APPENDIX I

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 in 2007 during his tenure at INSEAD. The goal was to find and determine metrics and methods that could better capture the richness of innovation in society, going beyond the traditional measures of innovation such 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 center of their growth strategies. Second, the definition of innovation has broadened—it is no longer restricted to R&D laboratories and published scientific papers. Innovation could be and is more general and horizontal in nature, including social, business model, and technical innovation. Last, but foremost, recognizing and celebrating innovation in emerging markets is critical for inspiring people—especially the next generation of entrepreneurs and innovators.

Now in its 13th edition, the GII helps to create an environment in which innovation factors are under continual evaluation. 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 its impact 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 measurement, understanding innovation, and in identifying targeted policies, good practices, and other levers that foster innovation. The rich data metrics, at index, sub-index, or indicator level, can be used to monitor performance over time and to benchmark developments against economies within the same region or income group 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 (Appendix IV).

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). In its fourth edition, the Oslo Manual 2018 introduces a more general definition of innovation:[2]

An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).

This update of the Oslo Manual also introduces a series of definitions associated to innovation in business activities and for different types of innovation firms.[3] In this context, innovation translates as improvements made to outcomes in the form of either new goods or services or any combination of these. While the GII focuses on a more general definition of innovation, it is important to highlight how these definitions capture the evolution of the way innovation has been perceived and understood over the last two decades.[4]

Economists and policymakers previously focused on R&D-based technological product innovation, largely produced in-house and mostly in manufacturing industries. Innovation of this nature was executed by a highly educated labor 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 economies, with low- or middle-income economies only playing "catch up".

Today innovation capability is increasingly seen 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 evolves in low- and middle-income economies 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, economy, and global levels, adding both new innovation actors from outside high-income economies and non-profit 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.[5] Direct official measures that quantify innovation outputs remain extremely scarce.[6] 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 the GII 2013, Chapter 1, Annex 1, Box 1). Most measurements also struggle to appropriately capture the innovation outputs of a wider spectrum of innovation actors, such as the services sector or public entities. This includes innovation surveys, which have contributed greatly to the measurement of innovation activities, but that fail to provide a good and reliable sense of cross-economy innovation output performance, and that are often not applicable to developing economies where innovation is often informal.[7]

The GII aims to move beyond the mere measurement of such simple innovation metrics. To do so will require the integration of new variables, with a trade-off between the quality of the variable on the one hand and achieving good economy coverage on the other. A key priority is to improve the measurement of innovation in the field of knowledge-intensive services, user and public sector innovation, including policy support to innovative entrepreneurship and venture capital, innovation linkages (in particular international ones), and innovation outputs and impacts more generally.[8]

The timeliest possible indicators are used for the GII: 29.9% of data obtained are from 2019, 41.5% are from 2018, 10.7% are from 2017, 3.6% are from 2016, 1.6% from 2015, and the small remainder of 3.1% from earlier years.[9]

The GII conceptual framework

The GII is an evolving project that builds on its previous editions, while incorporating newly available data, and is inspired by the latest research on the measurement of innovation. This year the GII model includes 131 countries/economies, which represent 93.5% of the world's population and 97.4% of the world's GDP in purchasing power parity current international dollars. The GII relies on two sub-indices—the Innovation Input Sub-Index and the Innovation Output Sub-Index—each built around pillars. Three measures are calculated (Figure I.1):[10]

Innovation Input Sub-Index: Five input pillars capture elements of the national economy that enable innovative activities.

Innovation Output Sub-Index: Innovation outputs are the result 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.

The overall GII score is the average of the Input and Output Sub-Indices.

Each pillar is divided into three sub-pillars, each of which is composed of individual indicators, a total of 80 this year. The GII pays special attention to presenting a scoreboard for each economy that includes strengths and weaknesses and makes the data series accessible (Appendix II); providing data sources and definitions (Appendix III); and detailed technical notes and adjustments to the GII framework, including a detailed analysis of the factors influencing year-on-year changes (Appendix IV). In addition, since 2011 the GII has undergone an independent statistical audit performed by the Joint Research Centre of the European Union (Appendix V).

