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Guidance and benchmarking tool for national innovation system analysis

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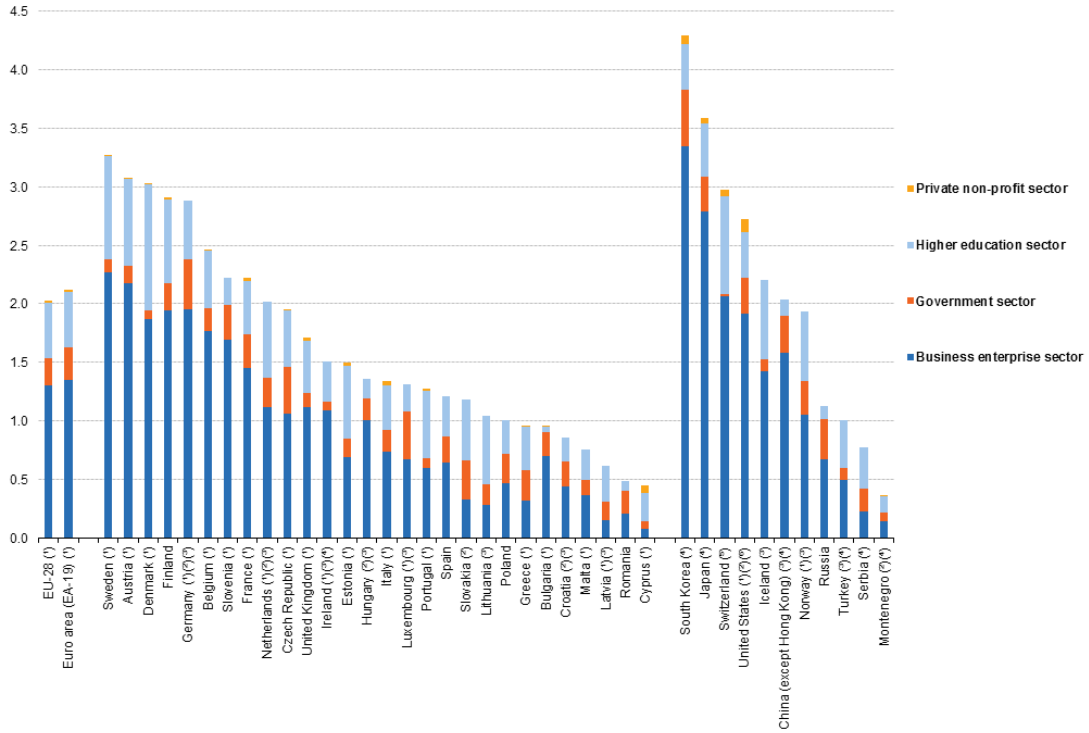
I. Key indicators for evaluating the performance of the National Innovation System (NIS)

Indicator 1: Gross domestic expenditure on R&D

Measurement
- Gross domestic expenditure on R&D (as percentage of GDP)

- **Basis for cross-national comparison**

Gross domestic expenditure on R&D by sector, 2015 (% of GDP)



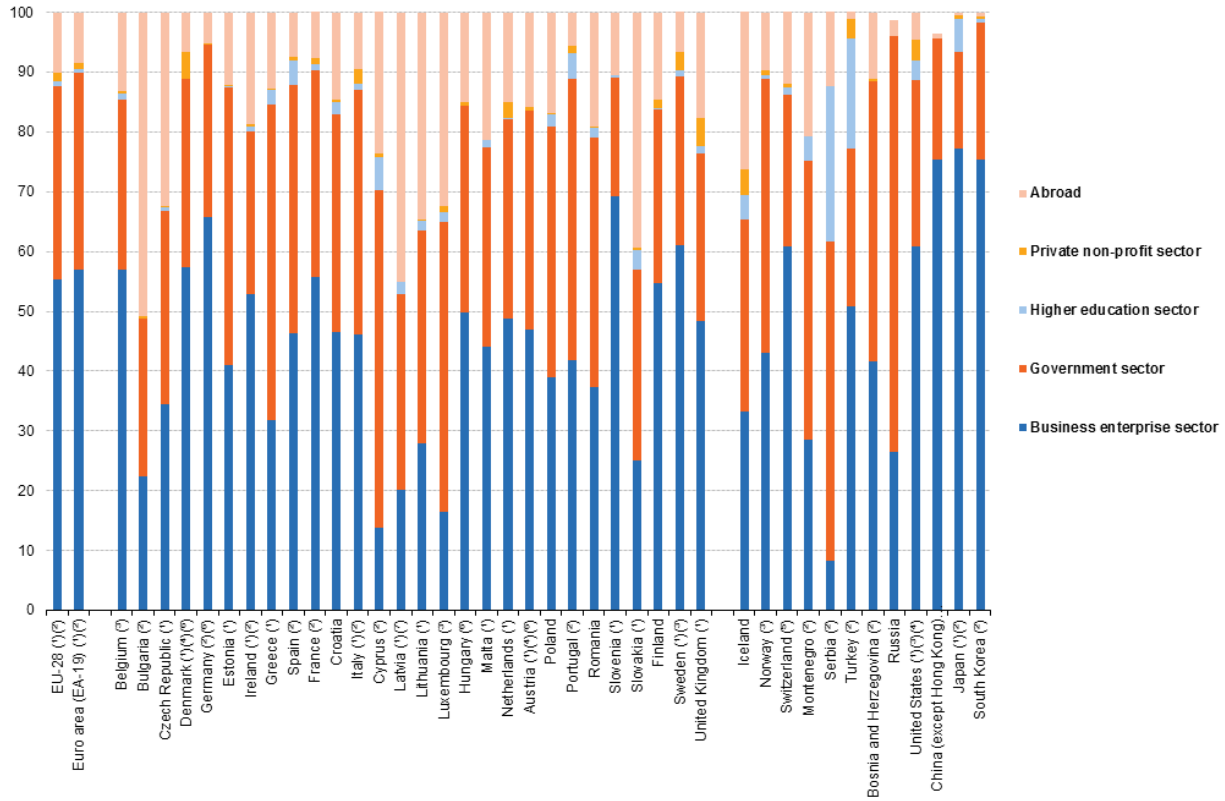
Note. When definitions differ, see http://ec.europa.eu/eurostat/cache/metadata/en/rd_esms.htm.
(1) Estimates or provisional.
(2) Definition differs.
(3) Private non-profit sector: not available.
(4) 2014.
(5) 2012.
(6) 2013.
Source: Eurostat (online data code: rd_e_gerdtot)

