European Innovation Scoreboard 2021

Methodology Report

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1. Introduction

The annual European Innovation Scoreboard (EIS) provides a comparative assessment of the research and innovation performance of the EU Member States and the relative strengths and weaknesses of their research and innovation systems. It helps Member States assess areas in which they need to concentrate their efforts to boost their innovation performance.

The European Innovation Scoreboard (EIS) provides a comparative analysis of innovation performance in EU countries, other European countries, and regional neighbours. The first edition of the EIS was published in 2001. Over time the measurement framework has been revised several times, with the latest major revision in 2017 reflecting the need to: 1) better align the EIS dimensions with changing policy priorities, 2) continuously improve the quality, timeliness and analytical soundness of indicators, 3) ensure that the EIS captures increasingly important phenomena in the context of business innovation, and 4) provide a contextual analysis of the data presented.

Section 2 of this Methodology report discusses the process on the revised measurement framework for the EIS 2021. Section 3 presents the revised measurement framework and Section 4 presents definitions for all the indicators. Section 5 provides a detailed discussion of the methodology used for calculating the Summary Innovation Index. Section 6 provides the definitions of the contextual indicators included in the EIS 2021 Country profiles.

2. Revision process

New policy developments have required a revision of the measurement framework of the EIS and its regional extension, the Regional Innovation Scoreboard (RIS). The revision process has included a number of reports and (virtual) workshops discussing the following topics:

- Methodological improvements to existing indicators.
- Redefining country performance groups.
- The identification of additional innovation dimensions and indicators to be included in the EIS.
- The identification of indicators and data sources for measuring digital skills.

  The Exploratory report on *Measuring Digital Skills*[1] has analysed different options for including indicators in the EIS of which two have been adopted: Individuals who have at least basic digital skills (percentage share of all individuals) and Employed ICT specialists (percentage share of total employment). Full details are provided in the Exploratory report.
- The identification of indicators and data sources for measuring social innovation.

  The Exploratory report on *How to measure social innovation*[2] has analysed different options for including indicators in the EIS but none could be included. Full details are provided in the Exploratory report.
- The identification of indicators and data sources for measuring environmental innovation.
- The Exploratory report on *How to measure environmental innovation*[3] has analysed different options for including indicators in the EIS of which three have been adopted: Resource productivity, Air emissions by fine particulates (PM2.5) in industry, and Development of environment-related technologies. Full details are provided in the Exploratory report.

The results of the revision process are implemented in the current 2021 editions of both the European Innovation Scoreboard and the Regional Innovation Scoreboard.

[1] https://ec.europa.eu/docsroom/documents/45666
[2] https://ec.europa.eu/docsroom/documents/45665
[3] https://ec.europa.eu/docsroom/documents/45664

3. The revised measurement framework for the EIS 2021

The EIS 2021 will, as the EIS 2020, distinguish between four main types of activities – Framework conditions, Investments, Innovation activities, and Impacts – and 12 innovation dimensions, capturing in total 32 indicators. Each main group includes an equal number of indicators and has an equal weight in the Summary Innovation Index. Within each group every indicator has the same weight. Indicators that are included in the revised measurement framework are presented in Table 1. Indicators highlighted with a * are either new or use a revised definition.

Table 1 Indicators included in the Revised measurement framework for the EIS 2021

FRAMEWORK CONDITIONS (8 indicators)

- Human resources
  - * New doctorate graduates (STEM) (% share)
  - Population with tertiary education (% share)
- Attractive research systems
  - International scientific co-publications per million population
  - Top 10% most cited publications (% share)
  - Foreign doctorate students (% share)
- Digitalisation
  - Broadband penetration (% share)
  - * Individuals who have above basic overall digital skills (% share)

INVESTMENTS (8 indicators)

- Finance and support
  - R&D expenditures public sector (% of GDP)
  - Venture capital expenditures (% of GDP)
  - * Direct government funding and government tax support for business R&D
- Firm investments
  - R&D expenditures business sector (% of GDP)
  - Non-R&D innovation expenditures (% of turnover)
  - * Innovation expenditure per person employed
- Use of information technologies
  - Enterprises providing training to develop or upgrade ICT skills of their personnel (% share)
  - * Employed ICT specialists (% of total employment)

INNOVATION ACTIVITIES (8 indicators)

- Innovators
  - * SMEs with product innovations (% share)
  - * SMEs with business process innovations (% share)
- Linkages
  - Innovative SMEs collaborating with others (% share)
  - * Public-private co-publications per million population
  - * Job-to-job mobility of Human Resources in Science & Technology (% share)
- Intellectual assets
  - PCT patent applications per billion GDP (in PPS)
  - * Trademark applications per billion GDP (in PPS)
  - Design applications per billion GDP (in PPS)

IMPACTS (8 indicators)

- Employment impacts
  - Employment in knowledge-intensive activities (% share)
  - * Employment in innovative enterprises (% share)
- Sales impacts
  - Medium and high-tech product exports (% share)
  - Knowledge-intensive services exports (% share)
  - Sales of new or improved products ('product innovations') (% of turnover)
- Environmental sustainability
  - * Resource productivity (measured as domestic material consumption (DMC) in relation to GDP)
  - * Air emissions by fine particulate matter (PM2.5) in Industry
  - * Development of environment-related technologies

* New or revised indicator

Framework conditions captures the main drivers of innovation performance external to the firm and differentiates between three innovation dimensions:

- *Human resources* includes three indicators and measures the availability of a high-skilled and educated workforce. Human resources includes New doctorate graduates in STEM, Population aged 25-34 with completed tertiary education, and Population aged 25-64 involved in lifelong learning activities. Compared to the EIS 2020, the indicator measuring New doctorate graduates is more focused as it only includes graduates in science, technology, engineering, and mathematics (STEM).
- *Attractive research systems* includes three indicators and measures the international competitiveness of the science base by focusing on International scientific co-publications, Most cited publications, and Foreign doctorate students.

  Compared to the EIS 2020, there have been no changes to the indicators.
- *Digitalisation* measures the level of digital technologies and includes two indicators, Broadband penetration among enterprises and (the supply of) Individuals with above basic overall digital skills. This dimension replaces the EIS 2020 dimension on Innovation-friendly environment. The broadband indicator is the same, and the indicator measuring digital skills is new following the recommendation in the Exploratory report. The inclusion of digital skills and the renaming of this dimension aims to improve the measurement of digitalisation and digital skills.

Investments captures investments made in both the public and business sector and differentiates between three innovation dimensions:

- *Finance and support* includes three indicators including private funding (Venture capital investments), R&D expenditures in universities and government research organisations and Direct government funding and government tax support for business R&D.

  Compared to the EIS 2020, the indicator on government support for R&D is new. This indicator is relevant as it captures indirect tax support for business R&D, a support mechanism which is used by an increasing number of countries. In the EU, 21 countries were offering R&D tax relief in 2018, a significant increase compared to only 12 countries offering R&D tax relief in 2000. Public financing of R&D can take two forms: direct funding for R&D through instruments such as grants and public procurement, and indirect support through the tax system. Direct funding is captured in the official data on R&D expenditures by source of funding. Over time, more and more countries have introduced R&D tax incentives. The OECD has started to collect such data systematically since 2017 and with the support of the European Commission, data are currently being collected on an annual basis and made available in the 'OECD R&D Tax Incentives database'.
- *Firm investments* includes three indicators on R&D and Non-R&D investments that firms make to generate innovations including Business R&D expenditures, Non-R&D innovation expenditures, and Innovation expenditures per person employed.

  Compared to the EIS 2020, the indicator on Innovation expenditures per person employed is new. The indicator measures the monetary input directly related to innovation activities and uses data from the Community Innovation Survey (CIS), controlling for purchasing power differences (PPP) across Member States.
- *Use of information technologies* captures the use of information technologies including two indicators: Enterprises actively increasing the ICT skills of their personnel and Employed ICT specialists.

  To improve the measurement on the use of information technologies, a new dimension has been included compared to the EIS 2020. Enterprises actively increasing the ICT skills of their personnel was included in previous editions of the EIS but under Framework conditions in the Innovation-friendly environment dimension. The indicator measuring Employed ICT specialists is new and is one of the indicators recommended in the Exploratory report on measuring digital skills. ICT specialists are defined as "workers who have the ability to develop, operate and maintain ICT systems, and for whom ICT constitute the main part of their job".

Innovation activities captures different aspects of innovation in the business sector and differentiates between three innovation dimensions:

- *Innovators* includes two indicators measuring the share of SMEs that have introduced innovations on the market or within their organisations, covering both product and business process innovators.

  Compared to the EIS 2020 the definition of both indicators has changed following the revised questionnaire in the CIS after adopting the recommendations from the 2018 edition of the Oslo Manual on measuring innovation activities. The first indicator now focuses on product innovations, and the second on business process innovation, combining process, marketing and organisational innovations as used in the CIS editions before the latest CIS 2018.

- *Linkages* includes three indicators measuring innovation capabilities by looking at Collaboration efforts between innovating firms, Research collaboration between the private and public sector, and Job-to-job mobility of Human Resources in Science & Technology (HRST).

  Compared to the EIS 2020, the indicator on Job-to-job mobility of HRST is new. Mobility of skilled personnel affects the degree of knowledge creation, which is one of the key drivers of innovation. Human Resources in Science & Technology (HRST) are people who fulfil one or other of the following conditions: have successfully completed a tertiary level education; not formally qualified as above but employed in a S&T occupation where the above qualifications are normally required. Job-to-job mobility in this context is defined as the movement of individuals between one job and another from one year to the next. It does not include inflows into the labour market from a situation of unemployment or inactivity.

  Compared to the EIS 2020, the definition of the indicator measuring Public-private co-publications has changed. In the EIS 2020, publications were assigned to the country or countries in which the enterprises or other private sector organisations are located. In the EIS 2021, also those publications assigned to the country or countries in which the public sector organisations are located are included, thus also including co-publications between domestic public sector organisations and foreign enterprises.

- *Intellectual assets* captures different forms of Intellectual Property Rights (IPR) generated by the innovation process, including PCT patent applications, Trademark applications, and Design applications.

  Compared to the EIS 2020, the definition for the indicator measuring Trademark applications has changed. The indicator no longer includes trademark applications applied for at the World Intellectual Property Office (WIPO).

Impacts captures the effects of enterprises' innovation activities and differentiates between three innovation dimensions:

- *Employment impacts* measures the impact on employment and includes two indicators: Employment in knowledge-intensive activities and Employment in innovative enterprises.

  Compared to the EIS 2020, the indicator Employment in innovative enterprises is new. Innovation in enterprises has a profound impact on the employability of workers, but its effect on product- and process-innovation oriented enterprises varies across countries. Business innovation proves to be specifically important during a time of economic recession. The indicator captures the employment impact of innovation by measuring the share of employed persons in innovative enterprises in total business sector employment. and uses data from the Community Innovation Survey.

- *Sales impacts* measures the economic impact of innovation and includes three indicators: Exports of medium and high-tech products, Exports of knowledge-intensive services, and Sales resulting from innovative products.

  Compared to the EIS 2020, there have been no changes to the indicators.

- *Environmental sustainability* captures improvements to reducing the negative impact on the environment including three indicators: Resource productivity, Exposure to Air pollution by fine particulates PM2.5, and the Development of environment-related technologies.

  As the natural environment suffers from the loss of biodiversity, pollution and climate change, environmental innovation gains in importance. To improve the measurement of environmental innovation, a new dimension has been added which consists of three new indicators measuring

Environmental sustainability. These indicators were recommended in the Exploratory report on measuring environmental innovation.

Resource productivity is expressed by the amount of GDP generated per unit of direct material consumed, i.e. GDP / DMC in Euros per kg. Resource productivity is a measure of the total amount of materials directly used by an economy (measured as domestic material consumption (DMC)) in relation to GDP. It provides insights into whether decoupling between the use of natural resources and economic growth is taking place and is the EU sustainable development indicator for policy evaluation. Domestic material consumption (DMC) measures the total amount of materials directly used by an economy and is defined as the annual quantity of raw materials extracted domestically, plus all physical imports minus all physical exports.

