CHAPTER 6

JRC Statistical Audit of the Global Talent Competitiveness Index 2019

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More than capital, talents and individual skills are considered to be the driving forces that will enable human beings to thrive in the future. Since 2013 the business school INSEAD has developed the Global Talent Competitiveness Index (GTCI), which aims to summarise complex and versatile concepts related to human capital and talent competitiveness at the national scale worldwide. In so doing, it raises some conceptual and practical challenges, which are discussed in the GTCI 2019 report. This chapter focuses on the practical challenges related to the data quality and the methodological choices made in the grouping of 68 variables into 14 sub-pillars, six pillars, two sub-indices, and an overall index for a total of 125 countries.

The GTCI 2019 has a very high statistical reliability (it has a Cronbach's alpha value of 0.97) and captures the single latent phenomenon underlying the six main dimensions of the GTCI conceptual framework. Country ranks are also robust to methodological choices related to the treatment of missing values, weighting, and aggregation rule (with a shift less than or equal to ±2 positions with respect to the simulated median in 89% of the countries). The added value of the GTCI lies in its ability to summarise different aspects of talent competitiveness in a more efficient and parsimonious manner than is possible with the variables and pillars taken separately. In fact, the overall ranking differs from any of the six pillar rankings by 10 positions or more in at least one-third of the countries included in this year's GTCI.

The European Commission's Competence Centre on Composite Indicators and Scoreboards at the Joint Research Centre (JRC) has been invited to assess the statistical properties of the GTCI each year since its first release in 2013. Thus this audit represents the sixth analysis of the GTCI performed by the JRC. Overall, the JRC concluded that the GTCI 2019 is robust and reliable, with a statistically coherent and balanced multi-level structure. The analysis has been performed in order to ensure the transparency and reliability of the GTCI and thus to enable policymakers to derive more accurate and meaningful conclusions about human capital and national competitiveness, and potentially to guide their choices on priority setting and policy formulation.

As in the previous audits, the present JRC assessment of the GTCI 2019 focuses on two main issues: (1) the statistical coherence of the structure and (2) the impact of key modelling assumptions on the GTCI scores and ranks.[1] The JRC analysis complements the reported country rankings for the GTCI, and for the Input and Output sub-indices, with confidence intervals in order to better appreciate the robustness of these ranks to the computation methodology (in particular, the missing data estimation, weights, and aggregation formula). Furthermore, the JRC analysis includes an assessment of the added value of the GTCI and a comparison with other global measures of human capital, competitiveness, and innovation. Its main conclusions can be summarised as follows: the version of the GTCI model presented in 2019 is coherent, balanced, and robust, displaying strong associations between the underlying variables and the GTCI sub-pillars, pillars, and sub-indices, and hence offers a sound basis for policy interpretations. Some minor issues, which are outlined in this chapter, are also recommended for examination in the next version of the GTCI.

The practical items addressed in this chapter relate to the statistical soundness of the GTCI, which should be considered to be a necessary (though not necessarily sufficient) condition for a sound index. Given that the present statistical analysis of the GTCI will mostly, though not exclusively, be based on correlations, the correspondence of the GTCI to a real-world phenomenon needs to be critically addressed because *'correlations need not necessarily represent the real influence of the individual indicators on the phenomenon being measured'*.[2] The point is that the validity of the GTCI relies on the combination of both statistical and conceptual soundness. In this respect, the GTCI has been developed following an iterative process that went back and forth between the theoretical understanding of human capital and talent competitiveness on the one hand, and empirical observations on the other.

STATISTICAL COHERENCE IN THE GTCI FRAMEWORK

An initial assessment of the GTCI 2019 data set was undertaken by the JRC in July 2018. The latest GTCI model provided by the development team largely incorporated the issues identified and discussed in previous editions. In particular, the full normalisation of the data was addressed in order to scale all variables onto the same scale. No critical issues were identified in the 2019 model during this preliminary phase of the audit.