Source: Eurostat

Indicator 2: Business enterprise expenditure on R&D (BERD) and Government sector expenditure on R&D (GERD)

Measurement
- BERD as a percentage of GDP (* Survey-based country rankings on company spending on R&D are also available in the Global Competitiveness Report of the World Economic Forum available from: http://reports.weforum.org/global-competitiveness-index-2017-2018) - GERD as a percentage of GDP

- **Basis for cross-national comparison**



Note. When definitions differ, see http://ec.europa.eu/eurostat/cache/metadata/en/rd_esms.htm.
(1) Estimates or provisional.
(2) 2014 instead of 2015.
(3) 2013 instead of 2015.
(4) Definition differs.
(5) 2012 instead of 2015.
(6) Higher education sector: not available.
(7) Private non-profit sector: not available.
Source: Eurostat (online data code: rd_e_fundgerd)

Source: Eurostat

Indicator 3: Patents and licenses

Measurement
- Royalty and license fees payments (per capita) - Royalty and license fees receipts (per capita) - IP filing activity originating in the country (data is available from the World Intellectual Property Organization

http://www.wipo.int/publications/en/details.jsp?id=4234) - Number of IP applications and grants (*Country rankings on Patent Cooperation Treaty patents / applications per million population are available in the Global Competitiveness Report) - Success rate of IP applications from locally-based individuals / companies (ratio of IP grants to the number of applications)

- **Basis for cross-national comparison**

Comparison can be performed on the basis of the data published by WIPO: http://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2017.pdf

Indicator 4: Scientific production

Measurement
- Number of publications included in Scopus and Web of Science databases - Scientific publications rated among the top 10% most cited - Number of scientific and technical journal articles

- **Basis for cross-national comparison**

Country rankings based on the information contained in Scopus: http://www.scimagojr.com/countryrank.php

Comparison with countries leading in the number of scientific and technical journal articles: data by the National Science Board of the United States can be used, available from https://www.nsf.gov/statistics/2018/nsb20181/assets/968/tables/tt05-22.pdf

Indicator 5: Research capacity

Measurement
- Number of researchers per million of inhabitants

- **Basis for cross-national comparison**

Data for some countries is available from UNESCO Institute for Statistics, and downloadable from https://data.worldbank.org/indicator/SP.POP.SCIE.RD.P6

II. Indicators for evaluating the context and structure of the National Innovation System (NIS)

Business Environment

1. Business structure and business financing system

Descriptors and indicators:

Descriptor 1.1: Industrial structure

Measurement
- Share of large firms and mature SMEs in the total number of enterprises - Share of technology-based high-growth companies in the total number of enterprises - Size of the informal sector in the economy: Large/Medium/Small *Survey data about the informal sector can be found in World Bank's Enterprise Surveys

(www.enterprisesurveys.org)

Guidelines for evaluation

Large firms are more likely to engage in innovation activities and to have a strong absorption capacity for innovations. SMEs generally experience more barriers to innovation. SMEs are less connected than large firms to international knowledge networks, lag behind in the adoption of sophisticated digital technologies and are less likely than larger firms to conduct Research and Development (R&D). Micro enterprises tend to have lower awareness of innovation concepts, processes and procedures and typically do not purposefully manage innovation or systematically plan or evaluate their innovation processes. Industrial structures dominated by micro enterprises and non-mature SMEs are therefore less likely to be strong innovator economies. Innovation is particularly unlikely in the informal sector.

A number of SMEs, however, can be characterized as innovative and technology-based. In the OECD, the percentage of SMEs that can be characterized as innovative is between 30% and 60%.

Descriptor 1.2: Firms' capacity for innovation creation and absorption

Measurement
-Innovation capacity of national firms *Survey data is available from www.enterprisesurveys.org. For Kenya, data is also available from the Kenya Innovation Survey Report 2012 (54.213.151.253/nada/index.php/catalog/79) *Survey-based country rankings on companies' capacity to innovate are available in the Global Competitiveness Report (latest report is available from: reports.weforum.org/global-competitiveness-index-2017-2018)

The descriptor correlates positively with innovation. The innovation capacity of firms is posited to depend on a number of factors internal to the companies, including: strong mission-oriented culture; a culture of quality management and customer satisfaction; team-based style of work; employee empowerment; senior managers' commitment to innovation; the firm's ability for networking with its external environment, including customers, suppliers, investors, competitors and local institutions; available resources, including technology; a workforce with a variety of skills; managerial talent; experience of the senior management.

Descriptor 1.3: Level of development of banking and venture capital

Measurement
- Availability of financing through the local equity market - Availability of venture capital - Ease of access to loans - Affordability of loans for enterprises - Stability of the banking system - Availability of financial services - Affordability of financial services * Survey-based country rankings on most of these three indicators are available in the Global Competitiveness Report. These rankings should be complemented by local survey results or expert opinion

Guidelines for evaluation

Weak development of banking and venture capital creates an environment in which innovating firms experience difficulties in obtaining starting or operating capital.

- **Examples of good performers and poor performers**

SMEs and Innovation: Small and medium-sized enterprises represent 99% of all businesses in the EU. Large enterprises create a higher proportion of value added in the 'high and medium/low tech manufacturing' sector, while SMEs create a higher proportion of value added in the services sector. In the low- and medium-low technology sectors, however, Gross Value Added and employment are created by a roughly even proportion of large enterprises and SMEs.

Around 63% of the micro enterprises in the EU declared having introduced at least one innovation since 2011, compared to 85% of the enterprises with 500 employees or more. The microenterprises were also much more likely to have encountered difficulties when trying to commercialise their innovations. For this reason, the EU has made SMEs the primary focus of innovation support policies.

Access to finance: The United States (US) has pioneered the venture capital industry and remains a leader, with venture funding available in every state. In addition to venture capital, there is an "angel capital" system. Relative to the size of their economies, venture capital markets in countries like Canada and Israel are also large. EU countries are introducing measures to improve innovating firms' access to finance and to create vibrant start-up ecosystems. Yet venture capital investments in EU member states still remain a fraction of those in the US. Venture capital activity is even more negligible in the rest of the world.

