



## JRC TECHNICAL REPORTS

# JRC Statistical Audit of the 2022 Global Attractiveness Index

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## Abstract

Attractiveness is a crucial factor in the global scramble for talented people, investments and know-how. It is a prerequisite for competitiveness and it remains so also in the new challenging scenario depicted by the pandemic and recent geopolitical risks. While COVID-19 is still affecting large parts of the world giving rise to health and economic crises, an additional challenge has emerged: the geopolitical risks introduced by the Russian invasion of Ukraine. The European House – Ambrosetti has developed the Global Attractiveness Index (GAI) to provide countries with a tool to measure and benchmark national attractiveness as determining element of its ability to be competitive and to grow in a sustainable way. The GAI – now at this

seventh edition - builds on four attributes of attractiveness - Openness, Innovation, Efficiency, and Endowment - which are captured by 21 Key Performance Indicators, then aggregated into a single summary measure of attractiveness. The GAI 2022 ranks 148 countries which cover approximately 95% of the world's population and 99% of Gross Domestic Product worldwide. This framework inevitably entails both conceptual and practical challenges. Conducted by the European Commission's Joint Research Centre, the statistical audit of the GAI 2022 edition aims at maximising the reliability and transparency of the index. This statistical quality check should enable policy analysts and researchers alike to draw more relevant and meaningful advice to improve or fully unleash countries' attractiveness potential.

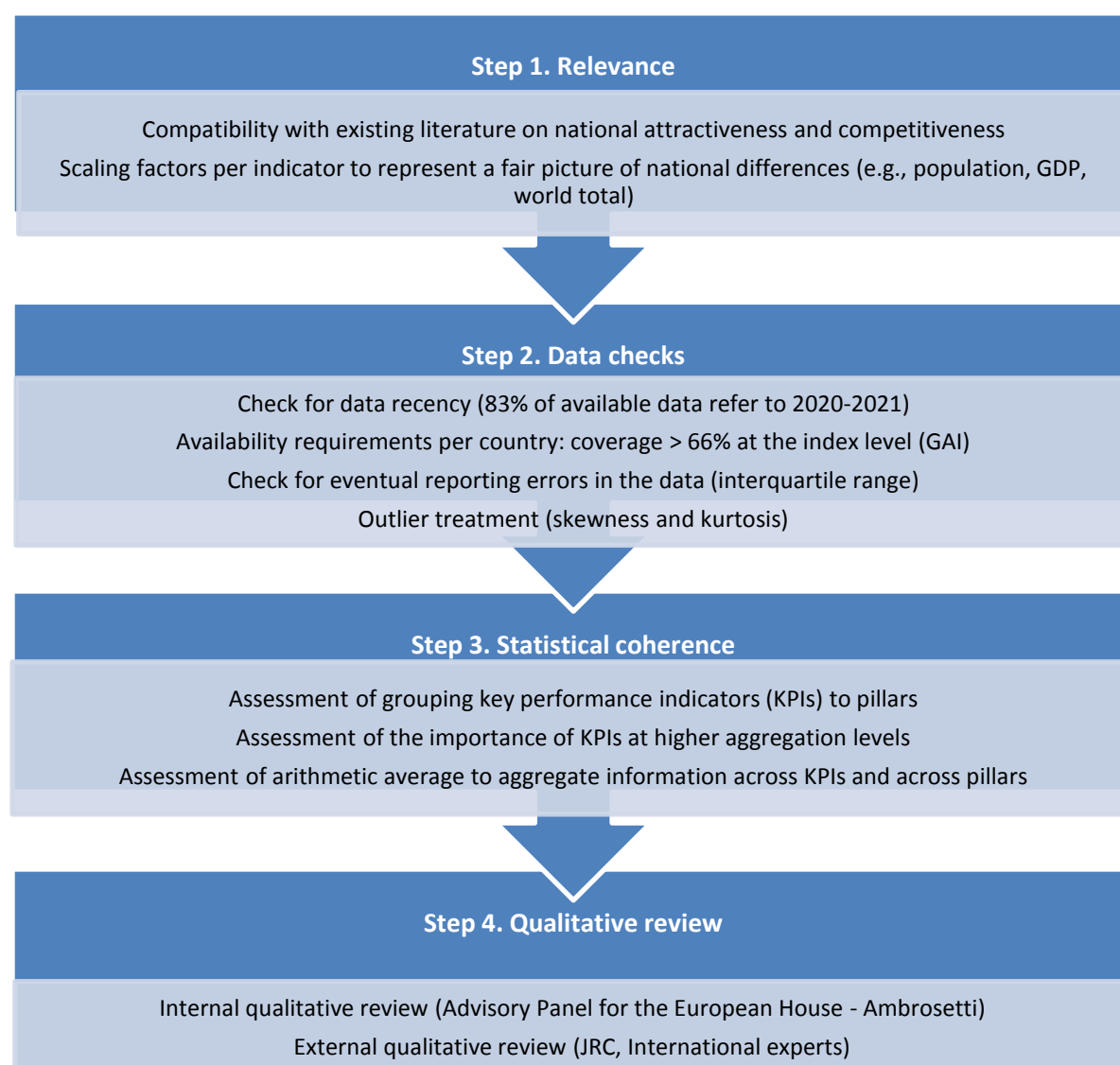
# **1 Conceptual and statistical coherence in the GAI framework**

The Global Attractiveness Index (GAI) – in this seventh edition – benchmarks 148 economies globally, which represent 95% of the world population and 99% of Gross Domestic Product in four macro-areas of attractiveness – Openness, Innovation, Efficiency and Endowment – and two cornerstones of competitiveness – Dynamism, and Sustainability. Specifically, the GAI analyses attractiveness from a dual perspective: internal — the ability to retain resources already present in the area; external — the ability to attract new resources from the outside.

The European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC) in Ispra has been invited for the seventh consecutive year to audit the GAI. As in previous editions, the present JRC audit focuses on the statistical soundness of the multi-level structure of the GAI as well as on the impact of key modeling assumptions on the results. The independent statistical assessment of the GAI provided by the JRC-COIN guarantees the transparency and reliability of the index for both policymakers and other stakeholders, thus facilitating more accurate priority setting and policy formulation in the field of competitiveness and attractiveness.

The focus of the JRC statistical audit is on the Global Attractiveness Index and its four macro-areas of attractiveness: Openness, Innovation, Efficiency and Endowment. Earlier versions of the Global Attractiveness Index were assessed by the JRC in May-July 2022. Fine-tuning suggestions made by the JRC were taken into account by the European House – Ambrosetti in the final computation of the rankings, with a view to setting the foundation for a balanced indicator framework. The entire process followed four steps ([Figure 1](#)).