The underlying concepts and framework used to describe global talent competitiveness in the GTCI 2019 have remained essentially the same as those in the GTCI 2018, although there are some minor adjustments in this year's edition. The first one relates to the denominator of the variable Scientific journal articles (variable 6.2.5), which has changed from being GDP-based to being population-based. The second consists of a refinement of the variable New product entrepreneurial activity (variable 6.2.3).

Following the iterative process during which the index has been fine-tuned, the current assessment of the statistical coherence in this final version of the GTCI 2019 followed four steps:

Step 1: Relevance

Variables were selected for their relevance to a specific pillar on the basis of the literature review, expert opinion, country coverage, and timeliness. To represent a fair picture of country differences, variables were scaled either at the source or by the GTCI team as appropriate and where needed.

Step 2: Data Checks

The most recently released data were used for each country. The cut-off year was set to 2007. Countries were included if data availability was at least 80% at the index level and at least 40% at the sub-pillar level. As a result, the GTCI 2019 data set comprises 125 countries and 68 variables.[3] Consequently, data availability is at least 88% at the Input sub-index level and 63% at the Output sub-index level. Potentially problematic variables that could bias the overall results were identified by the GTCI development team as those having absolute skewness greater than 2 and kurtosis greater than 3.5,[4] and were treated either by Winsorisation or by taking the natural logarithm (in the case of five or more outliers). In total, only three indicators were treated: 2.1.3 Migrant stock, 2.1.4 International students, and 6.2.2 High-value exports (see the Technical Notes of the main GTCI report for details). These criteria follow the WIPO-INSEAD Global Innovation Index practice (formulated with the JRC in 2011).

Step 3: Statistical Coherence

This section presents the JRC's analysis of the statistical coherence of the GTCI 2019, which consists of a principal component analysis to study the structure of the data, a multi-level analysis of the correlations of variables, and a comparison of GTCI rankings with its pillars and with other similar indices. This latter investigation demonstrates the added value of the GTCI both against its component pillars and vis-à-vis other relevant indices on competitiveness, innovation, and human capital.

1. Principal Component Analysis and Reliability Item Analysis

Principal component analysis (PCA) was used to assess the extent to which the conceptual framework is compatible with statistical properties of the data. PCA confirms the presence of a single statistical dimension (i.e., no more than one principal component with an eigenvalue significantly greater than 1.0) in the great majority (13) of the 14 sub-pillars, which captures 41% (Internal Openness) to 87% (Employability) of the total variance in the underlying variables.[5] A more detailed analysis of the correlation structure within and across the six pillars confirms the expectation that the GTCI sub-pillars are more correlated with their own pillar than with any other. This result suggests that the allocation of sub-pillars to pillars in the GTCI is consistent both from conceptual and statistical perspectives. Furthermore, all correlations within a pillar are positive, strong, and similar and well above 0.7, which suggests that roughly 50% (or more) of the variance in the GTCI pillar scores can be explained by an underlying sub-pillar (see Table 1). These results suggest that the conceptual grouping of GTCI sub-pillars into pillars is statistically confirmed and that the six pillars are statistically well balanced.

Table 1

Statistical coherence in the GTCI: Correlations between sub-pillars and pillars

	SUB-PILLAR	ENABLE	ATTRACT	GROW	RETAIN	VOCATIONAL AND TECHNICAL SKILLS	GLOBAL KNOWLEDGE SKILLS
INPUT	1.1 Regulatory Landscape	0.95	0.87	0.86	0.86	0.82	0.80
	1.2 Market Landscape	0.94	0.77	0.90	0.88	0.89	0.86
	1.3 Business and Labour Landscape	0.91	0.79	0.75	0.73	0.76	0.69
	2.1 External Openness	0.81	0.93	0.71	0.67	0.70	0.62
	2.2 Internal Openness	0.78	0.90	0.75	0.70	0.69	0.63
	3.1 Formal Education	0.70	0.51	0.86	0.81	0.76	0.83
	3.2 Lifelong Learning	0.84	0.81	0.94	0.75	0.82	0.75
	3.3 Access to Growth Opportunities	0.90	0.85	0.94	0.84	0.86	0.84
	4.1 Sustainability	0.92	0.82	0.90	0.95	0.87	0.84
	4.2 Lifestyle	0.75	0.57	0.75	0.94	0.81	0.83
OUTPUT	5.1 Mid-Level Skills	0.66	0.49	0.65	0.79	0.83	0.74
	5.2 Employability	0.80	0.77	0.83	0.69	0.83	0.69
	6.1 High-Level Skills	0.79	0.63	0.82	0.86	0.86	0.96
	6.2 Talent Impact	0.81	0.68	0.86	0.83	0.79	0.95

