APPENDIX IV

ADJUSTMENTS TO THE GLOBAL INNOVATION INDEX FRAMEWORK, YEAR-ON-YEAR COMPARABILITY OF RESULTS, AND TECHNICAL NOTES

Adjustments to the Global Innovation Index framework

The Global Innovation Index (GII) is a cross-economy performance assessment, compiled on an annual basis, which continuously seeks to update and improve the way innovation is measured. The GII report pays special attention to making the statistics used in the Economy Profiles and Data Tables accessible by providing data sources and definitions, and detailing the computation methodology (Appendix II, III, and IV). This segment summarizes the changes made this year and provides an assessment of the impact these changes have on the comparability of rankings.

The GII model is revised every year in a transparent exercise. This year no change was made at either the pillar or the sub-pillar level.

Beyond the use of the World Intellectual Property Organization (WIPO) data, we collaborate with public international bodies, such as the International Energy Agency, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Industrial Development Organization (UNIDO), the World Trade Organization (WTO), and the Joint Research Centre of the European Commission (JRC). We also collaborate with private organizations, such as the International Organization for Standardization (ISO), IHS Markit, Bureau van Dijk (BvD), ZookNIC Inc, Thomson Reuters, Wikimedia Foundation, and AppAnnie to obtain the best globally available data on innovation.

Table A-IV.1 provides a summary of adjustments to the GII 2019 framework. A total of seven indicators were modified this year. One indicator was replaced, five underwent methodological changes, and one's methodology changed at source.

Methodology and data

The nature of the 2019 adjustments are detailed below:

Indicator **1.1.1: Political stability and safety** from the World Banks World Governance Indicators, which measures the perception of the likelihood of political instability and/or politically motivated violence, including terrorism, was replaced in 2019 by the indicator Political and operational stability. The political, legal, and operational or security risk index developed by IHS Markit measures the likelihood and severity of these risks in relation to their impact on business operations.

TABLE A-IV.1

Changes to the GII 2019 framework

GII 2018	Adjustment	GII 2019
1.1.1 Political stability & safety	Replaced	1.1.1 Political & operational stability
3.3.2 Environmental performance	Indicator changed at source	3.3.2 Environmental performance
5.3.1 Intellectual property payments, % total trade	Methodology change	5.3.1 Intellectual property payments, % total trade (3 year avg.)
5.3.2 High-tech imports, % total trade	Methodology change	5.3.2 High-tech imports, % total trade
6.2.1 Growth rate of PPP$ GDP/worker, %	Methodology change	6.2.1 Growth rate of PPP$ GDP/worker, % (3 year avg.)
6.3.1 Intellectual property receipts, % total trade	Methodology change	6.3.1 Intellectual property receipts, % total trade (3 year avg.)
7.3.4 Mobile app creation/bn PPP$ GDP	Methodology change	7.3.4 Mobile app creation/bn PPP$ GDP

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.
Notes: Refer to Appendix I and III for a detailed explanation of terminology and acronyms. Refer to Appendix III for a detailed explanation of methodological changes at source.

Indicator **3.3.2: Environmental performance** is an index produced by Yale University and Columbia University that measures environmental health and ecosystem vitality. This year, the methodology changed, therefore the scores calculated under the old methodology are not comparable to the new scores.

The methodology underpinning indicators 5.3.1 and 6.3.1, Intellectual property payments and Receipts, respectively, was updated. This year, the GII considers the average of the three most recent years in order to avoid excessive volatility.

Data for indicator **5.3.2: High-tech net imports** are sourced directly from the United Nations Comtrade rather than from the World Integrated Trade Solutions (WITS). The change affects the calculation for net totals.

For indicator **6.2.1: Growth rate of GDP PPP$ per worker**, the methodology changed to capture the average of the three most recent years to produce a more stable variable.

Indicator **7.3.4: Mobile app creation**, introduced last year to measure the number of mobile apps created in an economy, was adjusted this year to measure the global downloads of mobile apps by origin of the headquarters of the developer or producing firm.