2. Firm behavior

Descriptors and indicators:

Descriptor 2.1: Managerial Talent

Measurement
- Share of higher education students studying in areas of business, administration and law - Reliance on professional management (*survey-based country rankings are available in the Global Competitiveness Report) - Quality of management schools (*survey-based country rankings are available in the Global Competitiveness Report).

Guidelines for evaluation

There is a direct causal link between managerial talent and innovation in companies. There is a less clear causal link between managerial talent and the number of graduates in areas of business, administration and law. Yet quantitative and qualitative indicators related to education and training in the field of management and business should be considered in the evaluation of the NIS as a proxy to firms' innovation capacity.

2.2. Time horizon and risk tolerance of firms

Measurement
- Level of capital investment in companies - Level of R&D investment in companies - National-level surveys or expert opinion

Guidelines for evaluation

Focusing on short-term performance and maximal returns/profits reduces firms' ability to invest in value creation for the long-term, including in innovation activities.

Descriptor 2.3: Adoption of ICT in firms

Measurement
- Corporate investment spending in hardware, software, and telecommunications as share of overall capital investment - Firm-level technology absorption (*survey-based country rankings are available in the Global Competitiveness Report; Enterprise Survey research (dated 2016) is available for Kenya, Uganda and Tanzania from: Cirera, Xavier; Lage, Filipe; Sabetti, Leonard, Policy Research Working Paper WPS7868, http://documents.worldbank.org/).

Guidelines for evaluation

Adoption of ICTs in firms can impact positively on the firm's productivity, output and innovation by enabling a number of innovation processes and freeing resources.

- **Good practices**

- Cloud computing emerges as an important platform for innovative services. It reduces information technology barriers for SMEs by allowing firms to avoid large investments in IT infrastructure and software and to instead adopt a pay-as-you-go model for computing resources.

- As part of the Digital Single Market initiative, the EU has introduced the ICT Innovation Vouchers Schemes. The EU regions can set up and fund an ICT Innovation Vouchers Scheme through the EU structural and investment funds. The schemes are thus tailored to the context in the particular region. They support micro-enterprises and SMEs to use digital technologies in order to innovate and increase their competitiveness. The ICT voucher provides firms with easy access to specialist services, such as creating a website, learning to use e-commerce tools, or adopting sophisticated ICT tools in view of improving internal processes.

3. Cultural factors

Descriptors and indicators:

Descriptor 3.1: Demand for innovation

Measurement
- Final consumption expenditure of households - Secondary education enrolment rate and tertiary education enrolment rate (as proxies to receptiveness to innovative products and services) - Surveys of population receptiveness to innovative products and services, or expert opinions - Innovation-intensive pockets within industries already exist: Yes/No

Guidelines for evaluation

This descriptor has a clear causal link to innovation. Demand on the side of consumers is strongly influenced by the overall receptiveness of the population to innovative products. Overall demand for innovation, however, can also be boosted by innovation

in industry itself, largely due to the effects of vertical integration. If innovations are introduced in upstream industries, this can induce innovation in downstream industries that now face changed market conditions and changed supply of intermediary products. Conversely, innovations introduced in downstream industries can induce innovation by changing the demand for intermediary products and thus changing the market conditions in which the upstream industries operate.

Descriptor 3.2: Social attitudes to risk-taking and entrepreneurship

Measurement
- Success and failure rates of new start-ups - Surveys or expert opinions on societal attitudes to business failure and entrepreneurship-related risk

Guidelines for evaluation

Strong negative social attitudes to risk-taking and the likelihood of business failure can significantly reduce the rate of entrepreneurial activity and thus reduce the likelihood that companies will innovate.

Descriptor 3.3: Social attitudes towards Science and Technology

Measurement
- Secondary education enrolment rate and tertiary education enrolment rate (as proxies for attitude of the population to science and technology) - Quality of math and science education at all levels (as a proxy for attitude of the population to science and technology) (*survey-based country rankings are available in the Global Competitiveness Report) -National-level surveys or expert opinions of attitudes to technology and its impact

Guidelines for evaluation

Typically, social attitudes to technology and technological change are complex, with pro-innovation attitudes coexisting with anti-innovation attitudes. The balance, however, is likely to determine if the particular society has an overall positive or an overall cautious attitude to technological change and innovation.

- **Examples of good performers and poor performers**

US customers are widely known for their high responsiveness and demand for innovative products and services. Societies with more traditional culture, however, may sustain more barriers to the consumption and diffusion of innovation.

Established liberal economies like the US and UK have a strong entrepreneurial mind-set and a strong culture of risk taking. There, unlike in many countries, failure in a new business is not considered a negative experience.

There are societies, such as the US, where technological change is valued and widely accepted. Yet, even in those societies there are anti-innovation forces that need to be considered. Specifically for the US, such forces appear to be currently gaining strength, fuelled by fears of job loss from automation processes, privacy incursions from the increasing use of the Internet and e-services, or environmental damage perceived to be associated with new technologies such as nanotechnologies and biotechnologies.

Trade, Tax, and Regulatory Environment

1. Long-term structural economic factors influencing the innovation system

Descriptors and indicators:

Descriptor 1.1: Specialization of industry

Measurement
- Contribution of high-tech, medium-tech and low-tech sectors to the trade balance - Manufacturing trade as percentage of GDP - High-technology exports as percentage of manufacturing exports - Capital goods imports as share of overall imports - Capital goods exports as share of overall exports

Guidelines for evaluation

High-technology sectors ("high-tech") are sectors with complex technology and R&D intensity or more than 5%. Examples include pharmaceuticals, the electronic industry, vehicle construction, mechanical engineering. Medium-high-technology ("medium-tech") sectors are those with relatively complex technology, with R&D intensity between 3% and 5%. Low-technology ("low-tech") sectors are not research-intensive and have R&D intensity below 3%. Examples of medium and low-technology industries include more mature industries such as production of household appliances, food industry, paper, publishing and print industry, wood and furniture industry, manufacture of metal products, manufacture of plastic products.

Strong innovation capacity and potential are typically found in high-tech industrial sectors, especially if we focus on radical innovations. However, much innovation happens in the medium- and low- technology sectors, too, even if these sectors are less likely to produce radical innovations and more likely to induce incremental innovation or other types of innovation such as new product applications. In such sectors, the absorption and diffusion of innovations developed in other countries can be of paramount importance. In fact, innovations in low- and medium-technology sectors can be more easily attainable in low-income countries. Knowing the industrial structure of the country is important in view of determining the type of innovations that are more likely to be induced in the NIS.