Source: European Commission, Joint Research Centre (2019).
Note: The values are the bivariate Pearson correlation coefficients (n = 125). Shaded values represent the coefficients between sub-pillars and the respective pillar based on the GTCI conceptual framework. Values greater than 0.70 within the shaded areas are desirable as they imply that the pillar captures at least 50% (≈ 0.70 × 0.70) of the variation in the underlying sub-pillars and vice-versa.

The six pillars also share a single statistical dimension that summarises 87% of the total variance, and the six loadings (correlation coefficients) are quite high and very similar to each other, ranging from 0.86 (Attract pillar) to 0.96 (Enablers pillar). The latter suggests that the six pillars contribute in a similar way to the variation of the GTCI scores, as envisaged by the development team: all six pillars are assigned equal weights. The reliability of the GTCI, measured by the Cronbach's alpha value, is very high at 0.97—well above the 0.70 threshold for a reliable aggregate.[6]

An important part of the analysis relates to clarifying the importance of the Input and Output sub-indices with respect to the variation of the GTCI scores. As mentioned above, the GTCI is built as the simple arithmetic average of the four Input sub-pillars and the two Output sub-pillars, which implies that the Input sub-index has a weight of 4/6 versus a weight of 2/6 for the Output sub-index. Yet this does not imply that the Input aspect is twice as important as the Output aspect in determining the variation of the GTCI scores. In fact, the correlation coefficient between the GTCI scores and the Input or Output sub-index is 0.99 and 0.97, respectively, which suggests that the sub-indices are effectively placed on an equal footing. Overall, the tests so far show that the grouping of variables into sub-pillars, pillars, and an overall index is statistically coherent, and that the GTCI has a balanced structure, whereby all six pillars are equally important in determining the variation in the GTCI scores.

2. Importance of the Variables in the GTCI Framework

The GTCI and its components are simple arithmetic averages of the underlying variables. Developers and users of composite indicators often consider that the weights assigned to the variables coincide with the variables' importance in the index. However, in practice, the correlation structure of the variables and their different variances do not always allow the weights assigned to the variables to be considered equivalent to their importance.[7]

This section assesses the importance of all 68 variables at the various levels of aggregation in the GTCI structure. As a statistical measure of the importance of variables in an index we use the squared Pearson correlation coefficient (otherwise known as the *coefficient of determination* R^2). The importance of the selected variables is taken to be equivalent to the contribution of those variables to the variation of the aggregate scores, be those sub-pillars, pillars, sub-indices, or the overall GTCI. The overarching consideration made by the GTCI development team was that all variables should be important at all levels of aggregation. The results of our analysis appear in Table 2. Examining the importance measures of the 68 variables, we see that almost all variables are important at the various levels of aggregation. For example, country variations in 1.1.1 Government effectiveness scores can capture 92% of the variance in the respective sub-pillar scores (Regulatory Landscape), and 90% of the variance in the respective pillar (Enable), Input sub-index, and overall GTCI scores. Similarly, country variations in 2.1.1 Foreign direct investment (FDI) and technology transfer scores can capture 64%, 60%, 62%, and 59% of the variance in the External Openness, Attract, Input, and GTCI scores, respectively.