Air pollution has the potential to harm both human health and the environment: particulate matter (PM), nitrogen dioxide and ground-level ozone are known to pose particular health risks. The indicator on Air emissions by fine particulate matter PM2.5 in Industry captures average air emissions by Industry. PM2.5 are particles with a diameter of 2.5 micrometres or less and are considered by the World Health Organisation (WHO) as the pollutant with the highest impact on human health.

The number of environment-related inventions is expressed as a percentage of all domestic inventions (in all technologies). Indicators of technology development are constructed by measuring inventive activity using patent data across a wide range of environment-related technological domains, including environmental management, water-related adaptation, and climate change mitigation technologies. Data are obtained from the OECD Environment Database.

In Chapter 4, definitions and possible impacts on the EIS are discussed for each indicator.

4. Definitions of EIS 2021 innovation indicators

Indicator	New doctorate graduates in science, technology, engineering, and mathematics (STEM) per 1000 population aged 25-34
Numerator	Number of doctorate graduates in science, technology, engineering, and mathematics (STEM)
Denominator	Population between and including 25 and 34 years
Interpretation	The indicator is a measure of the supply of new second-stage tertiary graduates in all fields of training (ISCED 8). For most countries, ISCED 8 captures PhD graduates. There is a complex relation between STEM-graduates and innovation in the private sector. STEM-graduates do well as an employee within firms with many of them taking up managerial positions. Graduates with a STEM-background who have completed a non-STEM study next to their core curriculum, show as much entrepreneurial activity as non-STEM graduates.
Data source	Eurostat (educ_uoe_grad07)
Change to EIS 2020	This indicator is more narrowly defined as in the EIS 2020 as it focuses on STEM graduates only whereas the EIS 2020 covered doctorate graduates in all fields.
Indicator	1.1.2 Percentage population aged 25-34 having completed tertiary education
Numerator	Number of persons in age class with some form of post-secondary education
Denominator	Population between and including 25 and 34 years
Interpretation	This is a general indicator of the supply of advanced skills. It is not limited to science and technical fields, because the adoption of innovations in many areas, in particular in the service sectors, depends on a wide range of skills. The indicator focuses on a relatively young age cohort of the population, aged 25 to 34, and will therefore easily and quickly reflect changes in educational policies leading to more tertiary graduates.
Data source	Eurostat (edat_lfse_03)
Indicator	1.1.3 Percentage population aged 25-64 participating in lifelong learning
Numerator	The target population for lifelong learning statistics refers to all persons in private households aged between 25 and 64 years. The information collected relates to all education or training, whether or not relevant to the respondent's current or possible future job. Data are collected through the EU Labour Force Survey. The reference period for the participation in education and training is the four weeks preceding the interview, as is usual in the Labour Force Survey.
Denominator	Total population of the same age group, excluding those who did not answer the question concerning participation in (formal and non-formal) education and training
Interpretation	Lifelong learning encompasses all purposeful learning activity, whether formal, non-formal or informal, undertaken on an ongoing basis with the aim of improving knowledge, skills and competence. The intention or aim to learn is the critical point that distinguishes these activities from non-learning activities, such as cultural or sporting activities.
Data source	Eurostat (trng_lfs_01)
Indicator	1.2.1 International scientific co-publications per million population
Numerator	Number of scientific publications with at least one co-author based abroad
Denominator	Total population
Interpretation	International scientific co-publications are a proxy for the quality of scientific research as collaboration increases scientific productivity.
Data source	Scopus database. Data calculated by Science-Metrix as part of a contract to the European Commission (DG Research and Innovation)

Indicator	1.2.2 Scientific publications among the top-10% most cited publications worldwide as percentage of total scientific publications of the country
Numerator	Number of scientific publications among the top-10% most cited publications worldwide
Denominator	Total number of scientific publications
Interpretation	The indicator is a measure for the efficiency of the research system, as highly cited publications are assumed to be of higher quality. There could be a bias towards small or English-speaking countries given the coverage of Scopus' publication data.
Data source	Scopus database. Data calculated by Science-Metrix as part of a contract to the European Commission (DG Research and Innovation)
Indicator	1.2.3 Foreign doctorate students as a percentage of all doctorate students
Numerator	Number of doctorate students from foreign countries
Denominator	Total number of doctorate students
Interpretation	The share of foreign doctorate students reflects the mobility of students as an effective way of diffusing knowledge. Attracting high-skilled foreign doctorate students will secure a continuous supply of researchers.
Data source	Eurostat (educ_uoe_mobs01, educ_uoe_enra03)
Indicator	1.3.1 Broadband penetration
Numerator	Number of enterprises with a maximum contracted download speed of the fastest fixed internet connection of at least 100 Mb/s
Denominator	Total number of enterprises
Interpretation	Realising Europe's full e-potential depends on creating the conditions for electronic commerce and the Internet to flourish. This indicator captures the relative use of this e-potential by the share of enterprises that have access to fast broadband.
Data source	Eurostat, Community Survey of ICT Usage and E-commerce in Enterprises (isoc_ci_it_en2)
Indicator	1.3.2 Individuals who have above basic overall digital skills (% share)
Definition	Number of individuals with above basic overall digital skills
Interpretation	Above basic overall digital skills represents the highest level of the overall digital skills indicator, which is a composite indicator based on selected activities performed by individuals aged 16-74 on the internet in four specific areas (information, communication, problem solving, content creation) during the previous 3 months
Data source	Eurostat, EU survey on the ICT usage in households and by individuals (isoc_sk_dskl_i)
Change to EIS 2020	This is a new indicator which has been introduced to better capture the aspect of digitalisation. The indicator is also included in the Digital Economy and Society Index (DESI) index[4], the ECs composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU Member States in digital competitiveness'.
Indicator	2.1.1 R&D expenditure in the public sector (percentage of GDP)
Numerator	All R&D expenditures in the government sector (GOVERD) and the higher education sector (HERD)
Denominator	Gross Domestic Product

[4] https://digital-strategy.ec.europa.eu/en/policies/desi

Interpretation	R&D expenditure represents one of the major drivers of economic growth in a knowledge-based economy. As such, trends in the R&D expenditure indicator provide key indications of the future competitiveness and wealth of the EU. Research and development spending is essential for making the transition to a knowledge-based economy as well as for improving production technologies and stimulating growth.
Data source	Eurostat (rd_e_gerdtot)
Indicator	2.1.2 Venture capital expenditures (percentage of GDP)
Numerator	Venture capital expenditures is defined as private equity being raised for investment in companies. Management buyouts, management buy-ins, and venture purchase of quoted shares are excluded. Venture capital includes early-stage (seed + start-up) and expansion and replacement capital.
Denominator	Gross Domestic Product
Interpretation	The amount of venture capital is a proxy for the relative dynamism of new business creation. In particular for enterprises using or developing new (risky) technologies, venture capital is often the only available means of financing their (expanding) business.
Comment	Three-year averages have been used for calculating the normalised scores for this indicator, which are used for calculating the Summary Innovation Index.
Data source	Venture capital data from Invest Europe. GDP data from Eurostat
Indicator	2.1.3 Direct government funding and government tax support for business R&D (percentage of GDP)
Numerator	Sum of GTARD and Direct funding of BERD
Denominator	Gross Domestic Product
Interpretation	Public financing of R&D can take two forms: Direct funding for R&D through instruments such as grants and public procurement, and Indirect support through the tax system. Direct funding is well captured in the official data on R&D expenditure by source of fund, differentiating between the following sources: Business enterprise sector, Government sector, Higher education sector, Private non-profit sector, and Abroad. Data on R&D funded by the Government sector are available from Eurostat (EU Member States and other European countries), OECD (OECD member states) and UIS (global coverage). Over time, more and more countries have introduced R&D tax incentives. The OECD has started to collect data on such systematically since 2017 and with the support of the EC data are currently being collected on an annual basis and made available in the 'OECD R&D Tax Incentives database'. In the EU, 21 countries were offering R&D tax relief in 2018, a significant increase compared to only 12 countries offering R&D tax relief in 2000.
Data source	OECD R&D Tax Incentive Database, http://oe.cd/rdtax, December 2020.
Change to EIS 2020	This is a new indicator which has been introduced to better capture the aspect of government support for business R&D. The indicator on total government support for R&D is relevant as it also captures indirect support for business R&D, a support mechanism which is used by an increasing number of countries. The indicator would also be a better measure for capturing the 1% funding target for the government as part of the overall target of spending 3% of GDP on R&D.
Indicator	2.2.1 R&D expenditure in the business sector (percentage of GDP)
Numerator	All R&D expenditures in the business sector (BERD)
Denominator	Gross Domestic Product
Interpretation	The indicator captures the formal creation of new knowledge within firms. It is particularly important in the science-based sectors (pharmaceuticals, chemicals and some areas of electronics) where most new knowledge is created in or near R&D laboratories.
Data source	Eurostat (rd_e_gerdtot)

Indicator	2.2.2 Non-R&D innovation expenditures (percentage of turnover)
Numerator	Sum of total innovation expenditure for enterprises, excluding intramural and extramural R&D expenditures
Denominator	Total turnover for all enterprises
Interpretation	This indicator measures non-R&D innovation expenditure as a percentage of total turnover. Several of the components of innovation expenditure, such as investment in equipment and machinery and the acquisition of patents and licenses, measure the diffusion of new production technology and ideas.
Data source	Eurostat (Community Innovation Survey) (inn_cis11_exp, inn_cis11_bas)
Indicator	2.2.3 Innovation expenditures per person employed
Numerator	Sum of total innovation expenditure by enterprises in all size classes in Purchasing Power Standards (PPS)
Denominator	Total employment in innovative enterprises in all size classes
Interpretation	The indicator measures the monetary input directly related to innovation activities.
Data source	Eurostat (Community Innovation Survey) (inn_cis11_exp, inn_cis11_bas)
Change to EIS 2020	This is a new indicator which has been introduced to better capture investments in innovation activities.
Indicator	2.3.1 Enterprises providing training to develop or upgrade ICT skills of their personnel
Numerator	Number of enterprises that provided any type of training to develop ICT related skills of their personnel
Denominator	Total number of enterprises
Interpretation	ICT skills are particularly important for innovation in an increasingly digital economy. The share of enterprises providing training in that respect is a proxy for the overall skills development of employees.
Data source	Eurostat, Community Survey of ICT Usage and E-commerce in Enterprises
Indicator	2.3.2 ICT specialists (as a percentage of total employment
Numerator	Number of employed ICT specialists
Denominator	Total employment
Interpretation	Eurostat defines ICT specialists as "workers who have the ability to develop, operate and maintain ICT systems, and for whom ICT constitute the main part of their job". Operationalised in terms of ISCO codes, this definition converts into a statistical definition of ICT specialists as follow: from 2011 onwards - corresponding to the application of the ISCO-08, Eurostat and OECD adopted a joint approach to define the occupations to be treated as ICT specialists (OECD, 2015[5]).
Data source	Eurostat (isoc_ske_ittn2)
Change to EIS 2020	This is a new indicator which has been introduced to better capture the use of Information technologies.
Indicator	3.1.1 SMEs introducing product innovations (percentage of SMEs)
Numerator	Number of Small and medium-sized enterprises (SMEs) who introduced at least one product innovation either new to the enterprise or new to their market
Denominator	Total number of Small and medium-sized enterprises (SMEs)