Indicator 1.2: Foreign Direct Investment (FDI)

Measurement
-FDI outflow as percent of GDP -FDI inflow as percent of GDP

Guidelines for evaluation

FDI is the primary source of technology transfer. Many countries follow a policy to encourage inward FDI in order to take advantage of the technology transfer that they entail. The effects of outward investment are less researched, but it has been argued that firms investing abroad are more likely to be under competitive pressure to conduct R&D and innovate. Also, they are more likely to be exposed to foreign knowledge and technology and to thus increase their innovation capacity

Descriptor 1.3: Macroeconomic Environment

Measurement
-Prevalent macroeconomic policies (qualitative measurement)

Guidelines for evaluation:

Macroeconomic policies focused on monetary stability rather than full employment tend to be more conducive to innovation. In addition, countries that primarily rely on monetary policy rather than on fiscal policy, tend to create a better environment for innovative firms.

Descriptor 1.4: Knowledge intensity of the economy

Measurement
- Share of knowledge-intensive industries and services in the value added in the business sector - Knowledge-intensive services exports as share of overall exports

Guidelines for evaluation

Knowledge-intensive industries and services are key enablers, as well as sources, of innovation. They include:

- Finance, insurance and other business services
- Communication services
- High-technology manufactures
- Medium-high-technology manufactures
- Community, social and personal services

The EU maintains regular statistics about knowledge-intensive services in the Member States. More information on the approach can be consulted at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Knowledge-intensive_services_(KIS).

Descriptor 1.5: Hotspots in key technologies

Measurement
- There are key technology sectors or regions specializing in technological industries that emerge as hotbeds of innovation: Yes/No

Guidelines for evaluation

Specific key technology sectors or regions with high level of industrial specialization can become hotbeds of innovation within the NIS. The effects would be stronger if public funding is directed at these sectors/regions in order to leverage innovation and research activities within them. It is generally believed that regions and regional governments are in a good position to support the emergence of industrial clusters that could become hotbeds of innovation. For a detailed analysis of the NIS, the sectors/regions in question need to be analysed in terms of their innovation capacity and performance.

Descriptor 1.6: Ongoing structural change / reforms in the economy

Measurement
- There are ongoing reforms to upgrade the manufacturing sectors through research and technologies

- There are ongoing reforms to upgrade the non-manufacturing sectors through research and technologies

Guidelines for evaluation

Reforms aimed at improving productivity, efficiency, infrastructure or the competitive structure in the main sectors of the economy are likely to induce innovations, especially if public funding prioritizes innovation and research activities. For a detailed evaluation of the NIS, planned reforms need to be analysed and factored in the evaluation.

Descriptor 1.7: Market size and market access

Measurement
- The national economy constitutes a large-size market: Yes/No - Firms in the national economy have access to large markets through preferential trade areas: Yes/No

Guidelines for evaluation

Access to large-size markets implies greater profitability from sales, thus inducing faster innovation for products.

Descriptor 1.8: Communication and ICT infrastructure

Measurement
- Internet subscribers per 100 inhabitants - Share of households with Internet access at home - Computers per 100 inhabitants - Share of households owning a computer - Fixed-broadband internet penetration (subscribers per 100 inhabitants) (*Country ratings available in Global Competitiveness Report) - Internet access tariffs (20 hours per month), as percentage of per capita income - Percentage of localities with public Internet access centres by number of inhabitants (rural/urban)

Guidelines for evaluation

The availability of well-developed communication and ICT infrastructure, coupled with broad access to and use of ICT, increases customers' perceptiveness to technology-based innovations and thus increases demand for innovation. It can also have an indirect effect on the skills of the human capital in the technology field. Finally, the adoption of ICT in firms will be significantly facilitated if the country has a well-developed communication and ICT infrastructure and if the costs associated with communication and ICT are not excessive.

- **The EU experience**

The medium-high and high technology manufacturing sector generates a significant part of total GVA in Germany (18 %), Finland (14 %), Denmark (10 %) and the Netherlands (9 %). They are the EU countries that rank higher in terms of capacity for radical innovation.

Finland is the world's leading innovator in the energy and environment sectors, notably in the fields of renewable energy (bio, hydro, wind, solar, wave, algae) and smart grids, energy and material efficiency, recycling technology and technology for cleaning air and

water. Around half of Finnish public funding for innovation and research is concentrated in these fields.

Regional specialization has also been shown to lead to the emergence of industrial districts and clusters involved in innovation. For example, the Italian region of Emilia-Romagna is specialized in automotive and motorcycle industries, food production and the ceramic industry. The regional innovation system is characterized by strong entrepreneurial activity, many start-ups, successful clusters, significant increase in investments in R&D, a higher than average number of registered patents.

2. Regulatory Environment

Descriptors and areas of measurement:

Descriptor 2.1: Antitrust and competition policy

Measurement
- Competition and anti-trust laws at national level are modernized and comparable to world standards: Yes/No - Competition is strong within the economy and there are not many monopolized market segments (* Survey-based country rankings on intensity of local competition and extent of market dominance are available in the Global Competitiveness Report) - Effectiveness of anti-monopoly policy (*Survey-based country rankings are available in the Global Competitiveness Report)

Guidelines for evaluation

Too stringent antitrust policy can prevent the achievement of scale which is needed for business success. However, in general, innovation flourishes in contexts where there are few barriers to entry into existing markets, where competition is strong and where 'creative' destruction is possible.

Descriptor 2.2: Ease of starting a business and ease of doing business

Measurement
- Ease of starting business - Ease of doing business *World Bank index exists: http://www.doingbusiness.org/rankings

Guidelines for evaluation

Innovative entrepreneurial firms are more likely to emerge in countries that do not create unnecessary barriers to starting a new business, and they are more likely to grow in countries that do not create unnecessary barriers to doing business. However, ease of doing business does not mean no regulation. In fact, sound business regulation is a must for any efficient economy. Ease of doing business refers to regulation that facilitates interactions in the marketplace while avoiding bureaucratic procedures and red tape.