Missing values

Since its inception, one of the core missions of the GII is to increase awareness of the importance of submitting timely data. In recent years, the GII has had a positive influence on data collection, helping improve the number of data points submitted to international data agencies. In the GII 2019, with the inclusion of three economies in the GII sample, coverage remains relatively close to the level seen last year, with 10% of data points missing.

When it comes to economy coverage, the objective is to include as many as possible. However, it is also important to maintain a good level of data coverage within each of these economies. Because the GII results depend on data availability (Appendix V), which in turn affects the overall GII rankings, the threshold rule for economies with missing data and the minimum coverage necessary per sub-pillar were progressively tightened in 2016 and 2017 (Appendix IV: Technical Notes).

The motivation behind the introduction of these adjustments is because of data availability, which, historically, was less satisfactory when considering innovation outputs in the GII. For instance, this year, 13.2% of all economies show data coverage of less than 75% but exhibit over 66% coverage in the Output Sub-Index, while only 3.2% of these economies have this coverage range in the Input Sub-Index.

In addition to the economies featured last year, three new economies, Burundi, Ethiopia, and Nicaragua, are included in the GII 2019 because data coverage has improved above the 66% threshold in the 27 variables of the Output Sub-Index.

Despite the requirement for a minimum level of coverage, for several economies the number of missing data points remains very high. Table A-IV.2 lists the economies with the highest number of missing data points (20 or more).

Conversely, Table A-IV.3 lists economies with the best data coverage. These economies are missing five data points at the most while others are missing none.

For the last three years, more stringent rules were introduced, resulting in significant data coverage improvements for various economies. Table A-IV.4 shows economies with improved data coverage from 2016 to 2019. At the same time, fewer economies witnessed a decline in data coverage, as shown in Table A-IV.5.

Year-on-year comparability of results—sources of change in the rankings

The GII compares the performance of national innovation systems across economies, and presents the changes in economy rankings over time.

Importantly, scores and rankings from one year to the next are not directly comparable (see GII 2013, Annex 2, for a full explanation). Making inferences about absolute or relative performance based on year-on-year differences in rankings can be misleading. Each ranking reflects the relative positioning of a particular economy based on the conceptual framework, data coverage, and the sample of economies in a given year, also reflecting changes in the underlying indicators at source and in data availability.

A few factors influence year-on-year rankings of an economy:

- the actual performance of the economy in question;
- adjustments made to the GII framework;
- data updates, the treatment of outliers, and missing values; and
- the inclusion or exclusion of economies in the sample.

Additionally, the following characteristics complicate the time-series analysis based on simple GII scores or rankings:

- **Missing values.** The GII produces relative index scores, which means that a missing value for one economy affects the index score of other economies. Because the number of missing values decreases every year, this problem reduces over time.
- **Reference year.** The data underlying the GII do not refer to a single year but to several years depending on the latest available year for any given variable. In addition, the reference years for different variables are not the same for each economy. The motivation for this approach is that it widens the set of data points for cross-economy comparability.
- **Normalization factor.** Most GII variables are normalized using either GDP or population, with the intention to enable cross-economy comparability. Yet, this implies that year-on-year changes in individual variables may be driven either by the variable's numerator or by its denominator.
- **Consistent data collection**. Measuring the change of year-on-year performance relies on the consistent collection of data over time. Changes in the definition of variables or in the data collection process could create movements in the rankings that are unrelated to performance.

