ANNEX 1

THE GLOBAL INNOVATION INDEX (GII) CONCEPTUAL FRAMEWORK

The rationale for the Global Innovation Index

The Global Innovation Index (GII) project was launched by Professor Dutta at INSEAD in 2007 with the simple goal of determining how to find metrics and approaches that better capture the richness of innovation in society and go beyond such traditional measures of innovation as the number of research articles and the level of research and development (R&D) expenditures.[1]

There were several motivations for setting this goal. First, innovation is important for driving economic progress and competitiveness—both for developed and developing economies. Many governments are putting innovation at the centre of their growth strategies. Second, the definition of innovation has broadened—it is no longer restricted to R&D laboratories and to published scientific papers. Innovation could be and is more general and horizontal in nature, and includes social innovations and business model innovations as well as technical ones. Last but not least, recognizing and celebrating innovation in emerging markets is seen as critical for inspiring people—especially the next generation of entrepreneurs and innovators.

Now in its 11th edition, the GII helps to create an environment in which innovation factors are under continual evaluation, and it provides a key tool for decision makers and a rich database of detailed metrics for refining innovation policies.

The GII is not meant to be the ultimate and definitive ranking of economies with respect to innovation. Measuring innovation outputs and impacts remains difficult, hence great emphasis is placed on measuring the climate and infrastructure for innovation and on assessing related outcomes.

Although the end results take the shape of several rankings, the GII is more concerned with improving the 'journey' to better measure and understand innovation and with identifying targeted policies, good practices, and other levers that foster innovation. The rich metrics can be used—on the level of the index, the sub-indices, or the actual raw data of individual indicators—to monitor performance over time and to benchmark developments against countries in the same region or income classification.

Drawing on the expertise of the GII's Knowledge Partners and its prominent Advisory Board, the GII model is continually updated to reflect the improved availability of statistics and our understanding of innovation. This year the model continues to evolve, although its mature state now requires only minor updates (refer to Annex 2).

An inclusive perspective on innovation

The GII adopts a broad notion of innovation, originally elaborated in the *Oslo Manual* developed by the European

Communities and the Organisation for Economic Co-operation and Development (OECD):[2]

> An innovation is the implementation of a new or significantly improved product (good or service), a new process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations.

This definition reflects the evolution of the way innovation has been perceived and understood over the last two decades.[3]

Economists and policy makers used to focus on R&D-based technological product innovation, largely produced in-house and mostly in manufacturing industries. This type of innovation was performed by a highly educated labour force in R&D-intensive companies. The process leading to such innovation was conceptualized as closed, internal, and localized. Technological breakthroughs were necessarily 'radical' and took place at the 'global knowledge frontier'. This characterization implied the existence of leading and lagging countries, with low- or middle-income economies only catching up.

Today innovation capability is seen more as the ability to exploit new technological combinations; it embraces the notion of incremental innovation and 'innovation without research'. Non-R&D innovative expenditure is an important component of reaping the rewards of technological innovation. Interest in understanding how innovation takes place in low- and middle-income countries is increasing, along with an awareness that incremental forms of innovation can impact development. Furthermore, the process of innovation itself has changed significantly. Investment in innovation-related activity has consistently intensified at the firm, country, and global levels, adding both new innovation actors from outside high-income economies and nonprofit actors. The structure of knowledge production activity is more complex and geographically dispersed than ever.

A key challenge is to find metrics that capture innovation as it actually happens in the world today.[4] Direct official measures that quantify innovation outputs remain extremely scarce.[5] For example, there are no official statistics on the amount of innovative activity—defined as the number of new products, processes, or other innovations—for any given innovation actor, let alone for any given country (see Box 1, Annex 1 of Chapter 1 in the GII 2013). Most measures also struggle to appropriately capture the innovation outputs of a wider spectrum of innovation actors, such as the services sector or public entities. These measures include innovation surveys that have contributed greatly to the measurement of innovation activities, but that fail to provide a good and reliable sense of cross-country innovation output performance and that are often not applicable to developing countries where innovation is often informal.[6]

The GII aims to move beyond the mere measurement of simple innovation metrics. To do so requires the integration of new variables, with a trade-off between the quality of the variable on the one hand and achieving good country coverage on the other hand. A key priority is to improve the measurement of innovation in the field of knowledge-intensive services, end-user and public-sector innovation, innovation linkages (in particular international ones), and innovation outputs and impacts more generally.[7]

The timeliest possible indicators are used for the GII: this year, 31.8% of data obtained are from 2017, 38.3% are from 2016, 10.6% are from 2015, 4.3% from 2014, and the small remainder 4.8% from earlier years.[8]