Descriptor 2.3: Ease of closing business, resolving insolvency and laying off workers

Measurement
-Entrepreneurs do not have to struggle with excessive bureaucratic requirements when downsizing business or closing business: Yes/No (*Survey-based country rankings on hiring and firing practices are available in the Global Competitiveness

Report) -Business does not have to meet excessive criteria or provide excessive compensations when laying off workers or making collective redundancies: Yes/No (*country rankings on redundancy costs /weeks of salary/ are available in the Global Competitiveness Report). -Investors can obtain reasonable capital recovery rates when a business goes bankrupt: Yes/No -The insolvency regime allows for companies facing temporary distress to restructure in order to avoid liquidation: Yes/No (* Survey-based country rankings on strength of investor protection and protection of minority shareholders' interests are available in the Global Competitiveness Report).

Guidelines for evaluation

Entrepreneurship flourishes in a regulatory environment that allows firms to close or downsize businesses relatively easily, and provides guarantees for investors to obtain reasonable capital recovery rates.

Legal protection of creditors and efficient enforcement are shown to result in larger and more developed capital markets. A good insolvency framework at national level should have clear rules that allow for the rehabilitation of viable companies and for the liquidation of non-viable ones. Modern insolvency regimes thus need to offer restructuring tools to companies that are economically viable but face temporary financial distress.

Descriptor 2.4: Transparency, anti-corruption and the rule of law

Measurement
-There are objective criteria on the basis of which firms can receive innovation-related government services, such as permits, subsidies, grants and quality certificates: Yes/No - The delivery of innovation-related government services is diversified (rather than monopolized): Yes/No - Overall level of transparency *Country ratings are available in the Corruption Perceptions Index developed by Transparency International: https://www.transparency.org/news/feature/corruption_perceptions_index_2016 *Survey-based country rankings on diversion of public funds, irregular payments and bribes, transparency of government policymaking, judicial independence, favoritism in decisions of government officials, efficiency of government spending, and strength of auditing and reporting standards are available in the Global Competitiveness Report.

Guidelines for evaluation

Corruption raises the costs (or the perception of costs) of innovation, including the cost of obtaining quality certificates and registering patents, and can thus inhibit innovation in the national economy. This effect has been shown to be stronger on smaller firms. Transparency and strong rule of law are key to fighting corruption. The diversification the delivery of government services (e.g. through collaboration with other public or private institutions) can help reduce the negative effects of corruption perceptions by shrinking the opportunities for bribery extortion.

Descriptor: 2.5. Tax policies

Measurement
- Tax support for business R&D (allowances, credits or other forms) - Rate of corporate tax

Guidelines for evaluation

Tax support for business R&D has direct effect on incentives for innovation. Too high corporate tax is likely to stifle entrepreneurial activity. However, a very low and flat corporate tax can also mute the awareness and the attractiveness of tax incentives for R&D.

2.6. Intellectual property protection regime

Measurement
- There are laws on patents: Yes/No - There are laws on utility models: Yes/No - There are laws on industrial design: Yes/No - There are laws on trademarks: Yes/No - There are laws on copyright and related rights: Yes/No - There are laws on trade secrets: Yes/No - There are laws on plant varieties: Yes/No - The national IP office has an independent legal status and enjoys autonomy from the government: Yes/No - The national IP office has regional coverage (i.e. is not operating only in the capital): Yes/No - The national IP office is appropriately staffed in terms of number of staff and qualifications of staff: Yes/No - The national IP office can perform both formal and substantive examination of patent applications: Yes/No - The work of the national IP office is automated and modernized (i.e. there is no reliance on manual processing): Yes/No - The mandate of the national IP office supports the enforcement of IP: Yes/No - The mandate of the national IP office includes promotion of innovation: Yes/No - There is a national body competent to deal with the prosecution and management of IP rights (e.g. an IP Tribunal): Yes/No

Guidelines for evaluation

Reasonable and efficient IP protection ensures that inventors and creators would have clear incentives to innovate and share their innovations with a broader group of stakeholders. The role of the national IP office is very important in this respect. Effective national IP offices would be autonomous, have regional outreach, be appropriately staffed and would have introduced automation of the registration process. Innovation would be further supported by a national IP office that also includes in its mandate issues such as innovation promotion and enforcement of IP.

Descriptor 2.7: Trade policy and FDI promotion

Measurement
- Active trade agreements encouraging exports: Yes/No - Trade promotion policies and funding: Yes/No

- Funding for FDI attraction: Yes/No

Guidelines for evaluation

Trade policy and FDI promotion can alter the background conditions for innovation related to trade openness, access to markets and FDI inflow as the primary source of technology transfer.

Descriptor 2.8: Public procurement rules

Measurement
-Public procurements is used strategically as a means of promoting innovation as a secondary objective: Yes/No (*survey-based country rankings on government procurement of advanced technology products are available in the Global Competitiveness Report) -There are plans or a strategy to introduce 'innovation' procurement in the country: Yes/No

Guidelines for evaluation

Public procurement can be utilized strategically as a mechanism for boosting the demand for innovative products and services and their uptake on the market. It can also be used by Governments to address societal chandelles.

Public procurement for innovation can involve:

-public procurement contracts 'buy' R&D of products, services or processes, which do not exist yet
-the public procurer chooses a product, service or process that is innovative and/or new to the market or the procurer.

- **Examples of good performers and poor performers**

Ease of starting and doing business: In order to support entrepreneurship and innovation, countries like Canada and New Zealand have prioritized the creation of an environment in which it is particularly easy to start a business. Currently, in the EU, Denmark ranks best in terms of ease of doing business. It is one of the first countries to introduce regulations allowing for almost all transactions to be conducted online.

Tax support for business R&D: Currently, 30 OECD members give preferential tax treatment to firms that invest in R&D. In Europe, Belgium and France provide the largest R&D tax support as percentage of GDP. On the other hand, Bulgaria is an example of a country where business is not sufficiently aware of tax incentives for R&D or such incentives are not perceived as too attractive due to the low and flat rate of corporate taxation in the country.

IP protection: The World Intellectual Property Organization has launched in 2001 a Program for Providing IP Automation Assistance targeted at IP offices in developing countries. For example, in India, the automation strategy has led to the establishment of electronic procedures from filing to grant. Application status was made available online, access to patent data was made easier and 26,000 publication backlogs were cleared.