[5] https://ec.europa.eu/eurostat/cache/metadata/Annexes/isoc_skslf_esms_an1.pdf

Interpretation	Product innovation is a key ingredient to innovation as they can create new markers and improve competitiveness. Higher shares of product innovators reflect a higher level of innovation activities.
Comment	SMEs are defined as including all enterprises with 10 to 249 employees
Data source	Eurostat (Community Innovation Survey) (inn_cis11_prodn, inn_cis11_bas)
Change to EIS 2020	This indicator replaces the EIS 2020 indicator on SMEs with product and/or process innovations as these data are no longer collected from the (revised) CIS 2018 onwards.
Indicator	3.1.2 SMEs introducing business process innovations (percentage of SMEs)
Numerator	Number of Small and medium-sized enterprises (SMEs) who introduced at least one business process innovation either new to the enterprise or new to their market
Denominator	Total number of Small and medium-sized enterprises (SMEs)
Interpretation	Many firms innovate not by improving new products but by improving their business processes. Business process innovations include process, marketing and organisational innovation.
Comment	SMEs are defined as including all enterprises with 10 to 249 employees
Data source	Eurostat (Community Innovation Survey) (inn_cis11_spec, inn_cis11_bas)
Change to EIS 2020	This indicator replaces the EIS 2020 indicator on SMEs with marketing and/or organisational innovations as these data are no longer collected from the (revised) CIS 2018 onwards.
Indicator	3.2.1 Innovative SMEs collaborating with others (percentage of SMEs)
Numerator	Number of Small and medium-sized enterprises (SMEs) with innovation co-operation activities including all enterprises firms that had any co-operation agreements on innovation activities with other enterprises or institutions in the three years of the survey period
Denominator	Total number of Small and medium-sized enterprises (SMEs)
Interpretation	This indicator measures the degree to which SMEs are involved in innovation co-operation. Complex innovations, in particular in ICT, often depend on the ability to draw on diverse sources of information and knowledge, or to collaborate in the development of an innovation. This indicator measures the flow of knowledge between public research institutions and firms, and between firms and other firms. The indicator is limited to SMEs, because almost all large firms are involved in innovation co-operation.
Comment	SMEs are defined as including all enterprises with 10 to 249 employees
Data source	Eurostat (Community Innovation Survey) (inn_cis11_co, inn_cis11_bas)
Indicator	3.2.2 Public-private co-publications per million population
Numerator	Number of public-private co-authored research publications with both domestic and foreign collaborators. The definition of the "private sector" excludes the private medical and health sector
Denominator	Total population
Interpretation	This indicator captures public-private research linkages and active collaboration activities between business sector researchers and public sector researchers resulting in academic publications.
Data source	Scopus database. Data calculated by Science-Metrix as part of a contract to the European Commission (DG Research and Innovation)

Change to EIS 2020	The EIS 2020 indicator measured the number of public-private co-authored research publications, where publications are assigned to the country/countries in which the business companies or other private sector organisations are located. The ES 2021 indicator used a broader definition as it also includes those public-private co-authored research publications, where publications are assigned to the country/countries in which the public sector organisations are located, thus also including co-publications between domestic public sector organisations and foreign enterprises.
Indicator	3.2.3 Job-to-job mobility of Human Resources in Science & Technology
Numerator	Job-to-job mobility of Human Resources in Science & Technology
Denominator	Working age population aged 25-64
Interpretation	Human Resources in Science & Technology (HRST) are people who fulfil one or other of the following conditions: 1) have successfully completed a tertiary level education; 2) not formally qualified as above but employed in a S&T occupation where the above qualifications are normally required. Job-to-job mobility in this context is defined as the movement of individuals between one job and another from one year to the next. It does not include inflows into the labour market from a situation of unemployment or inactivity.
Data source	Eurostat (hrst_fl_mobsex)
Change to EIS 2020	This is a new indicator and has been introduced to measure the exchange of knowledge resulting from people between one job and another. Not all changes in jobs include the creation of knowledge or the diffusion of knowledge, but one may assume that it is more likely that knowledge creation and diffusion takes place when more employees move between one job and another.
Indicator	3.3.1 PCT patent applications per billion GDP (in PPS)
Numerator	Number of patent applications filed under the PCT, at international phase, designating the European Patent Office (EPO). Patent counts are based on the priority date, the inventor's country of residence and fractional counts.
Denominator	Gross Domestic Product in Purchasing Power Standard
Interpretation	The capacity of firms to develop new products will determine their competitive advantage. One measure of the rate of new product innovation is the number of patents. This indicator measures the number of PCT patent applications.
Data source	Patent data from the OECD. GDP data from Eurostat
Indicator	3.3.2 Trademark applications per billion GDP (in PPS)
Numerator	Number of trademark applications applied for at EUIPO
Denominator	Gross Domestic Product in Purchasing Power Standard
Interpretation	Trademarks are an important innovation indicator, especially for the service sector. The Community trademark gives its proprietor a uniform right applicable in all Member States of the European Union through a single procedure which simplifies trademark policies at European level. It fulfils the three essential functions of a trademark: it identifies the origin of goods and services, guarantees consistent quality through evidence of the company's commitment vis-à-vis the consumer, and it is a form of communication, a basis for publicity and advertising.
Comment	Two-year averages have been used for calculating the normalised scores for this indicator, which are used for calculating the Summary Innovation Index.
Data source	Trademark data from European Union Intellectual Property Office (EUIPO). GDP data from Eurostat

Change to EIS 2020	This indicator has been revised compared to the EIS 2020 and no longer includes trademark applications applied for at the World Intellectual Property Office (WIPO) ("yearly Madrid applications by origin")
Indicator	3.3.3 Design applications per billion GDP (in PPS)
Numerator	Number of individual designs applied for at the European Union Intellectual Property Office (EUIPO)
Denominator	Gross Domestic Product in Purchasing Power Standard
Interpretation	A design is the outward appearance of a product or part of it resulting from the lines, contours, colours, shape, texture, materials, and/or its ornamentation. A product can be any industrial or handicraft item including packaging, graphic symbols and typographic typefaces but excluding computer programmes. It also includes products that are composed of multiple components, which may be disassembled and reassembled. Community design protection is directly enforceable in each Member State, and it provides both the option of an unregistered and a registered Community design right for one area encompassing all Member States.
Comment	Two-year averages have been used for calculating the normalised scores for this indicator, which are used for calculating the Summary Innovation Index.
Data source	Design data from European Union Intellectual Property Office (EUIPO). GDP data from Eurostat
Indicator	4.1.1 Employment in knowledge-intensive activities (percentage of total employment)
Numerator	Number of employed persons in knowledge-intensive activities in business industries. Knowledge-intensive activities are defined, based on EU Labour Force Survey data, as all NACE Rev.2 industries at 2-digit level where at least 33% of employment has a tertiary education degree (ISCED 5-8).
Denominator	Total employment
Interpretation	Knowledge-intensive activities provide services directly to consumers, such as telecommunications, and provide inputs to the innovative activities of other firms in all sectors of the economy.
Data source	Eurostat
Indicator	4.1.2 Employment in innovative enterprises
Numerator	Number of employed persons in innovative enterprises ('Enterprises that have either introduced an innovation or have any kind of innovation activity (including enterprises with abandoned/suspended or on-going innovation activities)
Denominator	Total employment for enterprises with 10 or more employees
Interpretation	Innovation in enterprises has a profound impact on the employability of workers, but its effect in product- and process-innovation oriented firms varies across countries. Firm innovation proves to be specifically important during a time of economic recession. Although high-skilled employees are less affected by a recession than low-skilled employees, a notable positive effect is observed for low-skilled employees in innovative firms as well
Data source	Eurostat (Community Innovation Survey) (inn_cis11_bas)
Change to EIS 2020	This is a new indicator which measures the impact of innovation on employment assuming that workers in innovative enterprises benefit more from innovation than workers in non-innovative enterprises
Indicator	4.2.1 Exports of medium and high technology products as a share of total product exports

Numerator	Value of medium and high-tech exports, in national currency and current prices, including exports of the following SITC Rev.3 products: 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
Denominator	Value of total product exports
Interpretation	Innovation in enterprises has a profound impact on the employability of workers, but its effect in product- and process-innovation oriented firms varies across countries. Firm innovation proves to be specifically important during a time of economic recession. Although high-skilled employees are less affected by a recession than low-skilled employees, a notable positive effect is observed for low-skilled employees in innovative firms as well.
Data source	Eurostat (ComExt - DS-018995) for Member States, UN ComTrade for non-EU countries
Indicator	4.2.2 Knowledge-intensive services exports as percentage of total services exports
Numerator	Exports of knowledge-intensive services is defined as the sum of credits in EBOPS 2010 (Extended Balance of Payments Services Classification) items: SC1 (Sea transport); SC2 (Air transport); SC3A (Space transport); SF (Insurance and pension services); SG (Financial services); SH (Charges for the use of intellectual property); SI (Telecommunications, computer, and information services); SJ (Other business services); SK1 (Audio-visual and related services)
Denominator	Total value of services exports
Interpretation	The indicator measures the competitiveness of the knowledge-intensive services sector. Competitiveness-enhancing measures and innovation strategies can be mutually reinforcing for the growth of employment, export shares, and turnover at the firm level. 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.
Data source	Eurostat (bop_its6_det)
Indicator	4.2.3 Sales of new-to-market and new-to-enterprise innovations as percentage of turnover
Numerator	Sum of total turnover of new or significantly improved products, either new-to-the-enterprise or new-to-the-market, for all enterprises
Denominator	Total turnover for all enterprises
Interpretation	This indicator measures the turnover of new or significantly improved products and includes both products which are only new to the enterprise and products which are also new to the market. The indicator thus captures both the creation of state-of-the-art technologies (new-to-market products) and the diffusion of these technologies (new-to-enterprise products).
Data source	Eurostat (Community Innovation Survey) (inn_cis11_prodt, inn_cis11_bas)
Indicator	4.3.1 Resource productivity
Numerator	Gross Domestic Product (GDP)
Denominator	Domestic Material Consumption (DMC) in euros per kg
Interpretation	Resource productivity is a measure of the total amount of materials directly used by an economy (measured as domestic material consumption (DMC)) in relation to GDP. It provides insights into whether decoupling between the use of natural resources and economic growth is taking place. Domestic material consumption (DMC) measures the total amount of materials directly used by an economy and is defined as the annual quantity of raw materials extracted from the domestic territory, plus all physical imports minus all physical exports.
Data source	Eurostat (env_ac_rp)

Change to EIS 2020	This a new indicator introduced to capture the impact of innovation on environmental sustainability. Resource productivity (GDP/DMC) is the EU sustainable development indicator for policy evaluation.
Indicator	4.3.2 Air emissions by fine particulate matter (PM2.5) in Industry
Numerator	Air emissions by fine particulate matter (PM2.5) in the Manufacturing sector in Tonnes
Denominator	Value added in the Manufacturing sector - Chain linked volumes (2010), million euro
Interpretation	Air pollution may be anthropogenic (human-induced) or of natural origin. Air pollution has the potential to harm both human health and the environment: particulate matter (PM), nitrogen dioxide and ground-level ozone are known to pose particular health risks. This indicator captures average concentration levels of fine particulate matter (PM2.5 — particles with a diameter of 2.5 micrometres or less) to which the population is exposed. The EU set an annual limit of 25 µg/m³ for fine particulate matter in Directive 2008/50/EC on ambient air quality and cleaner air, while the World Health Organisation (WHO) set a more stringent, but non-binding guideline value, whereby annual mean concentrations should not exceed 10 µg/m³ in order to protect human health. PM2.5 is considered by the WHO as the pollutant with the highest impact on human health.
Data source	Eurostat, Air emissions accounts (env_ac_ainah_r2)
Change to EIS 2020	This a new indicator introduced to capture the impact of innovation on environmental sustainability. Monitoring changes in the indicator over time will help to assess the impact of innovation and new technologies on improved air quality by reducing air emissions.
Indicator	4.3.3 Development of environment-related technologies, percentage of all technologies
Numerator	Number of environment-related inventions
Denominator	Total number of patents
Interpretation	The number of environment-related inventions is expressed as a percentage of all domestic inventions (in all technologies). Indicators of technology development are constructed by measuring inventive activity using patent data across a wide range of environment-related technological domains, including environmental management, water-related adaptation, and climate change mitigation technologies. The counts used include only higher-value inventions (with patent family size ≥ 2).
Comment	Two-year averages have been used for calculating the normalised scores for this indicator, which are used for calculating the Summary Innovation Index.
Data source	OECD Green Growth database
Change to EIS 2020	This a new indicator introduced to capture the impact of innovation on environmental sustainability. The indicator captures the development of technologies aimed at reducing the environmental impact of economic activities.