Five variables in the 2019 data set have a very low impact on the GTCI variance (less than 10%): 1.3.1 Ease of hiring, 1.3.2 Ease of redundancy, 2.2.5 Gender earnings gap, 3.1.3 Tertiary education expenditure, and 3.2.2 Prevalence of training in firms. Therefore these variables are not found to be important at the overall index level in the 2019 framework.[8] In fact, 1.3.1 Ease of hiring has consistently been a low-impact variable in the overall

Table 2

Importance measures for the variables at the various levels of the GTCI structure

PILLAR	SUB-PILLAR	VARIABLE NAME	SUB-PILLAR	PILLAR	INPUT/OUTPUT	GTCI INDEX
1. ENABLE	1.1 Regulatory Landscape	Government effectiveness	92%	90%	90%	90%
		Business-government relations	43%	41%	31%	26%
		Political stability	71%	52%	53%	48%
		Regulatory quality	89%	84%	84%	84%
		Corruption	90%	83%	85%	83%
	1.2 Market Landscape	Competition intensity	59%	46%	40%	39%
		Ease of doing business	66%	66%	62%	63%
		Cluster development	68%	60%	57%	55%
		R&D expenditure	68%	54%	55%	58%
		ICT infrastructure	70%	61%	70%	74%
		Technology utilisation	85%	80%	81%	80%
	1.3 Business and Labour Landscape	Ease of hiring	39%	18%	10%	8%
		Ease of redundancy	30%	15%	10%	9%
		Active labour market policies	70%	76%	74%	74%
		Labour-employer cooperation	70%	65%	60%	56%
		Professional management	66%	75%	76%	73%
2. ATTRACT	2.1 External Openness	Relationship of pay to productivity	78%	70%	61%	60%
		FDI and technology transfer	64%	60%	62%	59%
		Prevalence of foreign ownership	57%	53%	43%	39%
		Migrant stock	52%	43%	32%	31%
		International students	71%	58%	44%	42%
		Brain gain	69%	64%	46%	40%
	2.2 Internal Openness	Tolerance of minorities	60%	45%	41%	37%
		Tolerance of immigrants	31%	28%	15%	12%
		Social mobility	63%	75%	73%	69%
		Female graduates	20%	12%	15%	17%
		Gender earnings gap	16%	4%	2%	1%
		Leadership opportunities for women	51%	46%	37%	35%
3. GROW	3.1 Formal Education	Vocational enrolment	51%	30%	21%	23%
		Tertiary enrolment	71%	44%	39%	44%
		Tertiary education expenditure	21%	14%	8%	8%
		Reading, maths, and science	70%	52%	50%	53%
		University ranking	62%	64%	51%	54%
	3.2 Lifelong Learning	Quality of management schools	78%	70%	62%	62%
		Prevalence of training in firms	42%	23%	7%	6%
		Employee development	80%	75%	78%	76%
	3.3 Access to Growth Opportunities	Delegation of authority	83%	73%	73%	70%
		Personal rights	50%	46%	42%	42%
		Use of virtual social networks	60%	48%	54%	54%
		Use of virtual professional networks	72%	68%	68%	68%
		Collaboration within organisations	78%	67%	66%	66%
		Collaboration across organisations	67%	60%	59%	58%
4. RETAIN	4.1 Sustainability	Pension system	65%	79%	58%	63%
		Social protection	86%	72%	79%	74%
		Brain retention	57%	34%	56%	50%
	4.2 Lifestyle	Environmental performance	81%	78%	65%	68%
		Personal safety	63%	65%	58%	58%
		Physician density	80%	65%	43%	47%
		Sanitation	76%	60%	40%	44%
5. VOCATIONAL AND TECHNICAL SKILLS	5.1 Mid-level Skills	Workforce with secondary education	73%	30%	27%	18%
		Population with secondary education	74%	33%	30%	20%
		Technicians and associate professionals	79%	71%	72%	64%
		Labour productivity per employee	49%	64%	63%	68%
	5.2 Employability	Ease of finding skilled employees	84%	49%	44%	46%
		Relevance of education system to the economy	87%	59%	54%	59%
		Skills matching with secondary education	87%	74%	68%	71%
		Skills matching with tertiary education	90%	59%	52%	60%
6. GLOBAL KNOWLEDGE SKILLS	6.1 Higher-Level Skills	Workforce with tertiary education	84%	75%	68%	55%
		Population with tertiary education	81%	68%	62%	52%
		Professionals	80%	78%	75%	68%
		Researchers	79%	80%	78%	73%
		Senior officials and managers	52%	47%	41%	35%
		Availability of scientists and engineers	55%	51%	58%	55%
	6.2 Talent impact	Innovation output	80%	79%	74%	71%
		High-value exports	38%	32%	26%	24%
		New product entrepreneurial activity	40%	29%	26%	24%
			45%	34%	26%	26%
		Scientific journal articles	77%	79%	78%	77%