**Figure 1. Conceptual and statistical coherence in the GAI 2022 Framework**



*Source: European Commission, Joint Research Centre, 2022.*

## Step 1: Relevance

Almost 200 variables were initially considered by The European House – Ambrosetti for their relevance to the four attractiveness attributes – Openness, Innovation, Efficiency, and Endowment - on the basis of a literature review and expert consultation in 2016-2022.

**Openness** captures a country's efforts to promoting the circulation of economic, human and business resources both internally and externally.

**Innovation** synthesizes how a country's ecosystem (research network, public institutions, businesses, financial system) promote scientific and technological progress.

**Efficiency** monitors the ability of organisational and function-related structures to guarantee proper functioning (and quality) of capital markets, the labour market, services and government.

Finally, **Endowment** captures high-quality assets that are capable of being sources of competitive advantage.

After screening for data coverage and subsequently testing for statistical coherence, twenty-one key performance indicators (KPIs) were selected. To represent a fair picture of country differences, two types of denominators for the indicators were used:

- External factors: for those indicators that express magnitudes related to the attractiveness of a country in relation to others, raw data values were divided by the world total (e.g., KPI7 Exports of high-technology goods, compared with world total)<sup>(1)</sup>.
- Internal factors: for those indicators that capture aspects of internal attractiveness, raw data values were divided by relevant national factors (e.g., KPI4 Foreign university students, compared with youth population).

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<sup>(1)</sup> See Giampietro (2014) for a discussion on scaling factors for indicators (intensive versus extensive properties) and Becker et al.(2018) for an application of intensive and extensive connectivity in a European Union-Asian context..

## **Step 2: Data checks**

The most recently released data within the period 2015–2021 were used for each country to reconstruct its series from past data to reflect in each year's report the updates issued by the leading international statistical bodies from which the database is derived. In 2021, there is 83% of available data for the GAI across the 21 indicators and 148 countries. Countries are included in the GAI if data availability is at least 66%, namely 14 out of 21 indicators. Exceptionally, ten countries with lower data coverage have been included in the GAI 2022: Liberia, Puerto Rico, Seychelles, and Yemen (with 10 to 12 out of the 21 indicators of the GAI framework) and Cabo Verde, Chad, Guyana, Kuwait, Lesotho, and Timor-Leste (with 13/21 indicators).

The impact of missing values on the GAI results is further discussed in Section 2.

Potentially problematic indicators that could bias the overall results were identified on the basis of two measures related to the shape of the indicators' distribution: skewness and kurtosis. Values were treated if the indicators had absolute skewness greater than 3.0, approximately, and kurtosis greater than 3.5.<sup>(2)</sup> These criteria were proposed by the JRC back in 2016 for the specific dataset underpinning the GAI model. These indicators were treated by winsorization (four or less outliers per indicator) in order to avoid that few very high/low values result in polarised indicators and scores, and introduce distortion in the correlation coefficients that are subsequently used for the analysis of the statistical coherence in the GAI framework.

## **Step 3: Statistical Coherence**

The reliability of the Global Attractiveness Index depends, inter alia, on the degree of coherence between the conceptual framework – 21 indicators grouped into 4 pillars and finally into an index – and the statistical structure of the data. The more the statistical structure of the data is compatible with the GAI conceptual framework, the higher the reliability of the GAI will be. The coherence of the GAI framework was assessed by analysing whether the 21 KPIs explain a sufficient amount of variation in the aggregate scores (either in the four pillars or the overall index) by means of correlation, cross-correlation, and principal component analysis.

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<sup>(2)</sup> Groeneveld and Meeden (1984) set the criteria for absolute skewness above 1 and kurtosis above 3.5. The skewness criterion was relaxed in the GAI case after having conducted ad-hoc tests in the GAI timeseries.



Given that the analysis of statistical coherence of the Global Attractiveness Index is based on correlations, the correspondence of the GAI to a real-world phenomenon needs to be critically addressed by experts in the field because ‘correlations need not necessarily represent the real influence of the individual indicators on the phenomenon being measured’<sup>(3)</sup>. The point made here is that the validity of the GAI framework relies on the combination of both statistical and conceptual soundness. In this respect, the GAI framework has been developed following an iterative process that went back and forth between the theoretical understandings of national competitiveness and attractiveness on the one hand, and data observations on the other.

Principal component analysis was used to assess the extent to which the conceptual framework underpinning the GAI – 21 indicators grouped in 4 pillars and finally into an index – is compatible with the data statistical properties. Results suggest that the expectation of a single statistical dimension (i.e., no more than one principal component with eigenvalue greater than 1.0) is confirmed for only one of the four pillars, namely for the Innovation pillar. Instead there are two statistical dimensions within each of the other three pillars: Openness, Efficiency and Endowment. The presence of two statistical dimensions in each of those three pillars suggests that some of the information content of some KPIs does not arrive at the pillar level. This point merits further reflection and is discussed in more detail in the concluding remarks in this section.

A more detailed analysis of the correlation structure within and across the four GAI pillars confirms the expectation that the indicators are generally more correlated to their own pillar than to any other (see [Table 1](#)). This result suggests that the allocation of the 21 KPIs to a specific pillar of a country’s attractiveness is consistent both from conceptual and statistical perspectives. Furthermore, all associations between indicators and the respective pillar are statistically significant, and most correlation coefficients within a GAI pillar are close to or greater than 0.70, which suggests that at least half of the variance in the GAI pillar scores can be explained by the underlying indicators.

The relevance to overall GAI framework of the new data source used since the GAI 2019 edition for capturing the Net number of migrants (KPI5) and the addition of a new indicator on Digital Equipment (KPI8) in GAI 2021 is confirmed as both indicators have contributed to increasing the statistical coherence in the framework.

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<sup>(3)</sup> See (OECD-JRC, 2008).

Finally, the four GAI pillars share a single statistical dimension. The GAI captures 73% of the total variance in the four pillars, and the four correlation coefficients (between the index and each pillar) are sufficiently high, 0.77 or greater. This result supports the aggregation of the four GAI pillars into one number and suggests that all four pillars of a country's attractiveness can explain more than half of the variation of the GAI scores, and vice versa, as envisaged by the index developers. The reliability of the GAI, measured by the Cronbach-alpha value, is very good at 0.84—well above the 0.7 threshold for a reliable aggregate of the four pillars<sup>(4)</sup>.