5. Methodology for calculating composite scores

The overall performance of each country's innovation system has been summarised in a composite indicator, the Summary Innovation Index. Section 5.1 provides details on data availability per country and per indicator. Section 5.2 explains the methodology used for calculating the SII and performance relative to the EU.

5.1 Data availability

The EIS uses the most recent statistics from Eurostat and other internationally recognised sources as available at the time of analysis. International sources have been used wherever possible in order to ensure comparability between countries.

For the calculation of normalised scores, data have been used for an eight-year period. The availability of data by indicator for this eight-year period covered in the EIS 2021 is shown in Table 2, with data availability before imputing missing data between brackets. Data availability is below 60% for several indicators. For the indicators marked with an '#', full eight-year time series are not available. Data availability is shown in the third column.

For the seven indicators using CIS data, data are available for at most four years, as CIS data are collected once every two years. For Individuals who have above basic overall digital skills data are available or four years, for New doctorate graduates, Percentage population aged 25-34 having completed tertiary education, and Broadband penetration, data are available for six years, and for Enterprises providing training to develop or upgrade ICT skills of their personnel and Development of environment-related technologies, data are Available for seven years.

For several indicators, there are also breaks in series for several or even all countries, where the data before the break are not directly comparable with the data after the break. In all cases, data from before the break are excluded from the database (but included in the calculations in Table 2), even if Eurostat published data for these years. All missing data have been imputed as explained in step 2 in Section 5.2.

Table 1: Data availability by indicator

Innovation dimension / Indicator	Most recent year for which data are available	Number of years for which data are available	EU Member States	Other European and neighbouring countries
Human resources				
1.1.1 New doctorate graduates in STEM	2018	6 (2013-2018)	100% (97%)	100% (95%)
1.1.2 Percentage population aged 25-34 having completed tertiary education	2019	6 (2014-2019)	100%	91%
1.1.3 Percentage population aged 25-64 participating in lifelong learning	2019	8 (2012-2019)	100%	82% (80%)
Attractive research systems				
1.2.1 International scientific co-publications per million population	2020	8 (2013-2020)	100%	100%
1.2.2 Top 10% most cited publications	2018	8 (2011-2018)	100%	100%
1.2.3 Foreign doctorate students	2018	8 (2011-2018)	100% (96%)	82% (69%)
Digitalisation				
1.3.1 Broadband penetration	2019	6 (2014-2019)	100%	91% (61%)
1.3.2 Individuals who have above basic overall digital skills	2019	4 (2015-2017, 2018)	100% (99%)	82% (57%)
Finance and support				
2.1.1 R&D expenditure in the public sector	2019	8 (2012-2019)	100% (98%)	100% (77%)

Innovation dimension / Indicator	Most recent year for which data are available	Number of years for which data are available	EU Member States	Other European and neighbouring countries
2.1.2 Venture capital expenditures	2020	8 (2013-2020)	100%	45%
2.1.3 Direct government funding and government tax support for business R&D	2018	(2011-2018)	100%	100% (85%)
Firm investments				
2.2.1 R&D expenditure in the business sector	2019	8 (2012-2019)	100% (98%)	100% (76%)
2.2.2 Non-R&D innovation expenditures	2016	4 (2012, 2014, 2016, 2018)	100% (98%)	82% (45%)
2.2.3 Innovation expenditure per person employed	2018	4 (2012, 2014, 2016, 2018)	100% (97%)	73% (34%)
Use of information technologies				
2.3.1 Enterprises providing training to develop or upgrade ICT skills of their personnel	2020	7 (2014-2020)	100% (99%)	82% (49%)
2.3.2 ICT specialists	2019	8 (2012-2019)	100%	73% (72%)
Innovators				
3.1.1 SMEs introducing product innovations	2018	4 (2012, 2014, 2016, 2018)	100% (98%)	82% (57%)
3.1.2 SMEs introducing business process innovations	2018	4 (2012, 2014, 2016, 2018)	100% (96%)	82% (57%)
Linkages				
3.2.1 Innovative SMEs collaborating with others	2018	4 (2012, 2014, 2016, 2018)	100% (99%)	82% (57%)
3.2.2 Public-private co-publications	2020	8 (2013-2020)	100%	100%
3.2.3 Job-to-job mobility of Human Resources in Science & Technology	2019	8 (2012-2019)	100% (96%)	73% (64%)
Intellectual assets				
3.3.1 PCT patent applications	2017	8 (2010-2017)	100%	100% (98%)
3.3.2 Trademark applications	2020	8 (2013-2020)	100%	100%
3.3.3 Design applications	2020	8 (2013-2020)	100%	100%
Employment impacts				
4.1.1 Employment in knowledge-intensive activities	2018	8 (2012-2019)	100% (88%)	91% (81%)
4.1.2 Employment in innovative enterprises	2018	4 (2012, 2014, 2016, 2018)	100% (93%)	82% (45%)
Sales impacts				
4.2.1 Medium and high technology product exports	2020	8 (2013-2020)	100% (92%)	100% (93%)
4.2.2 Knowledge-intensive services export	2019	8 (2013-2020)	100% (99%)	100% (98%)
4.2.3 Sales of new-to-market and new-to-enterprise innovations	2018	4 (2012, 2014, 2016, 2018)	100% (50%)	91% (26%)
Environmental sustainability				
4.3.1 Resource productivity	2019	8 (2012-2019)	100%	73% (61%)
4.3.2 Air emissions by fine particulates (PM2.5) in Industry	2018	8 (2011-2018)	100%	45% (43%)
4.3.3 Development of environment-related technologies	2016	7 (2010-2016)	100%	100%

The availability of data after imputation of missing data by country for this eight-year period covered in the EIS 2020 is shown in Table 3. For all Member States, except Ireland, data availability is 100%. For Data availability for 8 neighbouring and other European countries is above 90%. Data availability is relatively weak for Bosnia and Herzegovina but improvements in data availability are expected after including the country for the first time in the EIS. Data availability for both Israel and Ukraine are weak. Both countries are still included in the EIS 2021 as they have been included already for several years but are likely candidates to be excluded from the EIS if data availability does not improve.

Table 2: Data availability by country after imputation of missing data

		Data availability			Data availability
BE	Belgium	100%	AT	Austria	100%
BG	Bulgaria	100%	PL	Poland	100%
CZ	Czechia	100%	PT	Portugal	100%
DK	Denmark	100%	RO	Romania	100%
DE	Germany	100%	SI	Slovenia	100%
EE	Estonia	100%	SK	Slovakia	100%
IE	Ireland	97%	FI	Finland	100%
EL	Greece	100%	SE	Sweden	100%
ES	Spain	100%	BA	Bosnia and Herzegovina	72%
FR	France	100%	IS	Iceland	97%
HR	Croatia	100%	IL	Israel	47%
IT	Italy	100%	MK	North Macedonia	94%
CY	Cyprus	100%	ME	Montenegro	91%
LV	Latvia	100%	NO	Norway	100%
LT	Lithuania	100%	RS	Serbia	100%
LU	Luxembourg	100%	CH	Switzerland	91%
HU	Hungary	100%	TR	Turkey	94%
MT	Malta	100%	UA	Ukraine	63%
NL	Netherlands	100%	UK	United Kingdom	100%

5.2 Methodology for calculating the Summary Innovation Index

The overall performance of each country's innovation system has been summarised in a composite indicator, the Summary Innovation Index. The methodology used for calculating the Summary Innovation Index is explained below. “All countries” include all Member States and other European and neighbouring countries included in the EIS.

Step 1: Setting reference years

For each indicator, a reference year is identified for all countries based on data availability for all those countries for which data availability is at least 75%. For most indicators, this reference year lags one or two years behind the year to which the EIS refers.

Step 2: Imputing for missing values

Reference year data are then used for “2021”, etc. If data for a year-in-between are not available, missing values are replaced with the value for the previous year. If data are not available at the beginning of the time series, missing values are replaced with the next available year. The following examples clarify this step and show how ‘missing’ data are imputed. If data are missing for all years, no data will be imputed (the indicator will not contribute to the Summary Innovation Index).

Latest year missing	2021	2020	2019	2018	2017
Available data	N/A	45	40	35	30
Use most recent year	45	45	40	35	30
Year-in-between missing	2021	2020	2019	2018	2017
Available data	50	N/A	40	35	30
Substitute with previous year	50	40	40	35	30
Beginning-of-period missing	2021	2020	2019	2018	2017
Available data	50	45	40	35	N/A
Substitute with next available year	50	45	40	35	35

Step 3: Identifying and replacing outliers

Positive outliers are identified as those country scores which are higher than the mean across all countries plus twice the standard deviation. Negative outliers are identified as those country scores which are smaller than the mean across all countries minus twice the standard deviation. These outliers are replaced by the respective maximum and minimum values observed over all the years and all countries. Table 4 summarises the outliers per indicator and year (negative outliers are shown in italics) for the full time series including imputed values

Table 4: Data availability by indicator

Innovation dimension / Indicator	Positive / *Negative* outlier
Human resources	
1.1.1 New doctorate graduates in STEM	SI: 2013-2015, 2018; CH: 2017-2020; *BA: 2016; ME: 2013-2015*
1.1.2 Percentage population aged 25-34 having completed tertiary education	CY: 2018-2020; *BA: 2013-2016; TR: 2013-2015*
1.1.3 Percentage population aged 25-64 participating in lifelong learning	FI: 2019, 2020; SE: 2013-2020; CH: 2013-2020; *RO: 2019*
Attractive research systems	
1.2.1 International scientific co-publications per million population	IS: 2013-2020; CH: 2020; *UA: 2013*
1.2.2 Top 10% most cited publications	NL: 2013; *UA: 2013*
1.2.3 Foreign doctorate students	LU: 2013-2020; CH: 2019, 2020; *LT: 2013*
Digitalisation	
1.3.1 Broadband penetration	DK: 2018-2020; PT: 2020; SE: 2019, 2020; CH: 2018-2020; *CY: 2013-2015*
1.3.2 Individuals who have above basic overall digital skills	DK: 2017; IS: 2013-2020; *RO: 2013-2017; BA: 2013-2020*
Finance and support	
2.1.1 R&D expenditure in the public sector	DK: 2014, 2016, 2017, 2019, 2020; *ME: 2013, 2014; BA: 2013, 2014, 2020*
2.1.2 Venture capital expenditures	CY: 2019, 2020; LV: 2017; LU: 2013, 2016-2018, 2020; MT: 2017-2019; FI: 2020; UK: 2019, 2020; *RS: 2013, 2014*
2.1.3 Direct government funding and government tax support for business R&D	IE: 2016, 2017; FR: 2013-2020; HU: 2015-2017; AT: 2014; SI: 2013-2015; UK: 20178-2020; *ME: 2013, 2014*