The GII conceptual framework

The GII is an evolving project that builds on its previous editions while incorporating newly available data and that is inspired by the latest research on the measurement of innovation. This year the GII model includes 126 countries/economies, which represent 90.8% of the world's population and 96.3% of the world's GDP (bn PPP $). The GII relies on two sub-indices—the Innovation Input Sub-Index and the Innovation Output Sub-Index—each built around pillars. Four measures are calculated (see Figure 1):

1. **Innovation Input Sub-Index:** Five input pillars capture elements of the national economy that enable innovative activities.
2. **Innovation Output Sub-Index:** Innovation outputs are the results of innovative activities within the economy. Although the Output Sub-Index includes only two pillars, it has the same weight in calculating the overall GII scores as the Input Sub-Index.
3. **The overall GII score** is the simple average of the Input and Output Sub-Indices.

Figure 1.
Framework of the Global Innovation Index 2018

4. **The Innovation Efficiency Ratio** is the ratio of the Output Sub-Index to the Input Sub-Index. It shows how much innovation output a given country is getting for its inputs.

Each pillar is divided into three sub-pillars, each of which is composed of individual indicators, for a total of 80 indicators this year. The GII pays special attention to presenting a scoreboard for each economy that includes strengths and weaknesses (Appendix I Country/Economy Profiles), making accessible the data series (Appendix II Data Tables, available online at http://globalinnovationindex.org), and providing data sources and definitions (Appendix III) and detailed technical notes (Appendix IV). Adjustments to the GII framework, including a detailed analysis of the factors influencing year-on-year changes, are detailed in Annex 2. In addition, since 2011 the GII has been submitted to an independent statistical audit performed by the Joint Research Centre of the European Union (results are detailed in Annex 3).

The Innovation Input Sub-Index

The first sub-index of the GII, the Innovation Input Sub-Index, has five enabler pillars: Institutions, Human capital and research, Infrastructure, Market sophistication, and Business sophistication. Enabler pillars define aspects of the environment conducive to innovation within an economy.

Pillar 1: Institutions

Nurturing an institutional framework that attracts business and fosters growth by providing good governance and the correct levels of protection and incentives is essential to innovation. The Institutions pillar captures the institutional framework of a country.

The Political environment sub-pillar includes two indices: one that reflects perceptions of the likelihood that a government might be destabilized; and one that reflects the quality of public and civil services, policy formulation, and implementation.

The Regulatory environment sub-pillar draws on two indices aimed at capturing perceptions of the ability of the government to formulate and implement cohesive policies that promote the development of the private sector and at evaluating the extent to which the rule of law prevails (in aspects such as contract enforcement, property rights, the police, and the courts). The third indicator evaluates the cost of redundancy dismissal as the sum, in salary weeks, of the cost of advance notice requirements added to severance payments due when terminating a redundant worker.

The Business environment sub-pillar expands on two aspects that directly affect private entrepreneurial endeavours by using the World Bank indices on the ease of starting a business and the ease of resolving insolvency (based on the recovery rate recorded as the cents on the dollar recouped by creditors through reorganization, liquidation, or debt enforcement/foreclosure proceedings). This year the model drops the indicator measuring ease of paying taxes (see Annex 2 for details).

Pillar 2: Human capital and research

The level and standard of education and research activity in a country are prime determinants of the innovation capacity of a nation. This pillar tries to gauge the human capital of countries.

The first sub-pillar includes a mix of indicators aimed at capturing achievements at the elementary and secondary education levels. Education expenditure and school life expectancy are good proxies for coverage. Government funding per pupil, secondary gives a sense of the level of priority given to secondary education by the state (excluding funding from abroad). The quality of education is measured through the results to the OECD Programme for International Student Assessment (PISA), which examines 15-year-old students' performances in reading, mathematics, and science, as well as the pupil-teacher ratio.

Higher education is crucial for economies to move up the value chain beyond simple production processes and products. The sub-pillar on tertiary education aims at capturing coverage (tertiary enrolment); priority is given to the sectors traditionally associated with innovation (with a series on the percentage of tertiary graduates in science, engineering, manufacturing, and construction); and the inbound and mobility of tertiary students, which plays a crucial role in the exchange of ideas and skills necessary for innovation.

The last sub-pillar, on R&D, measures the level and quality of R&D activities, with

indicators on researchers (full-time equivalent), gross expenditure, the R&D expenditures of top global R&D spenders, and the quality of scientific and research institutions as measured by the average score of the top three universities in the QS World University Ranking of 2017. The R&D expenditures of the top three firms in a given country looks at the average expenditure of these three firms that are part of the top 2,500 R&D spenders worldwide. The QS university rankings indicator gives the average scores of the country's top three universities that belong to the top 700 universities worldwide. These indicators are not aimed at assessing the average level of all institutions within a particular economy.