Innovation procurement: The EU stands out as an important example of promising new developments. It is currently improving public procurement practices in order to boost demand for innovative goods and services. The new trend is called 'innovation procurement'. All EU Member States were obliged to transpose the new EU Public

Procurement Directive (2014) into national legislation. This directive provides for facilitating innovation-friendly public procurement via two measures:

–innovation partnership - the public procurer contracts supplier(s) of innovation who have to create the innovative solution and supply its real scale implementation for the public procurer
–exemption on Pre-Commercial Procurement: a form of procurement of R&D services in which the public procurer does not reserve all the benefits from the research and development service but shares them with the economic operators under market conditions

Innovation policy environment

1. R&D and Technology

Descriptors and areas of measurement:

Descriptor 1.1: Government support for R&D

Measurement
- Government support for R&D in universities and public research organizations (PROs) - Direct government funding for Business R&D

Guidelines for evaluation

Government support for R&D conducted in universities and PROs typically takes the form of support for mission oriented research or basic research. It is argued that government support should be based on clear priorities, take into account the needs of the society and the commercial economy and should promote technology transfer. Recently, especially in the EU, government support for R&D has been strongly focused on finding solutions to societal challenges.

Direct government support for R&D in business, in conjunction with indirect such support though tax incentives, is seen as a major tool to change the incentive structure for innovation and R&D within firms.

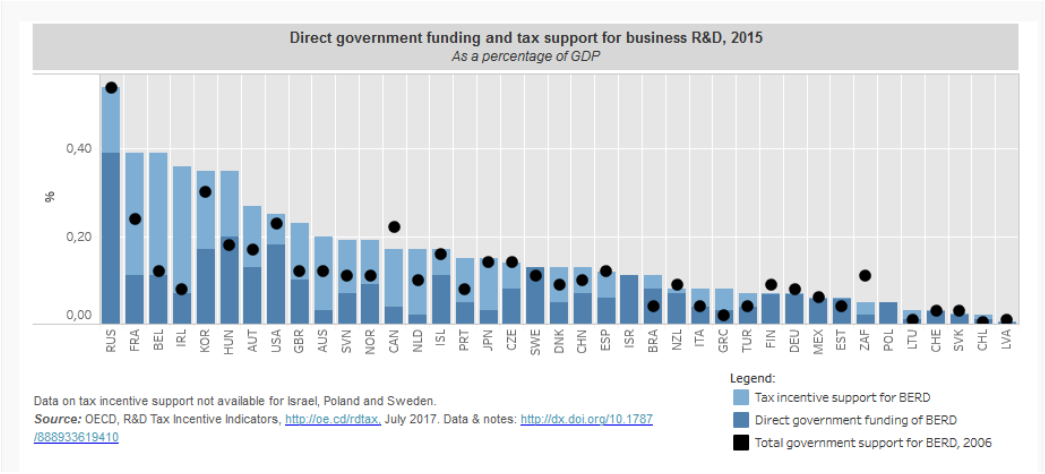
Descriptor 1.2: Technology transfer policy

Measurement
- There are legislative acts, policies or public agencies enabling or supporting the commercialization of research or technology transfer from universities or PROs to industry and the marketplace: Yes/No

Guidelines for evaluation

Intellectual property rules governing publicly funded research at universities may affect the incentives for universities to commercialize research.

- **Examples of good performers and poor performers**



Direct government support for Business R&D is relatively low in Europe. In the US, it is mostly focused on mission-oriented research in the defence and health areas. Among the successful examples are the not-for-profit consortium SEMATECH and the StarNet program that have supported advanced R&D in the semiconductor industry during the 1980s. Out of the OECD countries, Russia invests most public money in Business R&D.

2. Knowledge Flows

Descriptors and areas of measurement:

Descriptor 2.1: University-industry collaboration

Measurement
-Number of world-class research-intensive universities - Are public universities encouraged and supported by the national or regional/local governments to cooperate with industry? Yes/No - Capacity Building activities for knowledge transfer are organized: Yes/No - University-industry cooperation is well-developed: Yes/No (*Country rankings on university-industry collaboration in R&D are available in the Global Competitiveness Report)

Guidelines for evaluation

Knowledge flow between universities and firms determines the likelihood that firms will not rely on in-house innovation and R&D only but would rather pursue a more participatory and decentralized approach to innovation – the so-called "open innovation" approach. This approach is considered vastly superior in today's economies and societies where knowledge is widely distributed and successful innovation requires a degree of collaboration. Open innovation is also effective innovation because it reduces costs, accelerates time to market and increases market differentiation.

Descriptor 2.2: Technology Diffusion and Adoption Systems

Measurement
-Are there programs for firms encouraging them to adopt certain technologies? Yes/No

Guidelines for evaluation:

Technology adoption might be facilitated by programmes involving universities, colleges and a system of research extension through regional research centres.

- **Examples of good performers**

US universities are arguably the most advanced in terms of creating working university-business collaborations, with universities such as MIT, Cal Tech, and Stanford being textbook examples.

Technology diffusion programs for SMEs are part of regional innovation policies in the US and Europe. Among the countries with well-developed technology diffusion and adoption systems are Germany and Japan. In Japan, Kosetsushi (local public technology centres) are technology transfer organisations established and administrated by prefectural or municipal government and serving firms in the manufacture sector. Examples from other countries include the Manufacturing Extension Partnership in the US (https://www.nist.gov/mep), the National Research Council-Industrial Research Assistance Program in Canada (https://www.nrc-cnrc.gc.ca/index.html), the Steinbeis Foundation in Germany maintaining a network of 1.064 enterprises (https://www.steinbeis.de/en/), the German Fraunhofer Institutes (https://www.fraunhofer.de/en.html), the Regional Board for Economic Development in the region of Emilia-Romagna in Italy, the Technology Innovation Centres in the UK, and TNO - the Organisation for Applied Scientific Research in the Netherlands (https://www.tno.nl/en/).