**Table 1. Statistical coherence: correlations between GAI components**

Pillars of Attractiveness			Key Performance Indicators (KPIs)				Global Attractiveness Index (GAI)
			Openness	Innovation	Efficiency	Endowment	
Openness	KPI1	(Foreign Direct Investment flows into the country IN + the country's investment abroad OUT), % of world total	0.73	0.68	0.38	0.64	0.72
	KPI2	(Export + Import), % of world total	0.78	0.81	0.50	0.77	0.84
	KPI3	(No. foreign tourists IN + No. national tourists abroad OUT), compared with national population	0.46				0.19
	KPI4	Foreign university students, compared with youth population	0.63	0.37	0.54	0.30	0.52
	KPI5	Net number of migrants, compared with population	0.70	0.41	0.48	0.29	0.54
Innovation	KPI6	Employed in high-technology sectors, compared with employed	0.23	0.68			0.39
	KPI7	Exports of high-technology goods, compared with world total	0.65	0.73	0.42	0.59	0.70
	KPI8	Digital Equipment Index	0.59	0.83	0.70	0.59	0.80
	KPI9	Number of scientific publications, compared with world total	0.58	0.73	0.35	0.74	0.72
	KPI10	Internet users, % of population	0.56	0.81	0.57	0.52	0.73
Efficiency	KPI11	Unemployment level	0.23		0.39		0.23
	KPI12	Logistics Performance Index	0.73	0.81	0.82	0.71	0.88
	KPI13	Total productivity of factors			0.24		0.03
	KPI14	Rule of Law Index	0.60	0.65	0.85	0.55	0.74
	KPI15	Total tax rate (% commercial profits)			0.40		0.14
Endowment	KPI16	Gross Domestic Product (GDP), compared with world total	0.58	0.72	0.34	0.75	0.71
	KPI17	Gross National Product, (GNP), per capita	0.76	0.73	0.75	0.67	0.84
	KPI18	Gross Fixed Investment, compared with GDP				0.42	0.16
	KPI19	Natural Endowment Index				0.18	-0.04
	KPI20	College graduates, compared with world total	0.26	0.43		0.57	0.37
	KPI21	PISA Test Score	0.45	0.46	0.80	0.58	0.62
Pillars of Attractiveness			Openness	Innovation	Efficiency	Endowment	GAI
	Openness		1.00	0.74	0.59	0.63	0.86
	Innovation		0.74	1.00	0.61	0.77	0.93
	Efficiency		0.59	0.61	1.00	0.53	0.77
	Endowment		0.63	0.77	0.53	1.00	0.86

Notes: Numbers represent the Pearson correlations coefficients between the GAI components (pillars or index) and the underlying indicators for 148 countries) for the latest year (2021). Values greater than 0.7 (in the shaded areas) are desirable because they imply that the pillar captures at least 50% ( $\approx 0.7 \times 0.7$ ) of the variation in the underlying KPIs. Values between 0.21 and 0.7 are acceptable. Instead, values lower than 0.21 are not presented because they are not statistically significant. Grey boxes show the conceptual grouping of the indicators.

Source: European Commission, Joint Research Centre, 2022.

Concluding, the statistical coherence tests corroborate the two-level structure in the GAI framework, and confirm the desired unidimensionality of one out of the four pillars – the Innovation pillar – and the overall index. Furthermore, all 21 indicators are found to be

<sup>(4)</sup> See Nunnally (1978).

influential, having statistically significant correlations, at least at the pillar level –with the only exception of the Natural Endowment Index, and for 16 out of the 21 indicators, this influence arrives up to the overall index. This is a desirable outcome as it suggests that the information content in the majority of the underlying indicators is maintained at all levels of aggregation in the GAI framework. Overall, in this seventh edition, the correlation structure remains relatively stable with most KPIs behaving as expected, meaning that they help measure countries performance on the different complex dimensions of attractiveness. The main changes are noted for one indicator – Number of foreign tourists and number of national tourists abroad (KPI3) – that has a much lower degree of association to the framework compared to past GAI editions. This result could be due to the fact that this indicator has been strongly affected by the COVID-19 crisis.

At the same time, the results in [Table 1](#) evidence several issues that are worth of further reflection by the index developers, either because they indicate avenues for refining the indicator framework or for further policy analysis.

First, there are five indicators that do not significantly correlate with this year's overall index: Number of tourists (KPI3) within Openness, Total productivity of factors (KPI13) and Total tax rate (KPI15) within Efficiency, and Gross fixed investment (KPI18) and Natural Endowment Index (KPI19) within Endowment. Although conceptually enriching the overall GAI framework, these KPIs are found not to co-vary with the overall index. This means that countries may achieve high GAI scores in spite of the high or low values in KPIs 3, 13, 15, 18 and 19, and the same holds for low GAI scores. The considerations to be made next are indicator-specific. The poor correlation between the Number of tourists (KPI3) and the overall index of competitiveness is considered to be directly impacted by the covid pandemic; in fact this indicator was well correlated with the overall index in past GAI editions, which supports the inclusion of this indicator in the framework. Instead, the poor correlation between Total productivity of factors (KPI13), Total tax rate (KPI15), Gross fixed investment (KPI18) and the overall competitiveness index has persisted in all editions of the GAI; for these indicators the JRC recommendation to the GAI team is to fine-tune the framework by considering a different formulation or different data sources for these indicators. Finally, the poor correlation between the Natural Endowment Index (KPI19) and the overall competitiveness index is more worrisome, as it has persisted through almost all editions of the index and in line with relevant scientific literature and a recent article in *Nature Communications* <sup>(5)</sup> it may point towards a masking rather than a synergistic effect of

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<sup>(5)</sup>Zeng et al., 2020

competitiveness on environmental protection, and the more worrisome finding that there is a lack of integration of environmental priorities into countries' growth and competitiveness plans.

Second, for the first time in the past year's edition, the indicator on Investment flows (KPI1) had a significantly lower correlation (0.43) with the Openness pillar compared to the other four indicators within that pillar (0.64 or more). This result could have been explained by the exceptional year 2020 in terms of investment because of the COVID-19 crisis. As expected in this year's edition, the Investment flows indicator has become an important component of the Openness pillar with correlation coefficient at 0.72 in the GAI 2022, which is at the level (0.75) of past GAI editions.

Third, only two out of five indicators in the Efficiency pillar strongly determine the pillar scores. This is the case for the Logistics Performance Index (KPI12) and Rule of Law Index (KPI14) that correlate strongly with the Efficiency pillar (0.82 and 0.85, respectively), whilst the influence of the other three indicators measuring a country's Unemployment level (KPI11), Total productivity of factors (KPI13) and Total tax rate (KPI15) are relatively modest determinants of a country's efficiency (correlations 0.40 or lower).