Source: European Commission Joint Research Centre (2019).
Note: The values are the squared Pearson correlation coefficients, expressed as percentages (n = 125 countries). Cells with coefficients less than 10% are in a lighter shade.

Table 3

Distribution of differences between pillar and GTCI rankings

	GTCI INPUT SUB-INDEX				GTCI OUTPUT SUB-INDEX	
Rank differences	Enable	Attract	Grow	Retain	Vocational and Technical Skills	Global Knowledge Skills
More than 30 positions	5%	21%	8%	2%	2%	7%
20 to 29 positions	6%	17%	9%	9%	8%	14%
10 to 19 positions	22%	18%	17%	21%	35%	21%
10 or more positions*	**33%**	**57%**	**34%**	**33%**	**45%**	**42%**
5 to 9 positions	27%	21%	22%	27%	23%	31%
Less than 5 positions	33%	20%	38%	34%	25%	26%
0 positions	7%	2%	6%	7%	7%	1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Pearson correlation coefficient with the GTCI	0.96	0.86	0.95	0.95	0.95	0.92

Source: European Commission Joint Research Centre (2019).
Note: * This row is the sum of the prior three rows.

Table 4

Distribution of differences between the GTCI 2019 and other international rankings

Rank differences with respect to the GTCI 2019	2018 Global Innovation Index (Cornell, INSEAD, and WIPO)	2017–2018 Global Human Capital Index (World Economic Forum)	2017–2018 Global Competitiveness Index (World Economic Forum)
More than 30 positions	6%	5%	8%
20 to 29 positions	15%	21%	8%
10 to 19 positions	23%	23%	22%
10 or more positions*	**44%**	**49%**	**38%**
5 to 9 positions	25%	27%	23%
Less than 5 positions	25%	21%	36%
0 positions	5%	3%	3%
Total	**100%**	**100%**	**100%**
Countries in common with the GTCI	115	115	124

Source: European Commission Joint Research Centre (2019).
Notes: The comparison between the GTCI and the other indices was based on the common set of countries. *This row is the sum of the prior three rows.

index and has been flagged in the JRC's audits since 2014, and the variables 2.2.5 Gender earnings gap and 3.1.3 Tertiary education expenditure were already flagged as not statistically important in last year's report. That said, and given that these five variables are influential at the first and second aggregation levels (sub-pillars and pillars), their inclusion in the GTCI framework is corroborated by the analysis. The JRC recommendation to the GTCI development team is to carefully monitor how these five variables behave in the coming releases of the index and eventually to fine-tune the framework in this respect.

3. Added Value of the GTCI

A very high statistical reliability among the main components of an index can be the result of redundancy of information. This is not the case in the GTCI. In fact, the overall GTCI 2019 ranking differs from any of the six pillar rankings by 10 positions or more in at least one-third of the 125 countries included in the 2019 edition, peaking at 57% of the countries in the case of the Attract pillar (see Table 3). This is a desired outcome because it evidences the added value of the GTCI ranking, which helps to highlight other components of human capital and talent competitiveness that do not emerge directly by looking into the six pillars separately. At the same time, this result also points towards the value of duly taking into account the individual pillars, sub-pillars, and variables on their own merit. By doing so, country-specific strengths and bottlenecks in human capital and talent competitiveness can be identified and serve as an input for evidence-based policymaking.