3. Human Capital

Descriptors and areas of measurement:

Descriptor 3.1: Research capacity in the innovation system

Measurement
- Total R&D personnel as a percentage of total employment - Quality of research training - Quality of scientific research institutions (* Survey-based country ratings are available in the Global Competitiveness Report) - Science and engineering enrolment ratio - Availability of scientists and engineers (*Survey-based country ratings are available in the Global Competitiveness Report) - PhD degree completions per year per capita - Recruitment, promotion and funding of new researchers facilitate retention of researchers: Yes/No - Recruitment, promotion and funding of new researchers is performed in a transparent manner and on the basis of research excellence: Yes/No -Salaries of researchers are competitive: Yes/No

Descriptor 3.2: Education and training

Measurement
- Performance of students on internationally comparable standardized tests like PISA and TIMMS - Enrolment rate in secondary education

- Funding per pupil/student - Share of students from socio-economically disadvantaged families - School drop-outs (early school leavers) as a share of the student population - National curriculum standards: Yes/No - Shortage of teachers: Yes/No - School system encourages independent learning and creative thinking: Yes/No - Quality of education system (*survey-based country rankings are available in the Global Competitiveness Report) - Quality of Maths and Science education (*survey-based country rankings are available in the Global Competitiveness Report) - Share of schools with internet access (*survey-based country rankings are available in the Global Competitiveness Report)

Guidelines for evaluation:

This descriptor is linked to the availability of qualified labor force capable of initiating and managing innovation. Both the quality and the access to primary and secondary education are important determinants of the ability of a country to make the best use of its talent

Descriptor 3.3: Skills training

Measurement
- Private sector investment in skills training as a share of GDP - Support for disadvantaged students to access skills training: Yes/No - Youth apprenticeship programs: Yes/No - Tax credits for company investments in workforce development: Yes/No - Higher education institutions providing short-cycle degrees focused on skills training - Local availability of specialized training services (*survey-based country rankings are available in the Global Competitiveness Report)

Guidelines for evaluation

While education and training are responsible for the development of generic and transferrable skills, skills training for students and young people in real business environment should complement it in view of developing professional skills relevant for innovation and productivity enhancement in particular business sectors. Further professional development of employees within companies has the same impact, and in addition could contribute to creating organizational cultures of quality, excellence and innovation.

Descriptor 3.4: Brain drain issues or influx of high-skilled labor

Measurement
- Brain drain from the country: Yes/No - Ability of the country to retain talent (*survey-based country rankings are available in the Global Competitiveness Report) - Immigration policy encouraging the influx of high-skilled labor: Yes/No - Ability of the country to attract talent (survey-based country rankings are available in the Global Competitiveness Report) - Percentage of foreign students enrolled in PhD programmes

Guidelines for evaluation:

Brain drain can significantly reduce the available pool of qualified employees that are critical for innovation. Influx of high-skilled labor could on the other hand increase this pool and contribute to innovation capacity and competitiveness.

Descriptor 3.5: Lifelong learning

Measurement
- Share of the of the population aged 25 to 64 participating in education and training - Incentives for lifelong learning: Yes/No - Availability of opportunities for lifelong learning (qualitative measurement)

Guidelines for evaluation:

Lifelong learning is key for upskilling the workforce. It can significantly widen the pool of qualified workforce capable of contributing to economic competitiveness and innovation.

- **Examples of good performers**

At global level, Sweden, Denmark and Finland have the highest number of researchers per million inhabitants. The same countries are also leaders in the EU in terms of participation of adults in education and training. All three countries rank high in terms of innovation potential and capacity. Yet even within the EU, there are weak performers on these indicators, such as Romania and Bulgaria. Unsurprisingly, these two countries are also ranked as "modest innovators".

4. Structure and specificity of the higher education system

Descriptors and areas of measurement:

Indicator 4.1: Participation in Higher Education

Measurement
- Enrolment rate in tertiary education - Share of the population with tertiary education

Descriptor 4.2: Diversity, concentration and specialization in the Higher Education sector

Measurement
- Private HEIs exist: Yes/No - Enrolment is divided between many universities (as opposed to concentrated in one major university while the others serve much smaller percentages of enrolled students): Yes/No -Share of universities performing excellent research - There are universities focused primarily on teaching rather than research, while other universities typically characterized as research-intensive: Yes/No - Research funding is concentrated into those HEIs that perform research (as opposed to being thinly spread among many or all universities): Yes/No

Guidelines for evaluation

A more diverse HE landscape creates more opportunities for linkages between Higher Education and the world of work. Private HEIs typically have more freedom to engage with enterprises to both conduct applied research and adapt teaching to the needs of industry.

With regard to concentration, there are diverging views among policymakers. It has been argued that a high degree of specialization and concentration of research activities, and consequently, research funding, in the top performing universities leads to superior outcomes compared to research funding spread thinly across all universities. However, the rationale of concentration of research activities and funding has been widely disputed. Many policymakers therefore argue in favors of funding excellent research wherever it may be found, even if it is outside the universities that are characterized as research-intensive. In practice, some concentration of both research activities and funding in the top-performing universities is likely to emerge even if the principle of funding all excellent research is followed.

Descriptor 4.3: Funding of HEIs

Measurement
- Public investment in Higher Education (as percentage of GDP) - Funding for Higher Education is performance-based: Yes/No - Performance contracts/agreements are used to monitor university performance: Yes/No - Performance contracts/agreements are linked to funding: Yes/No - Industry funding for universities: Yes/No - Enrolment fees payable by students: Yes/No - International funding for universities: Yes/No

Guidelines for evaluation

Performance-based funding for universities is linked to superior research and innovation outcomes.

Performance agreements are contracts between the government and individual universities, which set out specific quantitative or qualitative goals that the institution is expected to achieve in a given time period. They may be linked to funding of universities.

Diversification of funding (industry funding, international funding, enrolment fees) provides more autonomy and leeway of universities to engage in collaboration with a variety of partners and promote innovation. Often, however, diversification of funding is itself preconditioned on university autonomy.

Descriptor 4.4: Integration of knowledge transfer with core university missions

Measurement
- Knowledge transfer is part of the mission and core strategy of public universities: Yes/No - Public funding is dedicated for knowledge exchange and knowledge transfer: Yes/No - Applied sciences degrees are offered: Yes/No

Descriptor 4.5: University governance

Measurement
- Prevalent governance model in the university system: a) centrally-driven, state-controlled universities b) universities are managed as profit-oriented corporate institutions c) academic-driven governance at universities: power for academic staff and academic interests d) trustee governance (Board of Trustees) e) representational governance (governance is vested in a wide array of stakeholders, such as students, academic staff, alumni, corporate partners, government, and civil society). - Universities have autonomy from the state in academic matters: Yes/No - Universities have autonomy from the state in financial matters: Yes/No - Universities have organizational autonomy from the state: Yes/No - Universities have autonomy with regard to staffing decisions: Yes/No - University missions are clearly stated and differentiated in terms of the goals that the institution seeks to achieve - Universities have strong management and strategic planning: Yes/No - Universities are accountable to a variety of stakeholders other than the government (civil society, students, etc.) with regard to their: a) academic output: Yes/No b) social impact: Yes/No c) financial management: Yes/No - Stakeholders other than the government have a say in university governance: Yes/No

Guidelines for evaluation

University governance and autonomy are strong predictors of the ability of universities to engage with the surrounding economic environment and society.