Pillar 3: Infrastructure

The third pillar includes three sub-pillars: Information and communication technologies (ICTs), General infrastructure, and Ecological sustainability.

Good and ecologically friendly communication, transport, and energy infrastructures facilitate the production and exchange of ideas, services, and goods and feed into the innovation system through increased productivity and efficiency, lower transaction costs, better access to markets, and sustainable growth.

The ICTs sub-pillar includes four indices developed by international organizations on ICT access, ICT use, online service by governments, and online participation of citizens.

The sub-pillar on general infrastructure includes the average of electricity output in kWh per capita; a composite indicator on logistics performance; and gross capital formation, which consists of outlays on additions to the fixed assets and net inventories of the economy, including land improvements (fences, ditches, drains); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

The sub-pillar on ecological sustainability includes three indicators: GDP per unit of energy use (a measure of efficiency in the use of energy), the Environmental Performance Index of Yale and Columbia Universities, and the number of certificates of conformity with standard ISO 14001 on environmental management systems issued.

Pillar 4: Market sophistication

The availability of credit and an environment that supports investment, access to the international market, competition, and market scale are all critical for businesses to prosper and for innovation to occur. The Market sophistication pillar has three sub-pillars structured around market conditions and the total level of transactions.

The Credit sub-pillar includes a measure on the ease of getting credit aimed at measuring the degree to which collateral and bankruptcy laws facilitate lending by protecting the rights of borrowers and lenders, as well as the rules and practices affecting the coverage, scope, and accessibility of credit information. Transactions are given by the total value of domestic credit and, in an attempt to make the model more applicable to emerging markets, by the gross loan portfolio of microfinance institutions.

The Investment sub-pillar includes the ease of protecting minority investors index as well as two indicators on the level of transactions. These two indicators look at whether market size is matched by market dynamism and provide a hard data metric on venture capital deals.

The last sub-pillar tackles trade, competition, and market scale. The market conditions for trade are given in the first indicator measuring the average tariff rate weighted by import shares. The second indicator is a survey question that reflects the intensity of competition in local markets. Efforts made at finding hard data on competition so far remain unsuccessful. Domestic market scale, as measured by an economy's GDP, was incorporated in 2016, so the last sub-pillar takes into consideration the impact that the size of an economy has on its capacity to introduce and test innovations in the market place.

Pillar 5: Business sophistication

The last enabler pillar tries to capture the level of business sophistication to assess how conducive firms are to innovation activity. The Human capital and research pillar (pillar 2) made the case that the accumulation of human capital through education, particularly higher education and the prioritization of R&D activities, is an indispensable condition for innovation to take place. That logic is taken one step further here with the assertion that businesses foster their

productivity, competitiveness, and innovation potential with the employment of highly qualified professionals and technicians.

The first sub-pillar includes four quantitative indicators on knowledge workers: employment in knowledge-intensive services; the availability of formal training at the firm level; R&D performed by business enterprise (GERD) as a percentage of GDP (i.e., GERD over GDP); and the percentage of total gross expenditure of R&D that is financed by business enterprise. In addition, the sub-pillar includes an indicator related to the percentage of females employed with advanced degrees. This indicator, in addition to providing a glimpse into the gender labour distributions of nations, offers more information about the degree of sophistication of the local human capital currently employed.

Innovation linkages and public/private/academic partnerships are essential to innovation. In emerging markets, pockets of wealth have developed around industrial or technological clusters and networks, in sharp contrast to the poverty that may prevail in the rest of the territory. The Innovation linkages sub-pillar draws on both qualitative and quantitative data regarding business/university collaboration on R&D, the prevalence of well-developed and deep clusters, the level of gross R&D expenditure financed by abroad, and the number of deals on joint ventures and strategic alliances. In addition, the total number of Patent Cooperation Treaty (PCT) and national office published patent family applications filed by residents in at least two offices proxies for international linkages. The GII team has been evaluating various hard data–based indicators to measure innovation linkages in an economy. Measuring innovation linkages adequately remains challenging, if not impossible, based on existing innovation metrics.

New measures based on big data may provide better measurement indicators in the future (see Box 1).