Fourth, two indicators are found to have a transversal impact across different pillars in the GAI framework. Although Gross National Product (KPI17) belongs to the Endowment pillar (correlation 0.67), it is found to have stronger statistical association to the Openness, Innovation and Efficiency pillars (correlations 0.73 or more). Similarly, the trade indicator (KPI2) also has a strong correlation to the Innovation and Endowment pillars as it does to its assigned Openness pillar (0.77 vs. 0.78 or 0.81). This transversal impact of the Gross National Product and the Trade indicator across various pillars in the framework, which is present also in past editions of the GAI, may be worth of further reflection and analysis by the index developers, as they may offer additional insights on countries attractiveness attributes.

Fifth, although the indicator PISA Test score (KPI21) belongs to the Endowment pillar (correlation 0.58), it presents a much stronger correlation (0.80) with the Efficiency pillar. This strong association between the PISA test scores and the Efficiency scores are worth of further reflection and analysis by the index developers.

Last but not least, while 16 out of 21 indicators are influential at the index level, four of them – the Trade indicator on Export + Import (KPI2), the Digital Equipment Index (KPI8), the Logistics Performance Index (KPI12) and the Gross National Product (KPI17) – remain the

best single predictors for a country's attractiveness level (i.e. correlation coefficients with the GAI ranging from 0.80 to 0.88).

#### Step 4: Qualitative Review

The GAI results on countries attractiveness were also evaluated by an ad-hoc Advisory Panel and by international experts invited by the European House – Ambrosetti to verify that they are, to a great extent, consistent with current evidence, existing research and prevailing theory.

To complement this qualitative evaluation, the GAI results are compared herein vis-à-vis other similar indices. The expectation is that the GAI correlates strongly to other international indices on competitiveness and innovation. Table 2 compares the GAI 2022 with the most recent versions of the IMD World Competitiveness Ranking (2022), with Cornell University, INSEAD, and WIPO's Global Innovation Index (2022) and with INSEAD's Global Talent Competitiveness Index (2022). The rank correlation between GAI 2022 with all three international indices remains substantially high (correlation  $\approx 0.9$ ), which suggests that the GAI framework is consistent with other international frameworks that monitor innovation and competitiveness at national level worldwide.

**Table 2. Statistical consistency between GAI and relevant international indices**

	Global Innovation Index 2022 (Cornell, INSEAD, WIPO)	World Competitiveness Index 2022 (IMD)	Global Talent Competitiveness Index 2022 (INSEAD)
More than 30 positions	9%	0%	11%
20 to 29 positions	16%	8%	19%
10 to 19 positions	22%	28%	30%
<b>More than 10 positions (*)</b>	<b>48%</b>	<b>35%</b>	<b>60%</b>
5 to 9 positions	26%	29%	18%
Less than 5 positions	21%	28%	19%
0 positions	5%	8%	3%
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Pearson correlation coefficient with the GAI	0.88	0.77	0.84
Spearman rank correlation coefficient with the GAI	0.89	0.85	0.87
Common countries with the GAI	130	61	130

Notes: The comparison between the GAI and the other indices was based on the common set of countries. (\*) This row is the sum of the prior three rows.

Source: European Commission, Joint Research Centre, 2022.

At the same time, looking at the shifts in rankings, 35% up to 60% of the countries differ in ranking by more than 10 positions when comparing the GAI 2021 with the recent releases of three international indices under analysis. This result suggests that the GAI 2022 receives validity when compared to other relevant international indices, and at the same time

confirms that the GAI offers additional insights into nations' attractiveness and competitiveness that go beyond the findings of other international indices.

Notwithstanding these statistical tests and the positive outcomes on the statistical coherence together with the suggestions for refinement made above, the GAI model has been and should remain open for future improvements as better data, more comprehensive surveys and assessments, and new relevant research studies on national attractiveness and competitiveness become available.

## **2 Impact of modelling assumptions in the GAI**

Assessing the effect of varying modelling assumptions in the GAI inside plausible ranges is an important part of the statistical audit. The rationale for the choices made by the GAI developing team is manifold. For instance, literature review and expert opinion on national attractiveness and competitiveness, coupled with statistical analysis, is behind the selection of the 21 individual indicators and their grouping in four pillars and into an overall index; common practice and easy of interpretation suggests the use of a min-max normalization approach in the [0–100] range for the indicators; statistical analysis guides the choice on the treatment of outliers; and simplicity seems to advocate for not estimating missing data, assigning equal weights at all levels and adopting an arithmetic average formula.

Despite the well-substantiated rationale for the choices made during the GAI development, there is an unavoidable subjectivity (or uncertainty), which is accounted for in the robustness assessment carried out by the JRC. More precisely, the uncertainty analysis is conducted herein in order to allow for the joint analysis of the impact of the modelling choices on the GAI results, resulting in error estimates and confidence intervals calculated for the 148 countries included in the GAI.

As suggested in the relevant literature on composite indicators <sup>(6)</sup>, the robustness assessment of the GAI model was based on Monte Carlo simulation and multi-modelling approaches, applied to 'error-free' data where eventual errors and typos have already been corrected in a preliminary stage. In particular, the three key modelling issues considered in the assessment of the GAI were the treatment of missing data, the aggregation formula at the pillar level and finally the pillar weights.

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<sup>(6)</sup> Saisana et al., 2005; Saisana et al., 2011 ; Vértesy 2016; Vértesy and Deiss, 2016

**Missing data.** The GAI developers, for transparency and replicability and following common practice on composite indicator development, opted not to estimate missing data. Technically, the ‘no imputation’ choice is equivalent to replacing an indicator’s missing value for a given country with the respective pillar score. Hence, the available data (indicators) in the incomplete pillar may dominate the results, sometimes biasing the ranks up or down. Furthermore, the ‘no imputation’ choice might encourage countries not to report low data values. To test the impact of the ‘no imputation’ choice, the JRC estimated missing values in the GAI dataset using the Expectation Maximization (EM) algorithm that was applied in the entire set of 21 indicators.<sup>(7)</sup>

**Aggregation.** Regarding the aggregation formula, decision-theory practitioners challenge the use of simple arithmetic averages because of their fully compensatory nature, in which a comparative high advantage on a few indicators can compensate a comparative disadvantage on many indicators.<sup>(8)</sup> To assess the impact of this compensability issue, the strong perfect substitutability assumption inherent in the arithmetic average was relaxed in this analysis; instead the geometric average across the four GAI pillars was considered as an alternative. Nevertheless, the arithmetic average has been maintained at the indicator level, where full compensability may be justifiable. The geometric average is a partially compensatory approach that rewards countries with balanced profiles and motivates countries to improve in the GAI pillars in which they perform poorly, and not just in any GAI pillar.<sup>(9)</sup>