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

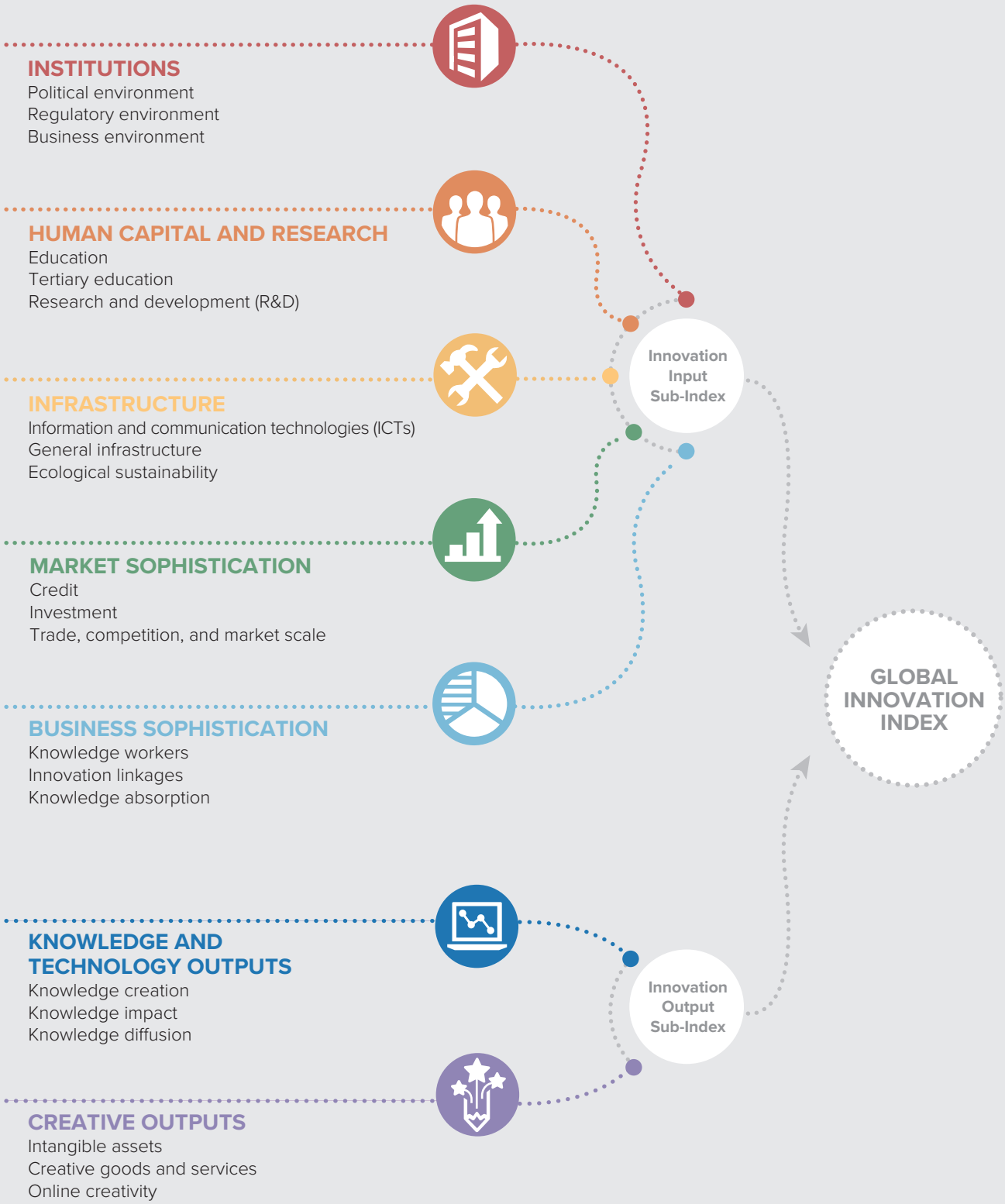
Nurturing an institutional framework that attracts business and fosters growth by providing good governance and the correct levels of protection and incentives is essential to innovation. The Institutions pillar captures the institutional framework of an economy.

The Political environment sub-pillar includes two indices: the first is the political, legal, operational or security risk index that replaces the political stability and safety indicator, reflecting more on the likelihood and severity of political, legal, operational or security risks impacting business operations; the second 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 on 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

FIGURE A-I.1

Framework of the Global Innovation Index 2020



Source: Global Innovation Index Database, Cornell, INSEAD, and WIPO, 2020.

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 endeavors 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).

Pillar 2: Human capital and research

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

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 equivalence), 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 2019. The R&D expenditures of the top three firms in a given economy 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 economy'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 an 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, each on ICT access, use, online service by governments, and online participation of citizens.

The sub-pillar on general infrastructure includes the average of electricity output in GWh 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, 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. 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 remain unsuccessful so far.

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 marketplace.

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 occur. 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 labor 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 gross R&D expenditure financed by abroad as a percentage of GDP, 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 to say, impossible based on existing innovation metrics.

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 mirror each other as much as possible—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 (three-year average); high-tech 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, methods, and systems, including business management.