TABLE A-IV.2

GII economies with the most missing values

Economy	Number of missing values	Economy	Number of missing values	Economy	Number of missing values
Niger	23	Guinea	21	Togo	20
Nicaragua	22	Nepal	21	Yemen	20
		Trinidad and Tobago	20		

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

TABLE A-IV.3

GII economies with the fewest missing values

Economy	Number of missing values	Economy	Number of missing values	Economy	Number of missing values
Turkey	0	Bulgaria	2	Morocco	3
Romania	0	Argentina	2	Costa Rica	3
Thailand	0	Indonesia	2	Tunisia	3
Malaysia	0	Italy	2	Cyprus	4
Chile	0	Portugal	2	Lithuania	4
Mexico	0	Philippines	2	Luxembourg	4
Colombia	0	Kazakhstan	2	United States of America	4
Russian Federation	1	Finland	3	United Kingdom	4
Poland	1	Israel	3	Republic of Moldova	4
Hungary	1	Estonia	3	New Zealand	4
Republic of Korea	2	Sweden	3	Malta	4
France	2	Singapore	3	Latvia	4
Ukraine	2	Denmark	3	Greece	4
Slovenia	2	Switzerland	3	South Africa	4
Czech Republic	2	Serbia	3	Egypt	4
Austria	2	Netherlands	3	Canada	5
Brazil	2	Norway	3	Ireland	5
Spain	2	Australia	3	Japan	5
Germany	2	India	3	Panama	5
Slovakia	2	Croatia	3	Kenya	5
		Belgium	3		

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

TABLE A-IV.4

Indicator coverage improvement, from 2016 to 2019, in % and number

Economy	2016-2019	Improvement	Number
Brunei Darussalam	From 30 to 18	15.7%	12
Algeria	From 17 to 7	25.6%	10
United Arab Emirates	From 17 to 8	22.2%	9
Mozambique	From 20 to 11	18.1%	9
Burkina Faso	From 23 to 14	15.3%	9
Zimbabwe	From 26 to 17	13.2%	9
Yemen	From 29 to 20	11.6%	9
Cambodia	From 20 to 12	15.7%	8
Honduras	From 21 to 13	14.8%	8
Burundi	From 27 to 19	11.1%	8
Iran, Islamic Republic of	From 16 to 9	17.5%	7
Jordan	From 17 to 10	16.2%	7
Bahrain	From 18 to 11	15.1%	7
Montenegro	From 18 to 11	15.1%	7
Tunisia	From 9 to 3	30.7%	6
Malta	From 10 to 4	26.3%	6
Albania	From 12 to 6	20.6%	6
El Salvador	From 14 to 8	17.0%	6
Zambia	From 19 to 13	11.9%	6
Tajikistan	From 22 to 16	10.1%	6
Togo	From 26 to 20	8.4%	6
Trinidad and Tobago*	From 25 to 20	7.2%	5
Spain	From 7 to 2	34.1%	5
Netherlands	From 8 to 3	27.9%	5
Morocco	From 8 to 3	27.9%	5
Ghana	From 16 to 11	11.7%	5
Namibia	From 18 to 13	10.3%	5
Rwanda	From 22 to 17	8.2%	5
Côte d'Ivoire	From 23 to 18	7.8%	5
Malawi	From 23 to 18	7.8%	5
Benin	From 24 to 19	7.5%	5
Nicaragua	From 27 to 22	6.6%	5

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.
Notes: Annualized growth. *Period: 2017 to 2019.

TABLE A-IV.5

Indicator coverage decline, from 2016 to 2019, in % and number

Economy	2016-2019	Improvement	Number
Madagascar	From 15 to 18	6.3%	3
Uganda	From 13 to 16	7.2%	3
Japan	From 2 to 5	35.7%	3
South Africa	From 2 to 4	26.0%	2

Source: Global Innovation Database, Cornell, INSEAD, and WIPO.
Note: Annualized growth.

A detailed economy study based on the GII database and the economy profile over time, coupled with analytical work on the ground, including innovation actors and decision makers, yields the best results in terms of grasping an economy's innovation performance over time as well as in identifying possible avenues for improvement.

Technical notes

Audit by the European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC).

The JRC-COIN has extensively researched the complexity of composite indicators that rank economies' performances along policy lines. For the ninth consecutive year, the JRC-COIN has performed a thorough "robustness" and "sensitivity" analysis of the GII to assess structural changes that are made to the list of indicators by the GII developing team (Table A-IV.1).