**Weights.** While the term multi-modelling refers to testing alternative assumptions—that is, an alternative aggregation method, and missing data estimation method—the Monte Carlo simulation explored the issue of weighting and comprised 1,000 runs, each corresponding to a different set of weights for the four pillars, randomly sampled from uniform continuous distributions centred in the reference values (equal weighting; pillar weights are 25%). The choice of the range for the weights’ variation was driven by two opposite needs: to ensure a wide enough interval to have meaningful robustness checks, and to respect the rationale of GAI that places equal importance on all four pillars – Openness, Innovation, Efficiency,

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<sup>(7)</sup> The Expectation-Maximization (EM) algorithm (Little and Rubin, 2002; Schneider, 2001) is an iterative procedure that finds the maximum likelihood estimates of the parameter vector by repeating two steps. Step 1: The expectation E-step: Given a set of parameter estimates, such as a mean vector and covariance matrix for a multivariate normal distribution, the E-step calculates the conditional expectation of the complete-data log likelihood given the observed data and the parameter estimates. Step 2: The maximization M-step: Given a complete-data log likelihood, the M-step finds the parameter estimates to maximize the complete-data log likelihood from the E-step. The two steps are iterated until the iterations converge.

<sup>(8)</sup> Munda, 2008.

<sup>(9)</sup> In the geometric average, pillars are multiplied as opposed to summed in the arithmetic average. Pillar weights appear as exponents in the multiplication. A constant of 0.001 was added to the pillar scores to avoid zero values that would have led to zero geometric averages.



Endowment. Given these considerations, limit values of uncertainty intervals for the pillar weights are 15% to 35% for the four pillars (see Table 3). In all simulations, sampled weights are then rescaled so that they always sum to 1.

Four models were tested based on the combination of no imputation versus EM imputation at the indicator level, arithmetic versus geometric average at the pillar level. Combined with 1,000 simulations per model (random weights versus fixed weights), a total of 4,000 simulations for the Global Attractiveness Index were run.

**Table 3. Uncertainty parameters in the GAI: missing values, weights, aggregation**

	Reference	Alternative
I. Uncertainty in the treatment of missing values	No estimation of missing data	Expectation Maximization (EM)
II. Uncertainty in the aggregation formula at pillar level	Arithmetic average	Geometric average
III. Uncertainty intervals for the weights of the four GAI pillars	Reference value for the weight	Distribution assigned for robustness analysis
Openness	0.25	U[0.15,0.35]
Innovation	0.25	U[0.15,0.35]
Efficiency	0.25	U[0.15,0.35]
Endowment	0.25	U[0.15,0.35]

Source: European Commission, Joint Research Centre, 2022.

The main results of the robustness analysis are shown in Figure 2 with median ranks and the 90% confidence intervals computed across the 4,000 Monte Carlo simulations for the Global Attractiveness Index. Countries are ordered from high to low performance according to their reference GAI rank (black line), the dot being the median rank over the simulations.

All published GAI 2022 ranks lay within the simulated 90% confidence intervals, and for the vast majority of the countries these ranks can be considered as representative of the plurality of scenarios simulated herein. Taking the median rank as the yardstick for an economy's expected rank in the realm of the GAI's unavoidable methodological uncertainties, 75% of the economies are found to shift fewer than four positions with respect to the median rank in the GAI.

Furthermore, for several economies the simulated rank intervals are narrow enough for meaningful inferences to be drawn: there are fewer than 10 positions for 67 of the 148 economies. These results are reassuring as they are similar to the GAI 2020 edition that was based on 2019 data and hence monitoring attractiveness before the COVID-19 pandemic. Instead, last year's results in the GAI 2021 edition were comparatively worse, with 50 countries found to be relatively stable, having simulated rank intervals less than 10 positions wide. Last year's lower reliability of some GAI country ranks could be attributed to two

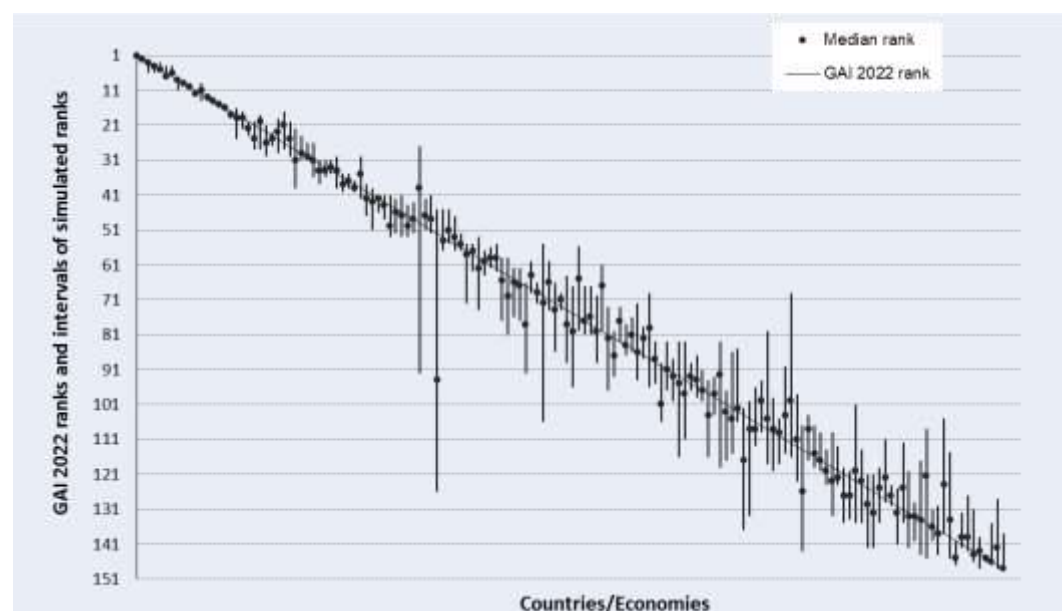


factors: the higher impact of missing values in the GAI dataset, and the impact of the COVID-19 pandemic to the associations between the GAI's indicators.

Particular caution is needed for those countries whose GAI ranks vary significantly with changes in the four pillar weights, the aggregation formula across the four pillars or the estimation of missing data (where applicable). Confidence interval widths are 30 or greater for the following fourteen countries that are placed between the 49th (Kuwait) and the 139th (Liberia) position: Kuwait, Timor-Leste, Gabon, Lao PDR, Ecuador, Cabo Verde, Paraguay, Lebanon, Jordan, Chad, Zimbabwe, Myanmar, Guyana, and Liberia. Furthermore, there are twenty six more countries with confidence interval widths between 20 and 29: Islamic Rep of Iran, Bulgaria, Iraq, Puerto Rico, Georgia, Algeria, Cote d'Ivoire, Uzbekistan, Bangladesh, Argentina, Colombia, Tanzania, Albania, Rwanda, Moldova, Jamaica, Gambia, Mauritania, Zambia, Tunisia, Nicaragua, Dem. Rep. of Congo, Mali, Sierra Leone, and Bolivia. For all these 40 countries the GAI ranks are highly sensitive to the modelling choices when building the GAI and should hence not be taken at face value.

