in knowledge-intensive activities in business industries .	11
Figure 5 The share of medium- and high-tech products in total exports (in %)	14
Figure 6 Knowledge-intensive services exports as percentage of total services exports .	16
Figure 7 Employment in fast-growing enterprises in the top 50% most innovative sectors as a percentage of total employment (in %)	18
Figure 8 Business dynamics in fast growing enterprises in top 50% most innovative sectors: a structural composition by country, 2014	22
Figure 9 Employment share in high-growth firms in the machinery and motor vehicles industries, 2013-2014	22
Figure 10 Scatterplot matrix for normalized IOI component scores, most recent year ...	25
Figure 11 IOI composite scores (EUR) by country and across time	28
Figure 12 Innovation Output Indicator and component scores by country for the latest time point. Left vertical axis shows re-normalized scores (EU2011=100), right axis shows scores before re-normalization.	29
Figure 13 The innovation Output Indicator 2017: EU28 in a global comparison	31
Figure 14 Innovation Output Indicator, global benchmark: country performance by components	32
Figure 15 Robustness of IOI country ranks due to uncertainty in weights, “2016” Eur. comparison	34
Figure 16 Deviation from baseline ranks in a scenario where old DYN scores (2013 figures) are used (in combination with the most recent data for the rest of the components)	36
Figure 17 Comparison of IOI scores between the 2017 and 2016 editions. Left panel shows “2016” time point, right panel shows “2014” time point from the 2017 edition.....	36
Figure 18 Comparison of country scores according to IOI, and the Summary Innovation Index as well as the EIS’s Impacts: Employment (4.1) pillar	37
Figure 19 The relationship between Innovation Output and R&D expenditure.....	38

List of Tables

Table 1 Key parameters of the PCT Component.....	8
Table 2 PCT: PCT Applications per billion GDP (PPS)	10
Table 3 Key parameters of the KIABI component.....	11
Table 4 KIABI: Employment share in knowledge-intensive activities in business industries	12
Table 5 Key parameters of the GOOD component	13
Table 6 GOOD: The share of medium- and high-tech products in total exports	15
Table 7 Key parameters of the SERV component	16
Table 8 SERV: Knowledge-intensive services exports as percentage of total services exports (in %)	17
Table 9 Key parameters of the DYN component.....	18
Table 10 DYN: Employment in fast-growing enterprises in the top 50% most innovative sectors as a percentage of total employment (in %)	19
Table 11 Inclusion of 2-digit sectors among the top 25-50% most innovative ones.....	21
Table 12 Descriptive statistics and correlation scores for the IOI variables (all 6 years). 23	
Table 13 Descriptive statistics and pairwise Pearson correlation for the normalized components (6 years, pooled dataset)	24
Table 14 Which source to use for different comparisons?.....	27
Table 15 Innovation Output Indicator scores by country: European countries' comparison.....	30
Table 16 Innovation Output Indicator scores by country: International Comparison	33

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Publications Office

doi:10.2760/971852

ISBN 978-92-79-76474-5