The recommendations from the JRC-COIN audit on the GII 2018 model were reviewed and incorporated into the GII 2019 model. This year, for an economy to feature in the GII 2019, the minimum symmetric data coverage is at least 35 indicators in the Innovation Input Sub-Index (66%) and 18 indicators in the Innovation Output Sub-Index (66%), with scores for at least two sub-pillars per pillar. In 2019, consideration was given to whether scores for all sub-pillars, for all pillars, would be required for economies to be considered in the GII. Ultimately, this rule was not applied this year, but will be reviewed again in 2020 and implemented if applicable.

A final audit of the GII 2019 model was performed in June 2019 (Appendix V).

Composite indicators

The GII relies on seven pillars, each divided into three sub-pillars, of which include two to five individual indicators. Sub-pillar scores are calculated using the weighted average of its individual indicators. Pillar scores are calculated using the weighted average of its sub-pillar scores.

The notion of weights as important coefficients was revised this year to ensure a greater statistical coherence of the model, following the recommendations of the JRC-COIN.[1]

The GII includes three indices:

1. The Innovation Input Sub-Index is the average of the first five pillar scores.
2. The Innovation Output Sub-Index is the average of the last two pillar scores.
3. The Global Innovation Index is the average of the Input and Output Sub-Indices.

Economy rankings are provided for indicators, sub-pillars, pillars, and index scores.

This year, following the advice of the JRC-COIN, the GII introduced a more statistically fitting alternative to analyzing the relation between innovation inputs and outputs. This approach replaces the Innovation Efficiency Ratio analysis (see Chapter 1, Figure 1.8 and relevant segment).[2]

Individual indicators

The GII 2019 model includes 80 indicators, which fall in three categories:

1. quantitative/objective/hard data (57 indicators),
2. composite indicators/index data (18 indicators), and
3. survey/qualitative/subjective/soft data (5 indicators).

Hard data

Hard data (57 indicators) are drawn from a variety of public and private sources. These include, among others, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Industrial Development Organization (UNIDO), the World Intellectual Property Organization (WIPO), the World Bank, the Joint Research Centre of the European Commission (JRC), PwC, Bureau van Dijk (BvD), Thomson Reuters, IHS Markit, Wikimedia Foundation, and AppAnnie.

Indicators are often correlated with population, gross domestic product (GDP), or some other size-related factor; they require scaling by a relevant size indicator for economy comparisons to be valid. Most indicators are either scaled at source or do not need to be scaled; for the rest, the scaling factor was chosen to represent a fair picture of economy differences. Scaling affected 40 indicators, which can be broadly divided into four groups:

1. Indicators scaled by GDP in current US$: 2.1.1, 2.3.2, 3.2.3, 4.1.2, 4.1.3, 4.2.2, 5.1.3, 5.3.4, 6.2.3, and 6.3.4.[3]

2. The count variables 3.3.3, 4.2.3, 5.2.4, 5.2.5, 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.2.4, 7.1.1, 7.1.2, and 7.3.4 are scaled by GDP in purchasing power parity current international dollars. This choice of denominator was dictated by a willingness to appropriately account for differences in development stages; in addition, scaling these variables by population would improperly bias results to the detriment of economies with a large young or ageing population.[4]

3. Variables 3.2.1, 5.1.5, 6.2.2, 7.2.2, 7.2.3, 7.3.1, 7.3.2, and 7.3.3 are scaled by population. Total population for 3.2.1, population 25+ years old for 5.1.5, population 15–64 years old for 6.2.2, and population 15–69 years old for the remaining.[5]

4. Sectoral indicators 5.3.1, 5.3.2, 5.3.3, 6.3.1, 6.3.2, 6.3.3, 7.2.1, and 7.2.5 are scaled by total trade; and indicators 6.2.5 and 7.2.4 by the total unit used to measure the particular statistic.[6]

Indices

Composite indicators are collected from a series of specialized agencies and academic institutions, such as the World Bank, the UN Public Administration Network (UNPAN), and Yale and Columbia Universities. Statisticians discourage the use of an "index within an index" on two main grounds: the distorting effect of the different computing methodologies used and the risk of duplicating variables. The normalization procedure partially solves the former (more on this below). To avoid the mistake of including a particular indicator more than once (directly and indirectly through a composite indicator), only indices with a narrow focus (18 in total) were selected.