The Innovation Output Sub-Index

Innovation outputs are the results of innovative activities within an 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 macro-economic level or related proxies: increases in labor productivity (three-year average), the entry density of new firms, spending on computer software, the number of certificates of 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, mirrors the knowledge absorption sub-pillar of pillar 5, except for indicators 5.3.2 (no longer net imports) and 5.3.5 (on research talent). 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 (three-year average); high-tech net exports as a percentage of total trade; 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 and, this year, introduces an indicator showing which economies have the most valuable brands. This novel indicator sums the values of all the top 5,000 most valuable brands of each economy and then scales this brand value by GDP. In this pillar, industrial designs included in applications at a regional or national office replaces one survey question on organizational models—a new area that is 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, to include broader sectoral coverage, a global entertainment and media output composite was added. In addition, that same year the indicator on audio-visual and related services exports was renamed "Cultural and creative services exports". It 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). This year this last segment is replaced by heritage and recreational services. These two indicators complement the remainder of the sub-pillar, which measures national feature films produced in a given economy (per capita count); printing and other media output (as a percentage of total manufactures output),and creative goods exports (as a percentage of total trade), all of which are aimed at providing an overall sense of the international reach of creative activities in an economy.

The third sub-pillar on online creativity includes four indicators: generic and economy/country-code top-level domains, 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 US$). In 2019, the indicator on mobile app creation was improved to capture more precisely the downloads of apps by origin of the headquarters of the developer/firm. This improvement offered more insight into how innovation, production, and trade of digitized creative products and services are evolving in an innovation-based economy.

Notes:

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

2 Eurostat and OECD, 2018.

3 The manual uses the term "innovation activities" to refer to processes while the term "innovation" is limited to outcomes. Business innovation is defined as a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm. Business processes include all core activities by the firm to produce products as well as all auxiliary or supporting activities. A product innovation is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market. A business process innovation is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use in the firm.

The innovation status of a firm is defined based on its engagement in innovation activities and its introduction of one or more innovations over the observation period of a data collection exercise. There are three categories of innovative and innovation-active firms: innovative, non-innovative, and innovation-active firms.

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

5 INSEAD, 2011; OECD Scoreboard, 2013; WIPO, 2011

6 INSEAD, 2011; OECD, 2011; WIPO, 2011.

7 Elahi et al., 2016.

8 See OECD Blue Sky Forum on Science and Innovation Indicators retrieved from http://www.oecd.org/innovation/blue-sky.htm

9 For completeness, 0.7% of data points are from 2014, 0.6% from 2013, 0.5% from 2012, 0.5% from 2011, 0.5% from 2010 and a few exceptions from 2009 (0.2%). In addition, the GII is calculated based on 9,468 data points (compared to 10,480 with complete series), implying that 9.7% of data points are missing. The Data Tables (Appendix II) include the reference year for each data point and mark missing data as not available (n/a).

10 In 2019, the GII introduced an alternative to study the connection between innovation inputs and outputs, replacing the Efficiency Ratio (Chapter 1, Figure 1.10 and relevant segment).

References

Cornell University, INSEAD, and WIPO (World Intellectual Property Organization). (2013). *The Global Innovation Index 2013: The Local Dynamics of Innovation*. Eds. S. Dutta and B. Lanvin. Geneva, Ithaca, and Fontainebleau: Cornell, INSEAD, and WIPO.

Elahi, S. et.al. (2016). Knowledge and Innovation in Africa: Scenarios for the Future. In E. Kraemer-Mbula & S. Wunsch-Vincent (Eds.), *The Informal Economy in Developing Nations: Hidden Engine of Innovation?* Cambridge University Press.

Eurostat and OECD (Organisation for Economic Co-operation and Development). (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (3rd ed.). Paris: OECD.

INSEAD. (2011). *The Global Innovation Index 2011: Accelerating Growth and Development*. Fontainebleau: INSEAD.

OECD (Organisation for Economic Co-operation and Development). (2010). The OECD Innovation Strategy: Getting a Head Start on Tomorrow. Paris: OECD.

———. (2011). OECD Science, Technology and Industry Scoreboard 2011. Paris: OECD.

———. (2013). OECD Science, Technology and Industry Scoreboard 2013. Paris: OECD.

WIPO (World Intellectual Property Organization). (2011). The Changing Nature of Innovation and Intellectual Property [Chapter 1]. In *World Intellectual Property Report 2011: The Changing Face of Innovation*. Geneva: WIPO. Retrieved from https://www.wipo.int/publications/en/details.jsp?id=227