Innovation dimension / Indicator	Positive / *Negative* outlier
Firm investments	
2.2.1 R&D expenditure in the business sector	SE: 2020; IL: 2013-2020; *BA: 2015-2019; ME: 2017*
2.2.2 Non-R&D innovation expenditures	RS: 2013-2015, 2018-2020; TR: 2013-2019 *BA: 2013-2020*
2.2.3 Innovation expenditure per person employed	BE: 2018-2020; DK: 2019, 2020; DE: 2016-2020; SE: 2013-2020; *RO: 2018, 2019; BA: 2013-2020*
Use of information technologies	
2.3.1 Enterprises providing training to develop or upgrade ICT skills of their personnel	FI: 2013, 2014, 2017, 2020; IS: 2018, 2019; NO: 2013-2018; *RO: 2013-2018*
2.3.2 ICT specialists	FI: 2016-2020; SE: 2013-2020; *TR: 2013-2015*
Innovators	
3.1.1 SMEs introducing product innovations	EE: 2020; CY: 2020; NO: 2018-2020; *LV: 2016, 2017; RO: 2013-2019*
3.1.2 SMEs introducing business process innovations	BE: 2020; CYL 2020; PT: 2018, 2019; *PL: 2016, 2017; RO: 2016-2020*
Linkages	
3.2.1 Innovative SMEs collaborating with others	BE: 2016, 2017; EE: 2020; CY: 2020; FI: 2020; NO: 2020; UK: 2018, 2019; *RO: 2013-2015*
3.2.2 Public-private co-publications	IS: 2013-2020; CH: 2020; *UA: 2014*
3.2.3 Job-to-job mobility of Human Resources in Science & Technology	IS: 2017, 2018; RO: 2017, 2019, 2020
Intellectual assets	
3.3.1 PCT patent applications	FI: 2013-2017, 2019; SE: 2013-2020; IL: 2013-2020; *MK: 2013; ME: 2014, 2019, 2020; RS: 2019, 2020*
3.3.2 Trademark applications	EE: 2019; LU: 2013-2020; MT: 2013-2020; *UA: 2013*
3.3.3 Design applications	BG: 2014, 2015; LU: 2013-2016; MT: 2013-2017; *BA: 2013, 2016, 2017, 2020; MK: 2014, 2015; ME: 2013-2020l*
Employment impacts	
4.1.1 Employment in knowledge-intensive activities	LU: 2019, 2020; IL: 2013-2020; *UA: 2013-2015*
4.1.2 Employment in innovative enterprises	CH: 2013-2017; *PL: 2016, 2017; RO: 2013-2018*
Sales impacts	
4.2.1 Medium and high technology product exports	HU: 2016; *IS: 2013-2010; ME: 2013-2016; NO: 2013-2020*
4.2.2 Knowledge-intensive services export	IE: 2013-2015, 2017, 2018, 2020; *HR: 2014; BA: 2013-2015*
4.2.3 Sales of new-to-market and new-to-enterprise innovations	IE: 2013-2015; EL: 2020; TR: 2013-2019; *DK: 2020*
Environmental sustainability	
4.3.1 Resource productivity	IT: 2020; NL: 2018-2020; NO: 2013-2020; CH: 2019, 2020; *BG: 2016*
4.3.2 Air emissions by fine particulates (PM2.5) in Industry	*EE: 2013, 2015, 2017, 2019; LV: 2013-2020l PT 2013-2020; RS: 2020*
4.3.3 Development of environment-related technologies	BG: 2019, 2020; DK: 2013-2016; EE: 2013-2016; MT: 2020; BA: 2016, 2017; RS: 2013-2015; *CY: 2020; MK: 2018; ME: 2013-2016, 2019, 2020*

Step 4: Transforming data that have highly skewed distributions across countries

Most of the indicators are fractional indicators with values between 0% and 100%. Some indicators are unbound indicators, where values are not limited to an upper threshold. These indicators can be highly volatile and can have skewed data distributions (where most countries show low performance levels, and a few countries show exceptionally high levels of performance). For these indicators where the degree of skewness across the full eight-year period is above one, data have been transformed using a square root transformation, i.e. using the square root of the indicator value instead of the original value. For the following indicators data have been transformed: International scientific co-publications, Broadband penetration, Non-R&D innovation expenditures, Public-private co-publications, Trademark applications, and Air emissions by fine particulates (PM2.5) in industry. A square root transformation means using the square root of the indicator value instead of the original value (Table 5). A square root transformation means using the square root of the indicator value instead of the original value.

Table 5: Data availability by indicator

Innovation dimension / Indicator	Skewness	Skewness after transformation
Human resources		
1.1.1 New doctorate graduates in STEM	0.385	--
1.1.2 Percentage population aged 25-34 having completed tertiary education	-0.022	--
1.1.3 Percentage population aged 25-64 participating in lifelong learning	0.804	--
Attractive research systems		
1.2.1 International scientific co-publications per million population	1.127	0.360
1.2.2 Top 10% most cited publications	0.029	--
1.2.3 Foreign doctorate students	0.809	--
Digitalisation		
1.3.1 Broadband penetration	1.111	0.045
1.3.2 Individuals who have above basic overall digital skills	0.172	--
Finance and support		
2.1.1 R&D expenditure in the public sector	0.198	--
2.1.2 Venture capital expenditures	0.881	--
2.1.3 Direct government funding and government tax support for business R&D	0.822	--
Firm investments		
2.2.1 R&D expenditure in the business sector	0.679	--
2.2.2 Non-R&D innovation expenditures	1.706	0.789
2.2.3 Innovation expenditure per person employed	0.675	--
Use of information technologies		
2.3.1 Enterprises providing training to develop or upgrade ICT skills of their personnel	0.050	--
2.3.2 ICT specialists	0.227	--
Innovators		
3.1.1 SMEs introducing product innovations	0.059	--
3.1.2 SMEs introducing business process innovations	-0.320	--
Linkages		
3.2.1 Innovative SMEs collaborating with others	0.730	--
3.2.2 Public-private co-publications	1.337	0.496
3.2.3 Job-to-job mobility of Human Resources in Science & Technology	0.101	--

Innovation dimension / Indicator	Skewness	Skewness after transformation
Intellectual assets		
3.3.1 PCT patent applications	0.998	--
3.3.2 Trademark applications	1.477	0.342
3.3.3 Design applications	0.723	--
Employment impacts		
4.1.1 Employment in knowledge-intensive activities	0.378	--
4.1.2 Employment in innovative enterprises	-0.324	--
Sales impacts		
4.2.1 Medium and high technology product exports	-0.564	--
4.2.2 Knowledge-intensive services export	0.158	--
4.2.3 Sales of new-to-market and new-to-enterprise innovations	0.758	--
Environmental sustainability		
4.3.1 Resource productivity	0.781	--
4.3.2 Air emissions by fine particulates (PM2.5) in Industry	1.486	0.863
4.3.3 Development of environment-related technologies	0.245	--

Step 5: Determining Maximum and Minimum scores

The Maximum score is the highest score found for the eight-year period within all countries excluding positive outliers. Similarly, the Minimum score is the lowest score found for the eight-year period within all countries excluding negative outliers.

Step 6: Calculating re-scaled scores

Re-scaled scores of the country scores (after correcting for outliers and a possible transformation of the data) for all years are calculated by first subtracting the Minimum score and then dividing by the difference between the Maximum and Minimum score. The maximum re-scaled score is thus equal to 1, and the minimum re-scaled score is equal to 0. For positive and negative outliers, the re-scaled score is equal to 1 or 0, respectively.

Step 7: Calculating composite innovation indexes

For each year, a composite Summary Innovation Index is calculated as the unweighted average of the re-scaled scores for all indicators where all indicators receive the same weight (1/32 if data are available for all 32 indicators).

Step 8: Calculating relative-to-EU performance scores

Performance scores relative to the EU are then calculated as the SII of the respective country divided by the SII of the EU multiplied by 100. Relative performance scores are calculated for the full eight-year period compared to the performance of the EU in 2014 and for the latest year also to that of the EU in 2021. For the definition of the performance groups, only the performance scores relative to the EU in 2021 have been used.

5.3 International benchmarking

The methodology for calculating average innovation performance for the EU and its major global competitors is similar to that used for calculating average innovation performance for the EU Member States but using a smaller set of countries and a smaller set of indicators.

5.4 Performance group membership

For determining performance group membership, the EIS uses the following classification scheme:

- Innovation Leaders are all countries with a relative performance in 2021 above 125% of the EU average in 2021.
- Strong Innovators are all countries with a relative performance in 2021 between 100% and 125% of the EU average in 2021.
- Moderate Innovators are all countries with a relative performance in 2021 between 70% and 100% of the EU average in 2021.
- Emerging Innovators are all countries with a relative performance in 2021 below 70% of the EU average in 2021.

6. Impact of structural differences between countries

6.1 Contextual indicators used for European countries

In response to a need for contextual analyses to better understand performance differences on the innovation indicators used in the main measurement framework, a set of contextual indicators was introduced to the country profiles in the 2017 edition and revised in the 2018 edition. For this year's report, two additional sets of indicators are introduced. The first set of seven indicators (Innovation Profiles) presents shares of different types of innovating and non-innovating enterprises. The second set includes three indicators measuring performance on climate change related indicators.

This section discusses the relevance of these structural aspects to provide for a better understanding of differences between countries in the performance of particular indicators. The list of contextual indicators used in the European comparison, the years for which average performance has been calculated, and data sources used are shown in Table 6. Full definitions of all contextual indicators are also provided in this section.

Table 6: Contextual indicators in the European Innovation Scoreboard

	Period	Source
PERFORMANCE AND STRUCTURE OF THE ECONOMY		
GDP per capita (PPS)	Average 2017-2019	Eurostat
Average annual GDP growth (%)	Between 2018 and 2020	Eurostat
Employment share Manufacturing (NACE C) (%)	Average 2018-2020	Eurostat
of which High and Medium high-tech (%)	Average 2018-2020	Eurostat
Employment share Services (NACE G-N) (%)	Average 2018-2020	Eurostat
of which Knowledge-intensive services (%)	Average 2018-2020	Eurostat
Turnover share SMEs (%)	Average 2016-2018	Eurostat
Turnover share large enterprises (%)	Average 2016-2018	Eurostat
Foreign-controlled enterprises – share of value added (%)	Average 2016-2018	Eurostat
BUSINESS AND ENTREPRENEURSHIP		
Enterprise births (10+ employees) (%)	Average 2016-2018	Eurostat
Total early-stage Entrepreneurial Activity (TEA) (%)	Average 2017-2019	Global Entrepreneurship Monitor
FDI net inflows (% GDP)	Average 2017-2019	World Bank: World Development Indicators
Top R&D spending enterprises per 10 million population	Average 2018-2020	EU Industrial R&D Investment Scoreboard
Buyer sophistication (1 to 7 best)	Average 2017-2019	World Economic Forum
INNOVATION PROFILES		
In-house product innovators with market novelties	2018	Eurostat, National Statistical Offices
In-house product innovators without market novelties	2018	Eurostat, National Statistical Offices
In-house business process innovators	2018	Eurostat, National Statistical Offices
Innovators that do not develop innovations themselves	2018	Eurostat, National Statistical Offices
Innovation active non-innovators	2018	Eurostat, National Statistical Offices

Non-innovators with potential to innovate	2018	Eurostat, National Statistical Offices
Non-innovators without disposition to innovate	2018	Eurostat, National Statistical Offices
GOVERNANCE AND POLICY FRAMEWORK		
Ease of starting a business (0 to 100 best)	Average 2018-2020	World Bank: Doing Business
Basic-school entrepreneurial education and training (1 to 5 best)	Average 2018-2020	Global Entrepreneurship Monitor
Government procurement of advanced technology products (1 to 7 best)	Average 2017-2019	World Economic Forum
Rule of law (-2.5 to 2.5 best)	Average 2017-2019	World Bank: Worldwide Governance Indicators
CLIMATE CHANGE		
Circular material use rate	Average 2017-2019	Eurostat
Greenhouse gas emissions intensity of energy consumption	Average 2016-2018	European Environment Agency (EEA), Eurostat
Eco-Innovation Index	2019	EC, DG Environment
DEMOGRAPHY		
Population size	Average 2018-2020	Eurostat
Average annual population growth (%)	Between 2018 and 2020	Eurostat
Population density	Average 2017-2019	Eurostat

Performance and structure of the economy

GDP per capita in purchasing power standards[6] is a measure for interpreting real income differences between countries. Higher income can increase the demand for new innovative goods and services. Economic growth is captured by the average annual growth rate of GDP for 2017-2019. In economies that grow faster, increasing demand may provide more favourable conditions for enterprises to sell their goods and services.