Any additional disadvantage is outweighed by what is gained with model parsimony, acknowledgement of expert opinion, and focus on multi-dimensional phenomena that can hardly be captured by a single indicator.[7]

Survey data

Survey data are drawn from the World Economic Forum's Executive Opinion Survey (EOS). Survey questions are drafted to capture subjective perceptions on specific topics; five EOS questions were retained to capture phenomena strongly linked to innovative activities for which hard data are nonexistent or have low coverage for economies.

Economy coverage and missing data

This year the GII covers 129 economies, selected based on the availability of data and achieves the same percentage of indicator coverage as in the GII 2018 (Appendix IV: Technical Notes)

For each economy, only the most recent yearly data was considered. As a rule, the GII enforced the cut-off year to be 2009 for considering data at the indicator level. A few exceptions were made for years prior to the cut-off year.[8]

For the sake of transparency and replicability of results, no additional effort was made to fill missing values. Missing values are indicated with "n/a" and are not considered in the sub-pillar score. However, the JRC-COIN audit assessed the robustness of the GII modelling choices (i.e., no imputation of missing data, fixed predefined weights, and arithmetic averages) by imputing missing data, applying random weights, and using geometric averages. Since 2012, based on this assessment, a confidence interval has been provided for each ranking in the GII as well as the Input and Output Sub-Indices (Appendix V).

Treatment of series with outliers

Potentially problematic indicators with outliers that could polarize results and unduly bias the rankings were treated according to the rules listed below, as per the recommendations of the JRC-COIN. This affected 29 indicators; 27 out of the 57 hard data indicators and 2 out of the 18 composite indicators.

First rule: selection

Problematic indicators were identified by skewness or kurtosis. The problematic indicators had either:

- an absolute value of skewness greater than 2.25, or
- a kurtosis greater than 3.5.[9]

Second rule: treatment

Series with one to five outliers (24 cases) were winsorized; the values distorting the indicator distribution were assigned the next highest value, up to the level where skewness and/or kurtosis entered within the ranges specified above.[10]

With two exceptions (see note 10) for series with five or more outliers, skewness and/or kurtosis entered within the ranges specified above after multiplication by a given factor *f* and transformation by natural logs.[11] Since only "goods" were affected (i.e., indicators for which higher values indicate better outcomes, as opposed to "bads"), the formula used was:

$$\ln\left[\frac{(Max \times f - 1)(economy\ value - Min)}{Max - Min} + 1\right]^{12}$$

...where "min" and "max" are the minimum and maximum indicator sample values.

For one case, neither winsorization nor multiplication by a given factor plus log transformation brought the series within the desired parameters.[12] For this particular case a variant of a Box-Cox transformation, defined as Yeo-Johnson, was applied to the entire series with a λ=0.6. The formula used was:

$$y_i^{(\lambda)} = ((y_i + 1)^{\lambda} - 1) / \lambda^{14}$$

where $0 \le \lambda \le 2$; $\lambda \neq 0$; $y \ge 0$; and y_i = economy value

Normalization

The 80 indicators were then normalized into the [0, 100] range, with higher scores representing better outcomes. Normalization was according to the min-max method; where the min and max values were given by the minimum and maximum indicator sample values respectively. The exception for index and survey data, for which the original series range of values was kept as min and max values (for example, [0, 1] for UNPAN indices; [1, 7] for the World Economic Forum Executive Opinion Survey questions; [0, 100] for World Bank's World Governance Indicators; etc.). The following formula was applied:

$$\text{Goods}: \frac{economy\ value - Min}{Max - Min} \times 100$$

$$\text{Bads}: \frac{Max - economy\ value}{Max - Min} \times 100$$

Notes:

1 Paruolo, P. et al. (2013) show that a theoretical inconsistency exists between the real theoretical meaning of weights and the meaning generally attributed to them by the standard practice in constructing composite indicators that use them as importance coefficients in combination with linear aggregation rules. The approach followed in the GII this year, as last year, is to assign weights of 0.5 or 1.0 to each component in a composite to ensure the highest correlations between them (i.e., indicator/sub-pillar, sub-pillar/pillar, etc.). Two sub-pillars (7.2 Creative goods and services, and 7.3 Online creativity) and 35 indicators (1.1.1, 1.2.1, 1.2.2, 2.1.4, 2.1.5, 2.2.1, 2.2.3, 3.2.1, 3.2.2, 3.3.3, 4.2.2, 4.2.3, 4.3.1, 4.3.2, 5.1.3, 5.1.4, 5.1.5, 5.2.1, 5.2.4, 5.3.1, 6.1.1, 6.1.2, 6.1.4, 6.2.2, 6.2.3, 6.2.4, 6.2.5, 6.3.1, 6.3.2, 6.3.3, 7.1.2, 7.2.1, 7.2.2, and 7.2.3) are weighted 0.5; the rest have a weight of 1. This year the weights for three indicators were adjusted to provide higher statistical coherence (5.2.5 Patent families 2+ offices and 6.1.5 Citable documents H-index now have a weight of 1 and 6.3.4FDI net outflows a weight of 0.5).

2 To account for differences in development, other composite indicators use weighting schemes differentiated by income level.

3 These indicators are expenditure on education (2.1.1); gross expenditure on R&D (GERD) (2.3.2); gross capital formation (3.2.3); domestic credit to private sector (4.1.2); microfinance institutions' gross loan portfolio (4.1.3); market capitalization (4.2.2); GERD performed by business enterprise (5.1.3); foreign direct investment net inflows (5.3.4); total computer software spending (6.2.3); and foreign direct investment net outflows (6.3.4).

4 These count variables are mainly indicators that increase disproportionately with economic growth. They include: ISO 14001 environmental certificates (3.3.3); venture capital deals; (4.2.3) joint venture/strategic alliance deals; (5.2.4) patent families filed in two or more offices (5.2.5); patent applications by origin (6.1.1); PCT international applications by origin (6.1.2); utility model applications by origin (6.1.3); scientific and technical publications (6.1.4); ISO 9001 quality certificates (6.2.4); trademark application class count by origin (7.1.1); industrial designs by origin (7.1.2); and mobile app creation (7.3.4)

5 These variables are electricity output (3.2.1); females employed with advanced degrees (5.1.5); new business density (6.2.2); national feature films produced (7.2.2); entertainment and media market (7.2.3); generic (7.3.1) and country-code (7.3.2) top-level Internet domains; and Wikipedia yearly edits (7.3.3).

6 Intellectual property payments (5.3.1); high-tech net imports (5.3.2); ICT services imports (5.3.3); intellectual property receipts (6.3.1); high-tech net exports (6.3.2); ICT services exports (6.3.3); cultural and creative services exports (7.2.1); and creative goods exports (7.2.5) were scaled by total trade; high-tech and medium-high-tech output (6.2.5) and printing and other media (7.2.4) were scaled by total manufactures output.

7 For example, GII sub-pillar 3.1 Information and communication technologies (ICTs) is composed of four indices: ICT Access and Use sub-indices, and UNPAN's Government Online Service and E-Participation indices. The first two, previously part of ITU's ICT Development Index, are now produced by the GII independently from other components from that original index, following the methodology of the ITU's ICT Development Index 2017. Similarly, the Online Service Index is a component of UNPAN's E-Government Development Index together with two indices on Telecommunication Infrastructure and Human Capital that were not considered, as they duplicate GII pillars 3 and 2, respectively. The e-Participation Index was developed separately by UNPAN in 2010.