In broad terms, pillar 4 on market sophistication makes the case that well-functioning markets contribute to the innovation environment through competitive pressure, efficiency gains, and economies of transaction and by allowing supply to meet demand. Markets that are open to foreign trade and investment have the additional effect of exposing domestic firms to best practices around the globe, which is critical to innovation through knowledge absorption and diffusion, which are considered in pillars 5 and 6. The rationale behind sub-pillars 5.3 on knowledge absorption (an enabler) and 6.3 on knowledge diffusion (a result)—two sub-pillars designed to be mirror images of each other—is precisely that together they will reveal how good economies are at absorbing and diffusing knowledge.

Sub-pillar 5.3 includes five metrics that are linked to sectors with high-tech content or are key to innovation: intellectual property payments as a percentage of total trade; high-tech net imports as a percentage of total imports; imports of communication, computer and information services as a percentage of total trade; and net inflows of foreign direct investment (FDI) as a percentage of GDP (three-year average). To strengthen the sub-pillar, the percentage of research talent in business was added in 2016 to provide a measurement of professionals engaged in the conception or creation of new knowledge, products, processes, and methods and systems, including business management.

The Innovation Output Sub-Index

Innovation outputs are the results of innovative activities within the economy. Although the Output Sub-Index includes only two pillars, it has the same weight in calculating the overall GII scores as the Input Sub-Index. There are two output pillars: Knowledge and technology outputs and Creative outputs.

Pillar 6: Knowledge and technology outputs

This pillar covers all those variables that are traditionally thought to be the fruits of inventions and/or innovations. The first sub-pillar refers to the creation of knowledge. It includes five indicators that are the result of inventive and innovative activities: patent applications filed by residents both at the national patent office and at the international level through the PCT; utility model applications filed by residents at the national office; scientific and technical published articles in peer-reviewed journals; and an economy's number of articles (H) that have received at least H citations.

The second sub-pillar, on knowledge impact, includes statistics representing the impact of innovation activities at the micro- and macroeconomic level or related proxies: increases in labour productivity, the entry density of new firms, spending on computer software, the number of certificates of

BOX 1

Big data for innovation policy

We are witnessing a rapid expansion in data sources and improvements in analytics that together offer unprecedented possibilities for measuring and mapping the innovation ecosystem. Data from unconventional sources such as business websites and social media, as well as novel proprietary databases (such as online job datasets), have become the loci of various projects and studies using techniques such as text mining and machine learning to examine questions of interest for innovation policy. These possibilities—and their associated practical, conceptual, and ethical considerations—are increasingly finding their way into the mainstream discourse of governments and their evidence advisory systems. Against a backdrop of increasingly complex global issues and grand challenges, the question of how to leverage the opportunities offered by big data while ensuring the utility and legitimacy of the findings derived from them has become increasingly urgent to address.

What promises are offered by big data to understand innovation performance?

Traditional data sources such as patents and innovation surveys have been essential to broadening and deepening our understanding of key dimensions of the innovation ecosystem. However, these data capture only certain types and facets of innovation, tend to be presented in a static and highly aggregated form, and can be months or years out of date by the time they are published. As our world is increasingly digitalized and new data sources become available, opportunities abound for fresh, timely, and granular insight into both existing and previously unexplored questions that are difficult or impossible to capture with traditional metrics.

Exciting examples of the use of big data for innovation questions are beginning to emerge. For instance, web data have been used to capture the emergence of industries that do not appear in established industrial classifications and to measure innovation in industries that are less reliant on patents and publications for their innovation activities (such as the creative industries).[1] Data from the crowdsourcing website/app Yelp have been used to 'nowcast' local economic activity in the United States of America (U.S.),[2] and new online interfaces have helped us visualize tech networking trends in Wales,[3] enabling active exploration of granular innovation data by empowered users.

New analytics and data combinations also allow us to assess existing data in a different light, providing needed insight on deep and pervasive trends in the innovation landscape. In one such case, researchers linked U.S. tax records and patent data to show how socioeconomic class, gender, ethnicity, and early exposure to inventors influences becoming an inventor later in life.[4] This is an important development at a time when a growing chorus of voices are demanding fairer, more inclusive and equitable innovation outcomes.

Traditional innovation indicators are stewarded by national and international bodies that oversee their quality, representativeness, and comparability across countries and over time. By comparison, innovation metrics produced using new data sources have largely been confined to regional or national pilots or research studies, which reduces comparability and raises concerns about representativeness. Scaling up successful pilots to 'full' production is slowed by challenges such as insufficient data science capacity, inadequate technological infrastructure, and institutional or procedural rigidity. In some cases, important ethical, privacy, and data access questions also remain.

One promising domain where big data are starting to gain widespread traction is labour statistics, with successful pilots using online job vacancies having been carried out in various countries and regions globally including the U.S., China, India, and Europe (including the United Kingdom).