In addition, we compared the GTCI 2019 with both the World Economic Forum's 2017–2018 Global Competitiveness Index and the Human Capital Index, and with Cornell University, INSEAD, and WIPO's 2018 Global Innovation Index. After having extracted data from both projects' websites, we find that the rank correlation between GTCI 2019 with all three indices is substantially high (correlation ≈ 0.9), which suggests that the GTCI framework has many aspects in common with the frameworks on global innovation, global competitiveness, and human capital. Looking at the shifts in rankings (see Table 4), we nevertheless

find that 38%, 49%, and 44% of the countries included in the GTCI 2019 that feature in the other three indices differ in ranking by more than 10 positions when comparing the GTCI 2019 with, respectively, the 2017–2018 Global Competitiveness Index, the 2017 Global Human Capital Index, and the 2018 Global Innovation Index. This indicates that the GTCI 2019 offers additional insights into nations' human capital and competitiveness compared to the three other international indices.

Step 4: Qualitative Review

Finally, the GTCI results, including overall country classifications and relative performances in terms of the Input and Output sub-indices, were evaluated by the development team and external experts to verify that the overall results are, to a great extent, consistent with current evidence, existing research, or prevailing theory.

Notwithstanding these statistical tests and the positive outcomes regarding the statistical soundness of the GTCI, it is important to mention that the GTCI has to remain open to future improvements as better data, more comprehensive surveys and assessments, and new relevant research studies become available.

IMPACT OF MODELLING ASSUMPTIONS ON THE GTCI RESULTS

Every country score on the overall GTCI and its two sub-indices depends on modelling choices: the six-pillar structure, the selected variables, the imputation or not of missing data, and the weights and aggregation method, among other elements. These choices are based on expert opinion (e.g., selection of variables) or common practice (e.g., min-max normalisation in the [0,100] range) and driven by statistical analysis (e.g., treatment of outliers) or simplicity (e.g., no imputation of missing data). The robustness analysis is aimed at assessing the simultaneous and joint impact of these modelling choices on the rankings. The data are assumed to be error-free since potential outliers and any errors and typos were corrected during the computation phase.

As suggested in the relevant literature on composite indicators,[9] the robustness assessment of the GTCI was based on a combination of a Monte Carlo experiment and a multi-modelling approach that dealt with three issues: pillar weights, missing data, and the aggregation formula. In general, the uncertainty analysis aims to respond to some extent to possible criticisms that the country scores associated with aggregate measures are generally not calculated under conditions of certainty, even though they are frequently presented as such.

While the term *multi-modelling* refers to testing alternative assumptions—that is, alternative aggregation methods and missing data estimation methods—the Monte Carlo simulation explored the issue of weighting and comprised 1,000 runs, each corresponding to a different set of weights for the six pillars, randomly sampled from uniform continuous distributions centred in the reference values. 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 the GTCI that places equal importance on all six pillars. Given these considerations, the limit values of uncertainty intervals for the pillar weights are 15% to 35% for the four Input pillars for the calculation of the Input sub-index, and 40% to 60% for the two Output pillars for the calculation of the Output sub-index (see Table 5). For the calculation of the GTCI, the limit values of uncertainty intervals for all six pillar weights are 12% to 20%. In all simulations, sampled weights are rescaled so that they always sum to 1.

The GTCI development team, for transparency and replicability, opted not to estimate the missing data (only 4.8% of data were missing in the data set of 125 countries for all 68 variables). The 'no imputation' choice, which is common in similar contexts, might encourage countries not to report low data values. The consequence of the 'no imputation' choice in an arithmetic average is that it is equivalent to replacing an indicator's missing value for a given country with the respective sub-pillar score. Hence the available data (indicators) in the incomplete pillar may dominate, sometimes biasing the ranks up or down. To test the impact of this assumption, the JRC also estimated missing data using the Expectation Maximisation (EM) algorithm.[10]

Regarding the aggregation formula, decision-theory practitioners have challenged the use of simple arithmetic averages because of their fully compensatory nature, in which a comparatively high advantage for a few variables can compensate for a comparative disadvantage for many variables.[11] Despite the arithmetic averaging formula receiving statistical support for the development of the GTCI, as discussed in the previous section, the geometric average was considered as a possible alternative. This is a partially compensatory approach that rewards countries with similar performance in all pillars; it motivates those countries with uneven performance to improve in those pillars in which they perform poorly, and not just in any pillar.