8 A total of 37 economies in 14 indicators show data that is previous to 2009. These are Saudi Arabia (2008), Egypt (2008), Algeria (2008), Zambia (2008), Yemen (2008) in Expenditure on education (2.1.1); Botswana (2008) and Cambodia (2008) in School life expectancy (2.1.3); Argentina (2008) in Pupil-teacher ratio (2.1.5); Philippines (2008) in Tertiary inbound mobility (2.2.3); Albania (2008) and Zambia (2008) in Researchers (2.3.1) and Gross expenditure on R&D (2.3.2); Iran (Islamic Republic of) (2008), Zambia (2008) in GERD performed by business (5.1.3); Australia (2008), Iran (Islamic Republic of) (2008), Albania (2008), Zambia (2008) in GERD financed by business (5.1.4); Australia (2008), Albania (2008), Zambia (2008), Burundi (2008) in GERD financed by abroad (5.2.3); Iran (Islamic Republic of) (2008), Panama (2008), Ecuador (2008), Zambia (2008) in Research talent (5.3.5); Kenya (2008) in New businesses (6.2.2); Cameroon (2008) in High- & medium-high-tech manufactures (6.2.5); El Salvador (2008) in National feature films (7.2.2); and Argentina (2002), Lebanon (2007), Trinidad and Tobago (2006), Pakistan (2006), Ghana (2003), Cameroon (2008), and Madagascar (2006) in Printing & other media (7.2.4).

9 Based on Groeneveld and Meeden (1984), which sets the criteria of absolute skewness above 1 and kurtosis above 3.5. The skewness criterion was relaxed to account for the small sample at hand (129 economies).

10 This distributional issue affects the following variables: 3.2.1, 4.2.3, 5.3.2, 5.3.3, 6.1.5, and 7.2.4 (1 outlier); 4.2.2, 5.2.4, 5.3.1, 6.1.3, 7.1.2, 7.2.1, 7.2.2, 7.3.2, and 7.3.4 (2 outliers); 2.2.3, 6.1.1, and 6.3.3 (3 outliers); 4.1.3 and 5.2.5 (4 outliers); and 6.1.2, 6.3.1, and 7.2.5 (5 outliers). The treatment criterion was relaxed this year to allow two series (6.3.2 and 6.3.4) with 6 outliers. For two particular economies—Malta and Iceland— values were removed for indicator 6.3.4. The reason for this was twofold: first, the data did not seem to capture the noted historic trend for these economies for this variable; second, the data produced a distortion in skewness and kurtosis for the indicator that neither winsorization nor any transformation could adequately correct.

11 This distributional issue affects variables 2.3.3 and 4.3.3 (factor f of 1).

12 These formulas achieve two things: converting all series into "goods" and scaling the series to the range [1, max] so that natural logs are positive starting at 0. Where "min" and "max" are the minimum and maximum indicator sample values.

The corresponding formula for bads is:

$$\ln\left[\frac{(Max \times f - 1)(Max - economy\ value)}{Max - Min} + 1\right]$$

13 This distributional issue affected variable 5.3.4 Foreign direct investment net inflows.

14 For negative values in that series the formula used was:

$$y_i^{(\lambda)} = -\left[(-y_i + 1)^{(2-\lambda)} - 1\right] / (2 - \lambda)$$

where $0 \le \lambda \le 2$; $\lambda \neq 2$; $y < 0$; λ; and y_i = economy value

References:

Groeneveld, R. A., & Meeden, G. (1984). Measuring Skewness and Kurtosis. *The Statistician, 33*, 391–99.

Paruolo P., Saisana, M., & Saltelli, A. (2013). Ratings and Rankings: Voodoo or Science?. *Journal of the Royal Statistical Society, A 176*(2), doi: 0964–1998/13/176000.