For full transparency and information, [Table 4](#) reports the GAI 2022 country ranks together with the simulated 90% confidence intervals in order to better appreciate the robustness of the results to the estimation of missing data, the choice of the four pillar weights and of the aggregation formula at pillar level.

**Figure 2. Robustness analysis (GAI rank vs. median rank, 90% confidence intervals)**



Notes: Median ranks and intervals are calculated over 4,000 simulated scenarios based on imputing (or not) missing values, random weights plus/minus 25% around the reference weights for the four pillars on Openness, Innovation, Efficiency, Endowment, and aggregation formula at pillar level (see Table 3). The Spearman rank correlation between the median rank of the simulations and the GAI 2022 rank is 0.992.

Source: European Commission, Joint Research Centre, 2021.

**Table 4. GAI 2022: Index ranks and simulated 90% intervals**

Germany	1 [1, 2]	Malta	51 [41, 52]	Albania	101 [97, 117]
United States	2 [1, 2]	Timor-Leste	52 [45, 126]	Rwanda	102 [86, 115]
Hong Kong, China (SAR)	3 [3, 6]	Romania	53 [45, 57]	Moldova	103 [85, 106]
United Kingdom	4 [4, 6]	Cyprus	54 [45, 55]	Cabo Verde	104 [102, 137]
Japan	5 [3, 6]	Mexico	55 [47, 57]	Paraguay	105 [100, 133]
Singapore	6 [4, 7]	Slovak Republic	56 [52, 57]	Nigeria	106 [96, 113]
China	7 [4, 7]	Seychelles	57 [55, 72]	El Salvador	107 [94, 109]
Korea, Rep.	8 [8, 11]	Chile	58 [55, 63]	Lebanon	108 [80, 118]
Australia	9 [8, 9]	Iran, Islamic Rep.	59 [53, 74]	Jamaica	109 [99, 120]
Canada	10 [9, 11]	Azerbaijan	60 [57, 64]	Tajikistan	110 [105, 118]
France	11 [11, 12]	Serbia	61 [56, 62]	Gambia, The	111 [90, 115]
United Arab Emirates	12 [9, 14]	Croatia	62 [55, 63]	Jordan	112 [69, 116]
Switzerland	13 [12, 14]	Panama	63 [59, 77]	Mauritania	113 [98, 123]
Ireland	14 [13, 15]	Bulgaria	64 [59, 81]	Chad	114 [107, 143]
Netherlands	15 [14, 16]	Mongolia	65 [62, 76]	Cambodia	115 [104, 117]
Belgium	16 [15, 17]	Greece	66 [62, 77]	Sri Lanka	116 [107, 119]
Sweden	17 [17, 19]	Iraq	67 [66, 92]	Senegal	117 [109, 120]
Denmark	18 [16, 25]	Belarus	68 [60, 69]	Guatemala	118 [114, 124]
Italy	19 [17, 22]	Montenegro	69 [66, 72]	Zambia	119 [109, 133]
Austria	20 [20, 24]	Gabon	70 [55, 106]	Pakistan	120 [113, 124]
Finland	21 [20, 28]	Ukraine	71 [60, 74]	Namibia	121 [119, 135]
Russian Federation	22 [18, 28]	Puerto Rico	72 [66, 86]	Kenya	122 [120, 134]
Luxembourg	23 [21, 30]	North Macedonia	73 [69, 74]	Zimbabwe	123 [101, 135]
Czech Republic	24 [23, 27]	Georgia	74 [64, 89]	Tunisia	124 [114, 135]
Saudi Arabia	25 [19, 29]	Algeria	75 [67, 96]	Nicaragua	125 [121, 142]
Qatar	26 [17, 28]	Cote d'Ivoire	76 [56, 80]	Congo, Dem. Rep.	126 [121, 142]
India	27 [20, 30]	Mauritius	77 [67, 81]	Nepal	127 [119, 135]
Oman	28 [22, 39]	Suriname	78 [67, 81]	Honduras	128 [111, 129]
New Zealand	29 [24, 31]	Uruguay	79 [70, 89]	Uganda	129 [124, 130]
Spain	30 [26, 31]	South Africa	80 [61, 80]	Benin	130 [125, 141]
Norway	31 [26, 36]	Uzbekistan	81 [73, 97]	Mali	131 [112, 135]
Israel	32 [31, 38]	Armenia	82 [80, 93]	Sierra Leone	132 [120, 142]
Poland	33 [31, 36]	Philippines	83 [73, 83]	Yemen, Rep.	133 [129, 140]
Brunei Darussalam	34 [31, 35]	Costa Rica	84 [78, 87]	Bolivia (Plurinational State of)	134 [117, 144]
Bahrain	35 [30, 39]	Dominican Republic	85 [76, 86]	Myanmar	135 [108, 145]
Estonia	36 [35, 40]	Bangladesh	86 [72, 94]	Togo	136 [131, 140]
Hungary	37 [35, 39]	Trinidad and Tobago	87 [79, 88]	Cameroon	137 [130, 144]
Malaysia	38 [37, 40]	Argentina	88 [69, 96]	Guyana	138 [105, 138]
Brazil	39 [30, 42]	Egypt, Arab Rep.	89 [83, 95]	Liberia	139 [115, 145]
Iceland	40 [38, 47]	Bhutan	90 [89, 106]	Burundi	140 [140, 147]
Slovenia	41 [39, 51]	Bosnia and Herzegovina	91 [83, 97]	Madagascar	141 [132, 142]
Portugal	42 [41, 46]	Peru	92 [88, 100]	Burkina Faso	142 [127, 143]
Thailand	43 [41, 48]	Lao PDR	93 [83, 116]	Malawi	143 [131, 146]
Indonesia	44 [41, 53]	Colombia	94 [83, 111]	Niger	144 [139, 148]
Lithuania	45 [42, 52]	Morocco	95 [89, 97]	Mozambique	145 [144, 146]
Turkey	46 [41, 53]	Kyrgyz Republic	96 [87, 99]	Haiti	146 [135, 147]
Latvia	47 [44, 53]	Ghana	97 [91, 100]	Lesotho	147 [128, 148]
Vietnam	48 [43, 52]	Tanzania	98 [94, 116]	Guinea	148 [138, 148]
Kuwait	49 [27, 92]	Botswana	99 [93, 104]		
Kazakhstan	50 [42, 51]	Ecuador	100 [83, 119]		

Notes: Rank intervals are calculated over 4,000 simulated scenarios based on imputing (or not) missing values, random weights plus/minus 25% around the reference weights for the four pillars on Openness, Innovation, Efficiency, Endowment, and aggregation formula at pillar level. Countries with confidence interval widths that are 30 positions or greater are highlighted in grey.