Differences in economic structures are important. In particular, differences in the share of manufacturing industry in GDP, and in the so-called high-tech activities in manufacturing and services, are important factors that explain why countries can perform better or worse on indicators like business R&D expenditures, PCT patents, and innovative enterprises. Medium-high and high-tech industries have higher technological intensities than other industries. These industries, on average, will have higher R&D expenditures, more patent applications, and higher shares of innovating enterprises. Countries with above-average shares of these industries are expected to perform better on several EIS indicators. For example, for the EU27 on average, 85% of R&D expenditures in manufacturing are accounted for by medium-high and high-technology manufacturing industries[7] [8]. Also, the share of enterprises that introduced a product

[6] The purchasing power standard, abbreviated as PPS, is an artificial currency unit. Theoretically, one PPS can buy the same amount of goods and services in each country. However, price differences across borders mean that different amounts of national currency units are needed for the same goods and services depending on the country. PPS are derived by dividing any economic aggregate of a country in national currency by its respective purchasing power parities. PPS is the technical term used by Eurostat for the common currency in which national accounts aggregates are expressed when adjusted for price level differences using PPPs. Thus, PPPs can be interpreted as the exchange rate of the PPS against the Euro.

[7] Based on NACE Rev. 2 3-digit level, manufacturing industries can be classified into high-technology, medium-high technology, medium-low-technology, and low-technology. The high-technology and medium-high technology industries include: Chemicals and chemical products (20); Basic pharmaceutical products and pharmaceutical preparations (21); Weapons and ammunition (25.4*); Computer, electronic and optical products (26); Electrical equipment (27); Machinery and equipment not elsewhere classified (28); Motor vehicles, trailers and semi-trailers (29); Other transport equipment (30) excluding Building of ships and boats (30.1); Air and spacecraft and related machinery (30.3); and Medical and dental

and/or business process innovation is higher in medium-high and high-technology manufacturing industries compared to all core industries covered in the Community Innovation Survey[9].

Foreign ownership, including ownership from both other EU Member States and non-Member States, is important as, on average, about 30% of business R&D expenditures in EU Member States is made by foreign affiliates, which is significantly higher compared to Japan and the United States and comparable to Australia and Canada[10]. The share of foreign-controlled enterprises in value-added serves as a proxy for differences in the impact of foreign ownership on the economy.

Business and entrepreneurship

Entrepreneurship is important for introducing new innovations on the market. The degree of entrepreneurship is measured by two contextual indicators measuring the share of new enterprise births in the economy and Total early-stage Entrepreneurial activity (TEA), which measures the share of the adult population aged 18–64 years who are in the process of starting a business (a nascent entrepreneur) or who started a business which is not older than 42 months at the time of the respective survey (owner-manager of a new business).

Inflows of new technologies are important as they add to a country's economic and technological capacities. Inward Foreign direct investment (FDI) can have a positive impact on innovation performance, although there are differences depending on the complexity of the receiving industry, political and economic framework conditions as well as the quality of the institutions of the receiving countries. Inward FDI flows are measured over a three-year period, as average net inflows of investments to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor.

Enterprise characteristics are important for explaining differences in R&D spending and innovation activities. Large enterprises, defined as enterprises with 250 or more employees, account for almost 80 percent of EU business R&D expenditures, whereas SMEs, defined as enterprises with 10 to 249 employees, account for only one-fifth. The presence of large R&D spending enterprises is captured by the *EU Industrial R&D Investment Scoreboard*, which provides economic and financial data and analysis of the top corporate R&D investors from the EU and abroad[11].

instruments and supplies (32.5**). If data are only available at the NACE Rev. 2 2-digit level, industries identified with an * are classified as medium-low-technology, and industries identified with an ** are classified as low-technology, and thus excluded from the high-technology and medium-high technology industries (Source: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries).

[8] Average results for 2015-2017 for 24 Member States for which data are available for at least one year. Data were extracted from Eurostat (Business enterprise R&D expenditure in high-tech sectors - NACE Rev. 2 [htec_sti_exp2].

[9] In accordance with Commission Regulation No 995/2012, the following industries and services are included in the Core target population covered in the CIS: Core Industry (excluding construction): Mining and quarrying (B), Manufacturing (C) (10-12: Manufacture of food products, beverages and tobacco; 13-15: Manufacture of textiles, wearing apparel, leather and related products; 16-18: Manufacture of wood, paper, printing and reproduction; 20: Manufacture of chemicals and chemical products; 21: Manufacture of basic pharmaceutical products and pharmaceutical preparations; 19-22 Manufacture of petroleum, chemical, pharmaceutical, rubber and plastic products; 23: Manufacture of other non-metallic mineral products; 24: Manufacture of basic metals; 25: Manufacture of fabricated metal products, except machinery and equipment; 26: Manufacture of computer, electronic and optical products; 25-30: Manufacture of fabricated metal products (except machinery and equipment), computer, electronic and optical products, electrical equipment, motor vehicles and other transport equipment; 31-33: Manufacture of furniture; jewellery, musical instruments, toys; repair and installation of machinery and equipment, Electricity, gas, steam and air conditioning supply (D), Water supply, sewerage, waste management and remediation activities (E) (36: Water collection, treatment and supply; 37-39: Sewerage, waste management, remediation activities). Core Services: Wholesale trade, except of motor vehicles and motorcycles (46), Transport and storage (H) (49-51: Land transport and transport via pipelines, water transport and air transport; 52-53: Warehousing and support activities for transportation and postal and courier activities); Information and communication (J) (58: Publishing activities; 61: Telecommunications; 62: Computer programming, consultancy and related activities; 63: Information service activities), Financial and insurance activities (K) (64: Financial service activities, except insurance and pension funding; 65: Insurance, reinsurance and pension funding, except compulsory social security; 66: Activities auxiliary to financial services and insurance activities), Professional, scientific and technical activities (M) (71-73: Architectural and engineering activities; technical testing and analysis; Scientific research and development; Advertising and market research).

[10] Average results for 2010-2016 for 14 Member States for which data were available (Austria, Belgium, Czechia, Finland, France, Germany, Hungary, Ireland, Italy, Netherlands, Poland, Slovenia Spain, and Sweden). Source of the data: OECD Main Science and Technology Indicators.

[11] http://iri.jrc.ec.europa.eu/scoreboard.html

Demand is an important driver of innovation. According to the Oslo Manual (2018)[12], demand factors shape innovation activity in two major ways: for the development of new products, as firms modify and differentiate products to increase sales and market share; and for the improvement of the production and supply processes in order to reduce costs and lower prices. A robust indicator measuring the demand for innovation is currently not available. The Executive Opinion Survey of the World Economic Forum includes an indicator that provides a measure of the preferences of individual consumers for innovative products. The degree of Buyer sophistication measures, on a scale from 1 (low) to 7 (high), whether buyers focus more on price or quality of products and services.

Innovation profiles

Innovation is a highly diverse activity. Enterprises can innovate through product or business process innovation, with the latter including process, marketing and organisational innovation. Enterprises can adopt new technologies developed by other enterprises or they engage in intensive in-house research and innovation activities. The capabilities needed by enterprises to innovate are very different in kind and size. More simple aggregate indicators of the percentage of 'innovative' enterprises in a particular country, as those currently used in the EIS, most likely provide information of limited value to policy makers. Instead, innovation indicators should differentiate between 'styles' or 'modes' of innovation in order to provide a clear picture of the structure of innovation capabilities within different businesses, economies, and countries (Arundel and Hollanders, 2005)[13].

Building on earlier work by academics and the OECD, Eurostat, UNU-MERIT (Maastricht University), ZEW – Leibniz Centre for European Economic Research, in collaboration with most National Statistical Offices, started work on developing a taxonomy of innovating and non-innovating enterprises based on CIS 2016 micro data. The following characteristics were used to identify seven mutually exclusive detailed innovation profiles: the degree of newness of product innovations, own in-house capacities to innovate, and R&D activities. Work has been continued using CIS 2018 micro data taking into account changes in the CIS 2018 questionnaire following the introduction of revised guidelines for measuring innovation 2018 Oslo Manual[14]. Where the CIS 2016 differentiated between six Innovation profiles, for the CIS 2018 seven Innovation profiles have been defined. Of these, four innovation profiles capture different types of enterprises that have introduced an innovation (product or business process) and three innovation profiles capture non-innovators:

- In-house product innovators with market novelties, including all enterprises that introduced a product innovation that was developed by the enterprise and that was not previously offered by competitors).
- In-house product innovators without market novelties, including all enterprises that introduced a product innovation that was developed by the enterprise but that is only new to the enterprise itself.
- In-house business process innovators, including all enterprises that did not introduce a product innovation, but that did introduce a business process innovation that was developed by the enterprise.
- Innovators that do not develop innovations themselves, including all enterprises that introduced an innovation of any kind but did not develop it themselves (enterprises without significant own innovation capabilities).
- Innovation active non-innovators, including all enterprises that did not introduce any innovation but that either had ongoing or abandoned innovation activities.
- Non-innovators with potential to innovate, including all enterprises that did not introduce any innovation, and which had no ongoing or abandoned innovation activities but that did consider to innovate.

[12] The Oslo Manual is the foremost international source of guidelines for the collection and use of data on innovation activities in industry. OECD/Eurostat (2018), Oslo Manual: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, OECD Publishing, Paris. DOI: https://doi.org/10.1787/9789264304604-en

[13] https://cris.maastrichtuniversity.nl/files/64448310/Arundel_Hollanders_EXIS.pdf

[14] https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c

- Non-innovators without disposition to innovate, including all other enterprises, those that neither introduced an innovation nor had any ongoing or abandoned innovation activities nor considered to innovate.

Data on Innovation profiles should not be interpreted as "more is better". Instead, the data should be used to better understand differences in the composition of different types of enterprises in a country, thereby helping policy makers to design policies that better target different enterprises.

Results for the EU are shown in Table 5 for all enterprises and for three different size classes, including small (10-49 employees), medium (50-249 employees) and large enterprises (250 or more employees). About 11% of enterprises are In-house innovators with market novelties. These enterprises are most frequent among large enterprises (29%). About 12% of enterprises are In-house innovators without market novelties. These enterprises are also more common among larger enterprises (19%). In-house business process innovators account for 11% of enterprises. There are no significant differences in the relevance of this profile among the different size classes. Innovators that do not develop innovations themselves account for 12% of enterprises. About 3% of enterprises are Innovation active non-innovators. Non-innovators account for more than half of EU enterprises. Non-innovators with potential to innovate account for 20% of all enterprises, and these enterprises are most frequent among the small enterprises (21%). The Non-innovators without disposition to innovate form the largest group accounting for 31% of all enterprises, ranging from only 14% among the large enterprises to 34% among the small enterprises.

The distribution for the number of persons employed is different as the distribution of the different size classes across the Innovation profiles is not equal. In-house innovators with market novelties account for 30% of EU employment. Among the large enterprises this share is 45%, whereas it is less than 10% among the small enterprises (Table 7). In-house innovators without market novelties account for 17% of EU employment, In-house business process innovators account for 10% of EU employment, and Innovators that do not develop innovations themselves also account for 10% of EU employment. The Innovation active non-innovators account for 3% of EU employment. Non-innovators with potential to innovate account for 12% of all enterprises in the EU, in particular in small enterprises (21%). Non-innovators without disposition to innovate account for 18% of EU employment and more than 30% in small enterprises.

Table 7: Distribution of enterprises and employment for seven Innovation profiles in the EU

	Share of enterprises				Share of employment			
	Small	Medium	Large	Total	Small	Medium	Large	Total
In-house product innovators with market novelties	8.5%	16.1%	29.4%	10.7%	9.2%	17.2%	44.8%	29.6%
In-house product innovators without market novelties	11.2%	15.2%	19.4%	12.3%	11.4%	15.6%	19.7%	16.8%
In-house business process innovators	10.7%	12.2%	11.0%	11.0%	11.1%	12.2%	8.6%	10.1%
Innovators that do not develop innovations themselves	11.1%	13.8%	12.0%	11.6%	11.7%	14.0%	7.7%	10.2%
Innovation active non-innovators	3.0%	4.5%	4.3%	3.3%	3.2%	4.6%	2.9%	3.4%
Non-innovators with potential to innovate	21.5%	15.3%	9.3%	19.9%	21.1%	14.4%	5.9%	11.5%
Non-innovators without disposition to innovate	34.0%	22.9%	14.5%	31.3%	32.4%	22.0%	10.4%	18.4%

Governance and policy framework

Institutional and legal differences between countries may make it more difficult to engage in business activities. The World Bank's Doing Business report provides an index, Ease of starting a business, which measures the distance of each economy to the "frontier" economy providing the most lenient regulatory framework for doing business. Countries with more favourable regulatory environments will obtain scores closer to the maximum score of 100.