Four models were tested based on the combination of no imputation versus EM imputation, and arithmetic versus geometric average, combined with 1,000 simulations per model (random weights versus fixed weights), for a total of 4,000 simulations for the GTCI and each of the two sub-indices (see Table 5 for a summary of the uncertainties considered in the GTCI 2019).

Uncertainty Analysis Results

The main results of the robustness analysis are shown in Figures 1a–1c, with median ranks and 90% confidence intervals computed across the 4,000 Monte Carlo simulations for the GTCI and the two sub-indices. Countries are ordered from best to worst according to their reference rank (black line), the dot being the simulated median rank. Error bars represent, for each country, the 90% interval across all simulations. Table 6 reports the published rankings and the 90% confidence intervals that account for uncertainties in the missing data estimation, the pillar weights, and the aggregation formula. All published country ranks lay within the simulated intervals, and these are narrow enough for most countries (less than or equal to 10 positions) to allow for meaningful inferences to be drawn.

GTCI ranks are shown to be both representative of a plurality of scenarios and robust to changes in the imputation method, the pillar weights, and the aggregation formula. If one considers the median rank across the simulated scenarios as being

Table 5

Uncertainty analysis for the GTCI 2019: Weights, missing data, and aggregation

		REFERENCE	ALTERNATIVE
I. Uncertainty in the treatment of missing values		**No estimation of missing data**	**Expectation Maximisation (EM)**
II. Uncertainty in the aggregation formula at pillar level		**Arithmetic average**	**Geometric average**
III. Uncertainty in the weights			
GTCI sub-index	Pillar	Reference value for the weight (within the sub-index)	Distribution assigned for robustness analysis (within the sub-index)
Input	Enable	0.25	U[0.15,0.35]
	Attract	0.25	U[0.15,0.35]
	Grow	0.25	U[0.15,0.35]
	Retain	0.25	U[0.15,0.35]
Output	Vocational and Technical Skills	0.50	U[0.40,0.60]
	Global Knowledge Skills	0.50	U[0.40,0.60]

Source: European Commission, Joint Research Centre (2019).

representative of these scenarios, then the fact that the GTCI rank is close to the median rank (differing by two positions or less) for 89% of the countries suggests that the GTCI is a suitable summary measure. Furthermore, the narrow confidence intervals for the majority of the countries' ranks (less than or equal to 10 positions for 95% of the countries) imply that the GTCI ranks are also, for the vast majority of the countries, robust to changes in the pillar weights, the imputation method, and the aggregation formula.

Results for the Input and Output sub-indices are also robust and representative of the plurality of scenarios considered. The Input rank is close to the median rank (less than or equal to two positions away) for 97% of the countries, and the rank intervals are less than or equal to 10 positions for 86% of the countries. Similarly, the Output rank is close to the median rank (less than or equal to two positions away) for 84% of the countries, and the rank intervals are less than or equal to 10 positions for 90% of the countries.

Overall, country ranks in the GTCI and its two sub-indices are fairly robust to changes in the pillar weights, the imputation method, and the aggregation formula for the majority of the countries considered. For full transparency and information, Table 6 reports the GTCI country ranks (and those of the sub-indices) together with the simulated intervals (90% of the 4,000 scenarios) in order to better appreciate the robustness of these ranks to the computation methodology.

Sensitivity Analysis Results

Complementary to the uncertainty analysis, sensitivity analysis has been used to identify which of the modelling assumptions have the highest impact on certain country ranks. Figure 2 plots the GTCI and both sub-index rankings versus one-at-a-time changes of either the EM imputation method or the geometric aggregation formula (assuming equal weights for the six pillars as in the GTCI).