Source: European Commission, Joint Research Centre, 2022.

Next, the impact of not estimating missing values in the GAI 2022 is analysed in more detail. The 2021 dataset has very good coverage: 83% data available across 148 countries and 21 indicators. Nevertheless, out of the 521 missing values, data gaps in 25 countries are found to have a high impact on the GAI ranks. These results represent an improvement compared to last year's GAI, where data gaps in 44 countries were found to have a high impact on the GAI ranks. [Table 5](#) lists these 25 countries that are strongly affected (moving 30 positions or more in a given GAI pillar) when missing values are estimated via the EM algorithm as opposed to not being estimated at all (reference scenario). Data availability per pillar is reported as well. Most country ranks are particularly sensitive to the missing data estimation in one or two pillars and in particular in the Openness pillar. The GAI rank for three countries - Lao, Myanmar, and Seychelles - is sensitive to the missing values in two pillars. For the remaining 21 countries the GAI rank is sensitive to missing values in only one pillar. It is worth noting that the sensitivity of country ranks to the treatment of missing data is not necessarily directly related to the amount of missing data in a given country but rather the result of the missing values in the ensemble of countries.

The JRC recommendation to readers and policy analysts is to consider the GAI pillar ranks (and scores) for these 25 countries with a grain of salt when drawing inferences on their performance when it comes to national Openness, Innovation, Efficiency or Endowment. The suggestion to the GAI developers is to find reliable estimates for those missing values in those 25 countries as indicated in [Table 5](#) because of the high impact on the GAI pillar ranks, and to eventually consider introducing a more stringent criterion for countries inclusion in the GAI, where economies are only included if data availability is at least 60% within each of the GAI pillars.

**Table 5. Impact of missing data estimation: most affected countries**

Country rank sensitive to the treatment of missing data					Data availability			
	Openness	Innovation	Efficiency	Endowment	Openness	Innovation	Efficiency	Endowment
Algeria		YES			80%	60%	100%	83%
Azerbaijan			YES		100%	80%	60%	83%
Bahrain				YES	60%	80%	80%	67%
Burundi			YES		60%	80%	60%	67%
Cabo Verde			YES		80%	80%	40%	50%
Chad			YES		40%	60%	80%	67%
Chile				YES	100%	80%	100%	100%
Colombia				YES	80%	80%	100%	100%
Ecuador	YES				60%	80%	100%	83%
Gabon		YES			60%	60%	80%	67%
Greece				YES	100%	100%	100%	100%
Iraq		YES			80%	60%	80%	50%
Kuwait				YES	60%	80%	80%	33%
Lao PDR			YES	YES	100%	80%	60%	67%
Liberia				YES	60%	60%	80%	33%
Myanmar	YES			YES	40%	80%	100%	50%
Oman		YES			80%	60%	80%	83%
Panama		YES			80%	60%	80%	50%
Puerto Rico	YES				40%	40%	40%	67%
Seychelles			YES	YES	60%	80%	20%	50%
Slovak Republic				YES	100%	80%	100%	100%
Suriname				YES	80%	80%	60%	50%
Tajikistan			YES		80%	60%	80%	67%
Tanzania			YES		60%	60%	80%	83%
Timor-Leste			YES		80%	60%	40%	67%
<b>Total</b>	<b>3</b>	<b>5</b>	<b>9</b>	<b>11</b>				

Notes: Countries are listed here if they are strongly affected with shifts of 30 positions or more in a given GAI pillar when missing values are estimated via the EM algorithm as opposed to not being estimated at all (reference scenario).

Source: European Commission, Joint Research Centre, 2022.

Concluding, the published GAI 2022 ranks are reliable and for the vast majority of countries the simulated 90% confidence intervals are narrow enough for meaningful inferences to be drawn. Given the sensitivity of some countries' pillar ranks to the estimation of missing values, the JRC recommendation to the index developers is to find a suitable way for approximating missing values, where possible by contacting national statistical offices or finding additional data sources. For the readers and policy analysts of the GAI 2022 report, the recommendation is to consider country ranks within the 90% confidence intervals in order to better appreciate to what degree a country's rank depends on the three key modelling choices accounted for, namely estimation of missing data, weights and aggregation formula at the pillar level.

### 3 GAI added value - From four pillars to one number of national attractiveness

This last section aims at touching upon the added value of the Global Attractiveness Index as a summary measure of the four pillars.

Table 6 shows that the GAI 2022 ranking and any of the four pillar rankings differ by 10 positions or more for at least 45% (up to 61%) of the 148 countries.

This finding suggests that there is an added value in referring to the GAI results in order to identify aspects of countries' attractiveness that do not directly emerge by looking into the four pillars separately. At the same time, this outcome points to the value of examining individual GAI pillars and indicators on their own merit in order to see which components are driving a country's attractiveness.

**Table 6. Distribution of differences between pillars and GAI rankings**

Shift with respect to the GAI	Openness	Innovation	Efficiency	Endowment
More than 30 positions	18%	7%	24%	21%
20 to 29 positions	12%	11%	11%	16%
10 to 19 positions	30%	27%	24%	25%
<i>More than 10 positions (*)</i>	61%	45%	59%	61%
5 to 9 positions	17%	22%	22%	20%
Less than 5 positions	20%	29%	16%	17%
0 positions	2%	4%	3%	2%
<i>Total</i>	100%	100%	100%	100%
Spearman rank correlation coefficient with the GAI	0.81	0.93	0.79	0.82

Notes: (\*) This row is the sum of the prior three rows.

Source: European Commission, Joint Research Centre, 2022.

## 4 Conclusions

For the seventh consecutive year, The European House – Ambrosetti's Global Attractiveness Index (GAI) enables policy makers, investors and other interested stakeholders to measure and benchmark 148 countries around the world on a number of aspects that together provide a representative profile of the attractiveness and competitive sustainability of countries and, as a result, provide dependable information to aid in making

system-wide choices about growth and optimization of the pro-business environment. With a view to maximise the reliability and transparency of the GAI, The European House – Ambrosetti has again asked the JRC to assess the impact of the methodological choices made in the development of the index. More specifically, in the present report, the JRC delves into the statistical properties of the data and the methodology used in the construction of the Global Attractiveness Index and provides advice for further improvements. Overall, the analysis herein confirms that GAI framework is accurately designed and built. This result signals the efforts that The European House – Ambrosetti's has put into the preparation of this work to identify the multiple determinants of a county's attractiveness and the best available data sources to measure them.