Entrepreneurial skills are important for successfully transforming ideas and inventions into innovations. These skills can be acquired on the job but also by formal schooling. Basic-school entrepreneurial education and training measures the extent to which training in creating or managing SMEs is incorporated within the education and training system at primary and secondary levels.

Governments play an important role in enhancing the innovation capacities of an economy. Government procurement of advanced technology products measures the extent to which government procurement decisions foster technological innovation – from 1 (not at all) to 7 (extremely effectively). Trust is important for creating a business environment for undertaking risky innovative activities. Rule of law captures differences in the extent to which people have confidence in and abide by the rules of society. Rule of law measures differences in the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

Climate change

As the natural environment increasingly suffers from the loss of biodiversity, pollution and climate change, the relationship between innovation performance and environment sustainability grows in importance. EU level policy developments, such as the European Green Deal and the Recovery plan for Europe, underline the need to take account of the pivotal role of research and innovation in contributing to societal challenges. In addition to the new innovation dimension on Environmental sustainability and the three indicators captured in this dimension, three additional indicators are included in the Contextual indicators relevant for measuring climate change and the role of innovation.

The circular material use rate measures, in percentages, the share of material recovered and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. The circular material use rate is defined as the ratio of the circular use of materials (U) to the overall material use (M). It covers households, the private and the public sector. A higher circular material use rate value indicates more secondary materials substituting for primary raw materials, i.e. avoiding the environmental impacts of extracting primary material. Data for all 27 Member States and the United Kingdom are available from Eurostat.

Greenhouse gas emissions intensity of energy consumption is an indicator that is part of the EU Sustainable Development Goals (SDG) indicator set. It is used to monitor progress towards Goal 13 on climate action and SDG 7 on affordable and clean energy. The indicator is calculated as the ratio between energy related GHG emissions and gross inland consumption of energy. It expresses how many tonnes CO2 equivalents of energy related GHGs are being emitted in a certain economy per unit of energy that is being consumed. Lower scores on this indicator imply an improvement in environmental performance. Data source is the European Environment Agency (EEA) and data for all 27 Member States and other countries are available from Eurostat.

The Eco-Innovation index is a composite indicator based on 16 sub-indicators in five thematic areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency outcomes and socio-economic outcomes. The overall score of an EU Member State is calculated by the unweighted mean of the 16 sub-indicators. It shows how well individual Member States perform in eco-innovation compared to the EU average, which is equated with 100 (index EU=100). The index is part of the Eco-Innovation Scoreboard (Eco-IS) [15]. For the EIS 2021 results from the 2019 edition of the Eco-IS are used as the 2021 Eco-IS is published in June after the publication of the EIS 2021.

Demography

Structural data also includes population size and the average annual growth rate of population for 2017-2019. Increasing demand following an increasing population may provide more favourable conditions for enterprises to sell their goods and services. Densely populated areas are more likely to be more innovative for several reasons. Firstly, knowledge diffuses more easily when people and enterprises are located closer to each other. Secondly, in more densely populated areas there tends to be a concentration of government and educational services. Densely populated areas provide better training opportunities and employ above-average shares of highly educated people. Furthermore, the amount of natural assets per capita tends to decline with population density. This positively impacts on the share of MHT exports and the share of employment in knowledge intensive activities.

The remainder of this section presents the definitions of the structural indicators used in the EIS 2020 report for EU Member States and other European or neighbouring countries.

[15] https://ec.europa.eu/environment/ecoap/indicators/index_en

Performance and structure of the economy

GDP per capita (PPS)	
Indicator	Nominal Gross Domestic Product per capita
Unit	Purchasing power standard (PPS) per inhabitant
Calculated as	Average value for the years 2016 to 2018
Data source	Eurostat: Annual national accounts data
Average annual GDP growth (%)	
Indicator	Gross Domestic Product at market prices
Unit	Chain linked volumes, index 2010=100
Calculated as	Average annual growth rate between 2017 and 2019
Data source	Eurostat: Annual national accounts data
Employment share Manufacturing (NACE C) (%)	
Numerator	Employment in Manufacturing (NACE Rev. 2 C)
Denominator	Total employment
Calculated as	Average percentage share for the years 2016 to 2018
Data source	Eurostat: Employment in technology and knowledge-intensive sectors at the national level, by type of occupation
Of which High and Medium high-tech (%)	
Numerator	Total employment in the following industries: • High technology: Basic pharmaceutical products and pharmaceutical preparations (NACE Rev. 2 21); Computer, electronic and optical products (NACE Rev. 2 26); Air and spacecraft and related machinery (NACE Rev. 2 30.3) • Medium-high-technology: Chemicals and chemical products (NACE Rev. 2 20); Weapons and ammunition (NACE Rev. 2 25.4); Electrical equipment (NACE Rev. 2 27) ; Machinery and equipment not elsewhere classified (NACE Rev. 2 28); Motor vehicles, trailers and semi-trailers (NACE Rev. 2 29); Other transport equipment (NACE Rev. 2 30) excluding Building of ships and boats (NACE Rev. 2 30.1) and excluding Air and spacecraft and related machinery (NACE Rev. 2 30.3); Medical and dental instruments and supplies (NACE Rev. 2 32.5)
Denominator	Employment in Manufacturing (NACE Rev. 2 C)
Calculated as	Average percentage share for the years 2016 to 2018
Data source	Eurostat: Employment in technology and knowledge-intensive sectors at the national level, by type of occupation
Employment share Services (NACE G-N) (%)	
Numerator	Employment in Services (NACE Rev. 2 G-N)
Calculated as	Average percentage share for the years 2016 to 2018
Denominator	Total employment
Data source	Eurostat: Employment in technology and knowledge-intensive sectors at the national level, by type of occupation
Of which Knowledge-intensive services (%)	

Numerator	Aggregate of employment in the following industries: Water transport; Air transport (NACE Rev. 2 50-51); Publishing activities; Motion picture, video and television programme production, sound recording and music publishing activities; Programming and broadcasting activities; Telecommunications; computer programming, consultancy and related activities; Information service activities (NACE Rev. 2 58-63); Financial and insurance activities (NACE Rev. 2 64-66); Legal and accounting activities; Activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis; Scientific research and development; Advertising and market research; Other professional, scientific and technical activities; Veterinary activities (NACE Rev. 2 69-75); Employment activities (NACE Rev. 2 78); Security and investigation activities (NACE Rev. 2 80)
Denominator	Employment in Services (NACE Rev. 2 G-N)
Calculated as	Average percentage share for the years 2016 to 2018
Data source	Eurostat: Employment in technology and knowledge-intensive sectors at the national level, by type of occupation
Turnover share SMEs (%)	
Numerator	Turnover in enterprises with 10 to 249 persons employed
Denominator	Turnover in Total business economy; repair of computers, personal and household goods; except financial and insurance activities
Calculated as	Average percentage share for the years 2014 to 2017
Data source	Eurostat: Annual enterprise statistics by size class for special aggregates of activities
Turnover share large enterprises (%)	
Numerator	Turnover in enterprises with 250 persons employed or more
Denominator	Turnover in Total business economy; repair of computers, personal and household goods; except financial and insurance activities
Calculated as	Average percentage share for the years 2014 to 2017
Data source	Eurostat: Annual enterprise statistics by size class for special aggregates of activities
Share of foreign controlled enterprises (%)	
Numerator	Value added by foreign-controlled enterprises at factor cost in million euros for Non-financial business economy. A foreign-controlled enterprise shall mean that the controlling institutional unit is resident in a different country from the one where the institutional unit over which it has control is resident.[16]
Data source	Eurostat: Foreign control of enterprises by economic activity and a selection of controlling countries (from 2008 onwards) [fats_g1a_08]
Denominator	Value added, gross
Data source	Eurostat: GDP and main components (output, expenditure, and income) [nama_10_gdp]
Calculated as	Average percentage share for the years 2015 to 2017

Business and entrepreneurship

Enterprise births (10+ employees) (%)	
Numerator	Number of births of enterprises in year t
Size class	10 employees or more
Industries	Business economy except activities of holding companies
Denominator	Population of active enterprises in year t
Size class	10 employees or more
Industries	Business economy except activities of holding companies

[16] A more detailed explanation is available at: http://ec.europa.eu/eurostat/cache/metadata/EN/fats_esms.htm

Calculated as	Average percentage share for the years 2015 to 2017
Data source	Eurostat: Business demography data
Total early-stage Entrepreneurial Activity (TEA) (%)	
Indicator	Percentage of population aged 18-64 who are either a nascent entrepreneur or owner-manager of a new enterprise (less than 3.5 years old)[17]
Calculated as	Average for the years 2017 to 2019
Data source	Global Entrepreneurship Monitor
FDI net inflows (% GDP)	
Indicator	Foreign direct investment, net inflows (% of GDP)
Calculated as	Average percentage share for the years 2016 to 2018
Data source	World Bank (World Development Indicators) - Series name: BX.KLT.DINV.WD.GD.ZS
Top R&D spending enterprises per 10 million population	
Numerator	Number of enterprises in the top 2500 enterprises investing the largest sums in R&D in the world
Data source	European Commission (IPTS) - The EU Industrial R&D Investment Scoreboard
Calculated as	Average number for the years 2016 to 2018
Denominator	Population
Data source	Eurostat
Buyer sophistication (1 to 7 best)	
Indicator	Average response to the following question: "In your country, on what basis do buyers make purchasing decisions? [1 = based solely on the lowest price; 7 = based on sophisticated performance attributes]"
Calculated as	Average number for the years 2017 to 2019
Data source	World Economic Forum, Global Competitiveness Report

Innovation profiles

In-house product innovators with market novelties	
Indicator	This group includes all enterprises that introduced a product innovation that was developed by the enterprise and that was not previously offered by competitors ('new to the market').
Calculated as	Enterprises are identified based on a combination of different questions in the CIS. Full details are available in the following document: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c
Data source	Eurostat and National Statistical Offices
In-house product innovators without market novelties	
Indicator	This group includes all enterprises that introduced a product innovation that was developed by the enterprise but that is identical or very similar to products already offered by competitors ('only new to the enterprise itself').
Calculated as	Enterprises are identified based on a combination of different questions in the CIS. Full details are available in the following document: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c
Data source	Eurostat and National Statistical Offices
In-house business process innovators	

[17] Total Entrepreneurial Activity (TEA) is explained in detail at http://www.gemconsortium.org/wiki/1176

Indicator	This group includes all enterprises that did not introduce a product innovation, but that did introduce a business process innovation that was developed by the enterprise.
Calculated as	Enterprises are identified based on a combination of different questions in the CIS. Full details are available in the following document: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c
Data source	Eurostat and National Statistical Offices
Innovators that do not develop innovations themselves	
Indicator	This group includes all enterprises that introduced an innovation of any kind but did not develop it themselves (enterprises without significant own innovation capabilities).
Calculated as	Enterprises are identified based on a combination of different questions in the CIS. Full details are available in the following document: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c
Data source	Eurostat and National Statistical Offices
Innovation active non-innovators	
Indicator	This group includes all enterprises that did not introduce any innovation but that either had ongoing or abandoned innovation activities.
Calculated as	Enterprises are identified based on a combination of different questions in the CIS. Full details are available in the following document: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c
Data source	Eurostat and National Statistical Offices
Non-innovators with potential to innovate	
Indicator	This group includes all enterprises that did not introduce any innovation, and which had no ongoing or abandoned innovation activities but that did consider to innovate.
Calculated as	Enterprises are identified based on a combination of different questions in the CIS. Full details are available in the following document: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c
Data source	Eurostat and National Statistical Offices
Non-innovators without disposition to innovate	
Indicator	This group includes all other enterprises, those that neither introduced an innovation nor had any ongoing or abandoned innovation activities nor considered to innovate.
Calculated as	Enterprises are identified based on a combination of different questions in the CIS. Full details are available in the following document: https://circabc.europa.eu/ui/group/47133480-29c1-4c23-9199-72a631f4fd96/library/be99ed75-c7ab-4119-804c-42867652481c
Data source	Eurostat and National Statistical Offices