The European University Association has developed a detailed list of indicators for measuring the different aspects of university autonomy (http://www.university-autonomy.eu/). It regularly measures and monitors the extent of university autonomy in Europe.

When developing or reforming their Higher Education systems, most countries face a dilemma whether to orient the system toward excellence in research or toward teaching and wide access to higher qualifications. While orienting university governance and goals toward research would strongly support the National Innovation System, educating a qualified workforce is critical for economic development and competitiveness. As a result, most countries seek a balance by developing two- or three-tier systems comprising different types of universities:

- research-intensive universities focused on the development of elite researchers and providing PhD programs
-traditional universities focused on teaching at Bachelor and Master levels
- colleges not involved in research and focused mainly on two- to four-year programs aimed at raising the qualifications of the workforce.

Indicator 4.6: Level of development of entrepreneurship education

Measurement
- Share of universities that offer courses on entrepreneurship or creativity

- **Examples of concentration in research funding**

It has been argued that the research advantage of US universities is due to the concentration of research funding in less than one-tenth of all US universities. Following a similar rationale, the European Research Council has tended to direct a large portion of its grants to Europe's top universities (typically no more than 50 universities).

- **Examples of university governance and autonomy models**

In the US and the UK, the corporate model and the trustee model of university governance are prevalent, with significant institutional and legal autonomy for universities. In Continental Europe, the governance model is more state-led, especially in countries such as France, Spain and the Eastern European countries. In both the US and Europe, however, there is an increasing emphasis on turning universities into institutions that are strongly embedded in, and contribute to the wellbeing of, the economy and society, including local communities. This third mission is seen as increasingly complementary to the traditional university missions of teaching and research. The increasing importance of the third mission, as well as the need to ensure that universities are able to adapt to new technologies and to innovate, underscores the need to increase university autonomy.

5. Structure and performance of the National Innovation System

Descriptors and areas of measurement:

Descriptor 5.1: Quality of public research organizations

Measurement
- Publishing activity of PROs - Engagement of PROs with industry - Financing of PROs - Professionalized management at PROs: Yes/No - Entrepreneurial culture within PROs: Yes/No - Participation of PROs in public-private partnerships

Descriptor 5.2: Links between universities, PROs and industry

Measurement
- Clusters exist in which research organization and universities take part: Yes/No

Descriptor 5.3: Research funding

Measurement
- There is an independent and professional research funding agency in the country: Yes/No - The process of evaluation and funding of scientific and scholarly proposals is in line with international standards and is transparent and peer-review based: Yes/No

Descriptor 5.4: Existence of innovation bridging institutions and boundary spanning organisations

Measurement
- Incubators: Yes/No - Accelerators: Yes/No - Technology and science parks: Yes/No - Technology transfer offices: Yes/No - Networks of companies: Yes/No - Regional development agencies: Yes/No - Research and development units within universities: Yes/No

Descriptor 5.5: Research ethics

Measurement
- Research ethics and responsibility are discussed within the public sphere and within research circles: Yes/No

Guidelines for evaluation

Research ethics and responsibility are increasingly becoming central issues in modern National Innovation Systems. This is largely due to the rapid development of various technologies that raise a number of ethical issues.

Descriptor 5.6: Involvement of stakeholders in the innovation system – users, grant making agencies, civil society organizations

Measurement
- Channels, initiatives or innovation platforms/networks exist for stakeholders and stakeholder organizations to become involved in innovation activities at the grassroots: Yes/No

Guidelines for evaluation

Innovation networks/platforms bringing together different stakeholders are becoming increasingly important in the process of joint development or improvement of socio-economic processes or products or finding solutions to common societal problems.

Indicator 5.7: International linkages and collaboration at Universities

Measurement
- Share of PhD students from the country relocating for a period of study to a different country - Share of universities involved in international consortia implementing international research or capacity-building projects

6. Policies and measures in support of innovation

Descriptors and areas of measurement:

Descriptor 6.1: Coordination of education, research and innovation policies

Measurement
- Government strategy/overall policy on research and innovation: Yes/No - Policies, strategies and reform plans of international /supranational institutions affecting research and innovation in the country: Yes/No - Government strategy/overall policy on higher education: Yes/No

Guidelines for evaluation

Not all states have a coordinated national innovation policy system. Among those that have such systems and where efforts to promote innovation are coordinated at national level are Germany, Sweden and Finland. Countries following the liberal economic tradition on the other hand prefer to leave it up to market forces to govern the innovation processes.

Descriptor 6.2: Reform and modernization of education and research

Measurement
-Policies, strategies and reform plans of international /supranational institutions affecting higher education in the country: Yes/No - Ongoing and planned modernization reforms in the HE and research sector: Yes/No

III. Additional descriptors that maybe considered

Form of regulation

Measurement
-Performance-based regulation is widespread: high score -Prescriptive regulation is widespread: low score -Regulation is hybrid: medium score -Efficiency and speed of work of regulatory agencies: High/Medium/Low

Guidelines for evaluation

Performance-based regulation (focused on the results rather than the means) is more likely to stimulate innovation than highly prescriptive business regulation (focused on the means of doing business). In addition, more efficient and better staffed regulatory agencies make it possible for firms to get regulatory approvals quicker and stimulate entrepreneurship and innovation.

Standards

Measurement
-The country has open standardization processes and standards that enable competition between and within technologies: Yes/No - There is a practice of transferring research results and outcomes of innovation activities into standardization: Yes/No -Research and innovation projects and programmes proposed at national level consider existing standards: Yes/No

Guidelines for evaluation

Standards codify and spread the state of the art in various technologies. Globally accepted standards work as technology drivers and ensure interoperability between new and existing products. In this way they can significantly support innovation, especially in the technology industry. In addition, standards have come to be considered as an important instrument for knowledge and technology transfer (e.g. if publicly funded R&D results become public goods via standards). Standards lead to economies of scale, reduce risk in anticipating technical requirements, lower transaction costs and enable the use of standardised components. Standards can thus increase productive and innovative efficiency.

In the process of innovation, various standards come into play: scientific standards, measurement and testing standards, interface standards, compatibility standards, quality and safety standards, variety-reducing standards, information standards. It is generally believed that governments should not choose and impose one standard among several competing ones. Standards should emerge from an open process of collaboration, consensus-building within industries and consumer choice.