The key findings of the 2022 statistical assessment can be summarised as follows.

1

*GAI: A  
conceptually  
coherent tool*

The analysis of the correlation structure finds the **conceptual grouping** of the 21 indicators into four pillars and an overall index statistically appropriate. It also shows that the overall GAI, which is the average of four key dimensions measuring Openness, Innovation, Efficiency and Endowment, is unidimensional and has high statistical reliability (Cronbach alpha 0.84) well above the recommended threshold (0.7) for a reliable aggregate. Sixteen out of the 21 indicators in the GAI framework are also found to be influential all the way up to the index level. The appropriateness of the new data source used since the GAI 2019 edition for capturing the Net number of migrants (KPI5) and this year's new indicator on Digital Equipment (KPI8) is confirmed as it has contributed to increasing their statistical coherence in the framework.

2

*KPIs to be  
kept under the  
spotlight*

The following issues call for further reflection and analysis.

First, five indicators – Number of tourists (KPI3) within Openness, Total productivity of factors (KPI13) and Total tax rate (KPI15) within Efficiency, and Gross fixed investment (KPI18) and Natural Endowment Index (KPI19) within Endowment – account for an almost negligible amount of variation in the GAI scores. Although these indicators are conceptually relevant to measure attractiveness and their statistical impact arrives up to the pillar level, we recommended the GAI's developers to monitor how these indicators relate to the GAI framework in the coming releases of the

index and consider fine-tuning the framework in this respect by considering a different formulation or different data source for these indicators. For the Number of tourists (KPI3) the poor correlation to the overall index of competitiveness is considered to be directly impacted by the covid pandemic; in fact this indicator was well correlated with the overall index in past GAI editions, which supports the inclusion of this indicator in the framework. Instead, the poor correlation between the Natural Endowment Index (KPI19) and the overall competitiveness index is more worrisome, as it has persisted through almost all GAI editions and in line with relevant scientific literature it may point towards a masking rather than a synergistic effect of competitiveness on environmental protection, and the more worrisome finding that there is a lack of integration of environmental priorities into countries' growth and competitiveness plans.

Second, the correlation of the indicator on Investment flows (KPI1) to the Openness pillar is now at 0.72 (it was as low as 0.43 in the last year's edition due to the exceptional year 2020 in terms of investment because of the COVID-19 crisis. This result is reassuring because it suggests that the Investment flows indicator is again an important component of the Openness pillar, as it was the case in pre-pandemic GAI editions.

Third, only two out of five indicators in the Efficiency pillar – Logistics Performance Index (KPI12) and Rule of Law Index (KPI14) – strongly determine the pillar scores.

Fourth, the transversal impact of the Gross National Product (KPI17) and the Trade indicator (KPI2) across various pillars in the GAI framework may be worth of further reflection and analysis, as they may offer additional insights on countries attractiveness attributes.

Fifth, although the indicator PISA Test score (KPI21) belongs to the Endowment pillar (correlation 0.58), it presents a much stronger correlation (0.80) with the Efficiency pillar. This strong association between the PISA test scores and the Efficiency scores are worth of further reflection.

Finally, while 16 out of 21 indicators are influential at the index level, four



### 3

*A moderate impact of missing data on shifts in the GAI rankings*

of them – the Trade indicator (KPI2), the Digital Equipment Index (KPI8), the Logistics Performance Index (KPI12) and the Gross National Product (KPI17) – remain the best single predictors for a country's attractiveness level (i.e. correlation coefficients with the GAI ranging from 0.80 to 0.88).

The GAI dataset has good data coverage: 83% of the data available in 2021 across 21 indicators and 148 countries. Uncertainty and sensitivity analysis have shown that it is important to find reliable estimates for data gaps in 25 countries (out of the 134 countries that miss at least one value) because of the very high impact on the country ranks along specific GAI pillars.

The tests helped to single out 40 countries with GAI ranks that are very sensitive to the modelling choices and hence these ranks should be interpreted cautiously. The JRC recommendation for next GAI editions is to eventually consider introducing a more stringent criterion for countries inclusion in the GAI, where economies are only included if data availability is at least 60% within each of the GAI pillars.

Compared to the reference GAI rank, 75% of the economies are found to shift fewer than four positions with respect to the median rank over 4,000 simulations. Thereafter, the GAI framework allows to reliably benchmark national attractiveness in the vast majority of the countries analysed.

### 4

*The GAI offers new insights on countries attractiveness, while at the same time receives external validity*

Last but not least, results show that there is an added value in referring to the GAI results in order to identify aspects of countries' attractiveness that do not directly emerge by looking into the four pillars separately. In fact, the GAI ranking and any of the four pillar rankings differ by 10 positions or more for at least 45% up to 61% of the 148 countries.

Also, the external validity testing of the GAI confirms the high degree of association (correlation  $\approx 0.9$ ) to the latest releases of three relevant international indices: the IMD World Global Competitiveness Ranking, the Cornell University, INSEAD, and WIPO's Global Innovation Index, and the INSEAD's Global Talent Competitiveness Index. At the same time, one finds that 35% up to 60% out of the countries included in the GAI 2022 that feature in these three indices differ in ranking by more than 10



## 5

*The JRC audit confirms that the GAI 2022 sufficiently meets international quality standards for statistical soundness*

positions when comparing the GAI 2022 with the recent releases of these international indices. This latter finding means that the GAI 2022 offers additional insights into national human capital and competitiveness that go beyond the findings of other international indices.

Overall, this year's JRC audit confirms that the Global Attractiveness Index 2022 sufficiently meets international quality standards for statistical soundness. Consequently, the GAI framework offers a sound starting point for more informed discussions on a country's attractiveness. Stakeholders should also to check the GAI's results beyond the index scores (and ranks) as the 21 individual indicators and four pillars can offer more in-depth insights on the areas to be more carefully addressed by policy action. The GAI represents a well-designed but ongoing work by The European House - Ambrosetti to stimulate public interest and help focus policy discussions on the multiple aspects that shape a country's 'charm'. Still, the GAI, as any other indicator framework aimed at capturing a complex and evolving reality, is subject to improvement. The GAI's developers intend to keep improving the tool in line with the theoretical advancement in the field and the availability of new (and relevant) data.

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