Governance and policy framework

Ease of starting a business (0 to 100 best)	
Indicator	The "Starting a Business" indicator records all procedures, time, cost and paid-in minimum capital that are officially required for an entrepreneur to start up and formally operate an industrial or commercial business. These include obtaining all necessary licenses and permits and completing any required notifications, verifications or inscriptions for the company and employees with relevant authorities.
Calculated as	Average for the years 2017 to 2019
Data source	World Bank - Doing Business
Basic-school entrepreneurial education and training (1 to 5 best)	

Indicator	The indicator measures the extent to which training in creating or managing SMEs is incorporated within the education and training system at primary and secondary school levels.
Calculated as	Average for the years 2017 to 2019
Data source	Global Entrepreneurship Monitor
Government procurement of advanced technology products (1 to 7 best)	
Indicator	The indicator measures the extent to which government procurement decisions in a country foster technological innovation by providing the average response to the following question: "Government purchase decisions for the procurement of advanced technology products are (1 = based solely on price, 7 = based on technical performance and innovativeness)"
Calculated as	Average for the years 2015 to 2017
Data source	World Economic Forum
Rule of law (-2.5 to 2.5 best)	
Indicator	Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.
Calculated as	Average for the years 2016 to 2018
Data source	World Bank: Worldwide Governance Indicators

Climate change

Circular material use rate	
Indicator	The indicator measures the share of material recovered and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. The overall material use is measured by summing up the aggregate domestic material consumption (DMC) and the circular use of materials. DMC is defined in economy-wide material flow accounts. The circular use of materials is approximated by the amount of waste recycled in domestic recovery plants minus imported waste destined for recovery plus exported waste destined for recovery abroad. Waste recycled in domestic recovery plants comprises the recovery operations R2 to R11 - as defined in the Waste Framework Directive 75/442/EEC. The imports and exports of waste destined for recycling - i.e. the amount of imported and exported waste bound for recovery – are approximated from the European statistics on international trade in goods. A higher circularity rate value indicates means that more secondary materials substitute for primary raw materials thus reducing the environmental impacts of extracting primary material. (https://ec.europa.eu/eurostat/web/products-datasets/-/cei_srm030)
Calculated as	The circular material use is defined as the ratio of the circular use of materials to the overall material use.
Data source	Eurostat
Greenhouse gas emissions intensity of energy consumption	
Indicator	The indicator is part of the EU Sustainable Development Goals (SDG) indicator set. It is used to monitor progress towards Goal 13 on climate action and SDG 7 on affordable and clean energy. SDG 13 aims to implement the commitment to the United Nations Framework Convention on Climate Change and operationalise the Green Climate Fund. It aims to strengthen countries' resilience and adaptive capacity to climate-related hazards and natural disasters by integrating climate change mitigation and adaptation measures into national strategies, policies and planning. SDG 7 calls for ensuring universal access to modern energy services, improving energy efficiency and increasing the share of renewable energy.

Calculated as	The indicator is calculated as the ratio between energy related GHG emissions and gross inland consumption of energy. It expresses how many tonnes CO2 equivalents of energy related GHGs are being emitted in a certain economy per unit of energy that is being consumed. The data on energy emissions are being sourced from the GHG emissions reported to the UNFCCC.
Data source	European Environment Agency (EEA), Eurostat
Eco-Innovation Index	
Indicator	The Eco-Innovation Index shows how well individual Member States perform in eco-innovation compared to the EU average, which is equated with 100 (index EU=100). The index complements other measurement approaches of innovativeness of EU countries and aims to promote a holistic view on economic, environmental and social performance.
Calculated as	The indicator is based on 16 sub-indicators from eight contributors in five thematic areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency outcomes and socio-economic outcomes. The overall score of an EU Member State is calculated by the unweighted mean of the 16 sub-indicators.
Data source	European Commission: Eco-Innovation Scoreboard https://ec.europa.eu/environment/ecoap/indicators/index_en

Demography

Population size	
Indicator	Population on 1 January
Calculated as	Average value for the years 2017 to 2019
Data source	Eurostat: Population data
Average annual population growth (%)	
Indicator	Population on 1 January
Calculated as	Average annual growth rate between 2017 to 2019
Data source	Eurostat: Population data
Population density	
Indicator	Inhabitants per km2
Calculated as	Average value for the years 2016 to 2018
Data source	Eurostat

6.2 Contextual indicators used for global economic competitors

For the international benchmarking, a comparable list of contextual indicators has been used, but for most indicators measuring Performance and structure of the economy and Demography, data have been retrieved from other data sources. For the international comparison, the number of so-called Unicorns is included. Unicorns are private start-ups with a value of US$1 billion or more. The list of contextual indicators used in the international comparison, the years for which average performance has been calculated, and data sources used are shown in Table 8.

Table 8: Contextual indicators in the international comparison

	Period	Source
PERFORMANCE AND STRUCTURE OF THE ECONOMY		
GDP per capita, PPP (international dollars)	Average 2017-2019	World Development Indicators*
Average annual GDP growth (%)	2017-2019	World Development Indicators*
Employment share in Agriculture (%)	Average 2017-2019	World Development Indicators*
Employment share in Industry (%)	Average 2017-2019	World Development Indicators*
Employment share in Services (%)	Average 2017-2019	World Development Indicators*

Manufacturing – share in total value added **	Average 2018-2020	UNIDO
BUSINESS AND ENTREPRENEURSHIP		
Total early-stage Entrepreneurial Activity (TEA) (%)	Average 2017-2019	Global Entrepreneurship Monitor
FDI net inflows (% GDP)	Average 2017-2019	World Development Indicators*
Top R&D spending enterprises per 10 million population	Average 2017-2019	EU Industrial R&D Investment Scoreboard
Top R&D spending enterprises, average R&D spending, million Euros	Average 2018-2020	EU Industrial R&D Investment Scoreboard
Number of Unicorns	All active enterprises May2021	CB Insights[18]
Buyer sophistication (1 to 7 best)	Average 2017-2019	World Economic Forum
GOVERNANCE AND POLICY FRAMEWORK		
Ease of starting a business (0 to 100 best)	Average 2017-2019	Doing Business*
Basic-school entrepreneurial education and training (1 to 5 best)	Average 2017-2019	Global Entrepreneurship Monitor
Government procurement of advanced technology products (1 to 7 best)	Average 2015-2017	World Economic Forum
Rule of law (-2.5 to 2.5 best)	Average 2016-2018	Worldwide Governance Indicators*
DEMOGRAPHY		
Population size (millions)	Average 2017-2019	World Development Indicators*
Average annual population growth (%)	2017-2019	World Development Indicators
Population density (inhabitants / km^2)	Average 2017-2019	World Development Indicators*

* Database from the World Bank ** Value added data are used in the international comparison as employment data are not available.

The following subsections present the definitions for each structural indicator used for the EU and its global competitors.

Performance and structure of the economy

GDP per capita (PPP)	
Indicator	GDP per capita, PPP (current international $)
Calculated as	Average value for the years 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: NY.GDP.PCAP.PP.CD
Average annual GDP growth (%)	
Indicator	GDP per capita (constant 2010 US$)
Calculated as	Average annual growth rate between 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: NY.GDP.MKTP.KD
Employment share in Agriculture (%)	
Indicator	Employment in agriculture (% of total employment)
Calculated as	Average percentage share for the years 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: SL.AGR.EMPL.ZS
Employment share in Industry (%)	
Indicator	Employment in industry (% of total employment)
Calculated as	Average percentage share for the years 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: SL.IND.EMPL.ZS

[18] https://www.cbinsights.com/research-unicorn-companies

Employment share in Services (%)	
Indicator	Employment in services (% of total employment)
Calculated as	Average percentage share for the years 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: SL.SRV.EMPL.ZS
Manufacturing – share in total value added (%)	
Numerator	Value added in manufacturing, million US$
Denominator	Gross domestic product, million US$
Calculated as	Average percentage share for the years 2018 to 2020
Data source	United Nations Industrial Development Organization (UNIDO)

Business and entrepreneurship

Total early-stage Entrepreneurial Activity (TEA) (%)	
Indicator	Percentage of population aged 18-64 who are either a nascent entrepreneur or owner-manager of a new enterprise (less than 3.5 years old)[19]
Calculated as	Average for the years 2017 to 2019
Data source	Global Entrepreneurship Monitor
FDI net inflows (% GDP)	
Indicator	Foreign direct investment, net inflows (% of GDP)
Calculated as	Average percentage share for the years 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: BX.KLT.DINV.WD.GD.ZS
Top R&D spending enterprises per 10 million population	
Numerator	Number of enterprises in the top 2500 enterprises investing the largest sums in R&D in the world
Data source	European Commission (IPTS) - The EU Industrial R&D Investment Scoreboard
Calculated as	Average number for the years 2018 to 2020
Denominator	Population
Data source	World Bank: World Development Indicators
Top R&D spending enterprises, average R&D spending, million Euros	
Numerator	Average R&D spending per enterprise listed in the top 2500 enterprises investing the largest sums in R&D in the world
Calculated as	Average number for the years 2018 to 2020
Data source	European Commission (IPTS) - The EU Industrial R&D Investment Scoreboard
Number of Unicorns	
Indicator	A unicorn is a private start-up company which, over time, has been valued at $1 billion or more
Calculated as	Total number of Unicorns listed May 2021
Data source	CB Insights: https://www.cbinsights.com/research-unicorn-companies
Buyer sophistication (1 to 7 best)	
Indicator	Average response to the following question: "In your country, on what basis do buyers make purchasing decisions? [1 = based solely on the lowest price; 7 = based on sophisticated performance attributes]"
Calculated as	Average number for the years 2017 to 2019
Data source	World Economic Forum, Global Competitiveness Report

[19] Total Entrepreneurial Activity (TEA) is explained in detail at http://www.gemconsortium.org/wiki/1176

Governance and policy framework

Ease of starting a business (0 to 100 best)	
Indicator	The "Starting a Business" indicator records all procedures, time, cost and paid-in minimum capital that are officially required for an entrepreneur to start up and formally operate an industrial or commercial business. These include obtaining all necessary licenses and permits and completing any required notifications, verifications or inscriptions for the company and employees with relevant authorities.
Calculated as	Average for the years 2017 to 2019
Data source	World Bank - Doing Business
Basic-school entrepreneurial education and training (1 to 5 best)	
Indicator	The indicator measures the extent to which training in creating or managing SMEs is incorporated within the education and training system at primary and secondary school levels.
Calculated as	Average for the years 2017 to 2019
Data source	Global Entrepreneurship Monitor
Government procurement of advanced technology products (1 to 7 best)	
Indicator	The indicator measures the extent to which government procurement decisions in a country foster technological innovation by providing the average response to the following question: "Government purchase decisions for the procurement of advanced technology products are (1 = based solely on price, 7 = based on technical performance and innovativeness)"
Calculated as	Average for the years 2015 to 2017
Data source	World Economic Forum
Rule of law (-2.5 to 2.5 best)	
Indicator	Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.
Calculated as	Average for the years 2016 to 2018
Data source	World Bank: Worldwide Governance Indicators

Demography

Population size	
Indicator	Population on 1 January
Calculated as	Average value for the years 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: SP.POP.TOTL
Average annual population growth (%)	
Indicator	Population on 1 January
Calculated as	Average annual growth rate between 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: SP.POP.TOTL
Population density	
Indicator	Population density (people per sq. km of land area)
Calculated as	Average value for the years 2017 to 2019
Data source	World Bank (World Development Indicators) - Series name: EN.POP.DNST


European
Commission