Another promising example is the use of inventor's or scientist's addresses associated with science and technology outputs such as patent and scientific publications and the ability to geocode them on maps to identify scientific or inventive activity—see, for example, the Special Section on Clusters in this Global Innovation Index (GII) report, which uses big data on international patent filings and scientific publishing to identify sub-national clusters of science and technology activity.

Whether big data are—broadly speaking—'ready' for inclusion in official reports must be considered within the broader goals of the publication, its intended audience, and the trade-offs between key dimensions such as novelty and geographic coverage. For instance, we may be able to add significant nuance to an existing innovation dimension or shed light on a previously unexplored question but only in a subset of countries where data coverage is adequate. These questions and trade-offs must be balanced against the relative strengths and shortcomings of existing indicators.

Going forward, more experimentation and experience with big data and new measurement approaches will be required to better assess the opportunities and challenges, to identify their optimal use in research and innovation policy making, and their potential use as input or output indicators to assess innovation performance in the GII.

Source

1 This box is based on the contribution of Juan Mateos-Garcia and Chantale Tippett of Nesta, U.K.

Notes

2 Bakhshi and Mateos-Garcia, 2016.
3 Glaeser, 2017.
4 Arloesiadur, a collaboration between Nesta and the Welsh government to map innovation in Wales, is an example of such an online interface. Information about Arloesiadur is available at https://arloesiadur.org/about.
5 Bell et al., 2017.

conformity with standard ISO 9001 on quality management systems issued, and the measure of high- and medium-high-tech industrial output over total manufactures output.

The third sub-pillar, on knowledge diffusion, is the mirror image of the knowledge absorption sub-pillar of pillar 5, with the exception of indicator 5.3.5. It includes four statistics all linked to sectors with high-tech content or that are key to innovation: intellectual property receipts as a percentage of total trade; high-tech net exports as a percentage of total exports; exports of ICT services as a percentage of total trade; and net outflows of FDI as a percentage of GDP (three-year average).

Pillar 7: Creative outputs

The role of creativity for innovation is still largely underappreciated in innovation measurement and policy debates. Since its inception, the GII has always emphasized measuring creativity as part of its Innovation Output Sub-Index. The last pillar, on creative outputs, has three sub-pillars.

The first sub-pillar on intangible assets includes statistics on trademark applications by residents at the national office; industrial designs included in applications at a regional or national office, and two survey questions regarding the use of ICTs in business and organizational models, new areas that are increasingly linked to process innovations in the literature.

The second sub-pillar on creative goods and services includes proxies to get at creativity and the creative outputs of an economy. In 2014, in an attempt to include broader sectoral coverage, a global entertainment and media output composite was added. In addition, in 2017 the indicator on audio-visual and related services exports was renamed 'Cultural and creative services exports' and expanded to include information services, advertising, market research and public opinion polling, and other, personal, cultural and recreational services (as a percentage of total trade). These two indicators complement the remainder of the sub-pillar, which measures national feature films produced in a given country (per capita count) and printing and recorded media output (as a percentage of total manufactures output), which underwent methodological change to precisely capture printing and media outputs and exclude paper industry outputs (see Annex 2 for details). Finally, the sub-pillar also measures creative goods exports (as a percentage of total trade), all which are aimed at providing an overall sense of the international reach of creative activities in the country.

The third sub-pillar on online creativity includes four indicators: generic and country-code top level domains and average yearly edits to Wikipedia, all scaled by population aged 15 through 69 years old, and mobile app creation, which is scaled by GDP (bn PPP $). This year the indicator on mobile app creation replaces the indicator video uploads on YouTube. Mobile apps represent the global commerce in digital goods, and therefore provide insight into how innovation, production and trade of digitalized creative products and services are evolving in an innovation-based economy.

Notes

1 For a fuller introduction to the Global Innovation Index, see the GII 2011.

2 Eurostat and OECD, 2005.

3 OECD, 2010; INSEAD, 2011; and WIPO, 2011.

4 INSEAD, 2011; OECD, 2013; WIPO, 2011.

5 INSEAD, 2011; OECD, 2011; WIPO, 2011.

6 See Elahi and De Beer, 2013; Charmes et al., 2016.

7 OECD, 2016.

8 For completeness, 1.7% of data points are from 2013, 0.7% from 2012, 0.7% from 2011, 0.7% from 20, 0.4% from 2009, 0.4% from 200, and 0.1% from 200. In addition, the GII is calculated on the basis of 9,042 data points (compared to 10,080 with complete series), implying that 10.3% of data points are missing. The Data Tables (Appendix II, available online at http://globalinnovationindex.org) include the reference year for each data point and mark missing data as not available (n/a).

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