The most influential methodological assumption turns out to be the choice of geometric aggregation versus arithmetic aggregation (given that a lower rank correlation indicates greater sensitivity). This choice has the largest impact on differences in ranking for the GTCI 2019 and the Output sub-index; it has less impact on differences for the Input sub-index. For example, in the most extreme case, Gambia falls by 15 positions in the Output ranking when geometric aggregation is applied, yet the country increases by four positions if missing data are imputed. Note, however, that these assumptions concern methodological choices only and might overall be less influential than choices related to the background assumptions in the conceptual framework.[12]

Overall, given the fairly modest ranges of uncertainty in the final rankings, the JRC recommendation is not to alter the GTCI methodology at this point, but to consider country ranks in the GTCI 2019 and in the Input and Output sub-indices within the 90% confidence intervals, as reported in Table 6, in order to better appreciate to what degree a country's rank depends on the modelling choices. It is reassuring that, for an overwhelming majority of the countries included in the GTCI, their ranks in the overall GTCI 2019 and the Input and Output sub-indices are the result of the underlying data and not of modelling choices.[13]

CONCLUSIONS

The European Institute of Business Administration INSEAD released the sixth edition of the Global Talent Competitiveness Index (GTCI) with a view to attracting attention to the growing challenges of talent attraction, development, and retention faced by countries worldwide. The JRC statistical audit has investigated the workings of the GTCI framework to assess the statistical properties of the data and the methodology used in the index construction. The JRC analysis suggests that the conceptualised multi-level structure of the GTCI 2019 is statistically coherent and balanced (i.e., not dominated by any pillar or sub-pillar; all variables contribute to the variation of the respective Input/Output sub-indices and to the overall GTCI). Furthermore, the analysis has offered statistical justification for the use of equal weights and arithmetic averaging at the various levels of aggregation, showing that the GTCI is statistically reliable in its current form as the simple average of the six pillars (as measured by a

Figure 1a

Robustness analysis (GTCI rank vs. median rank, 90% confidence intervals)

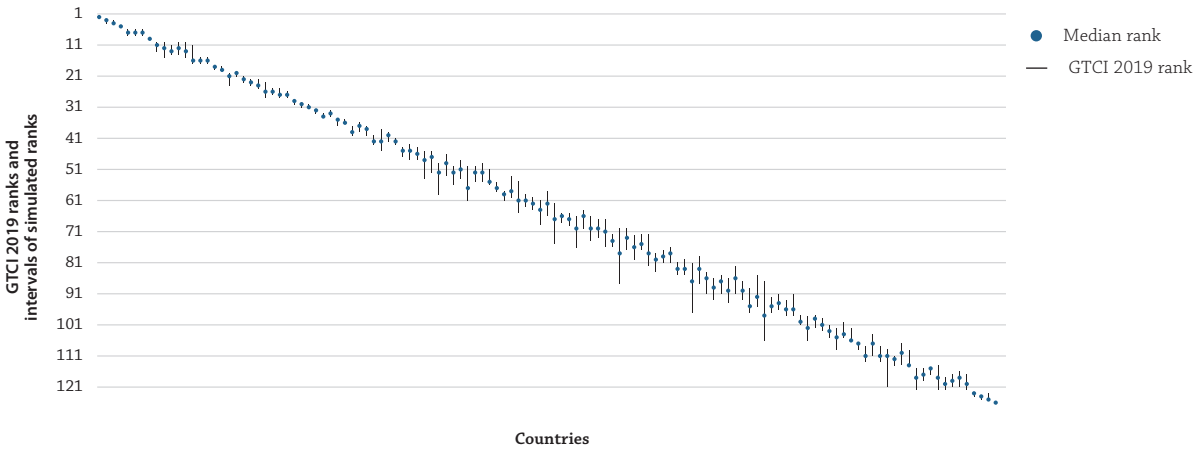


Figure 1b

Robustness analysis (Input rank vs. median rank, 90% confidence intervals)

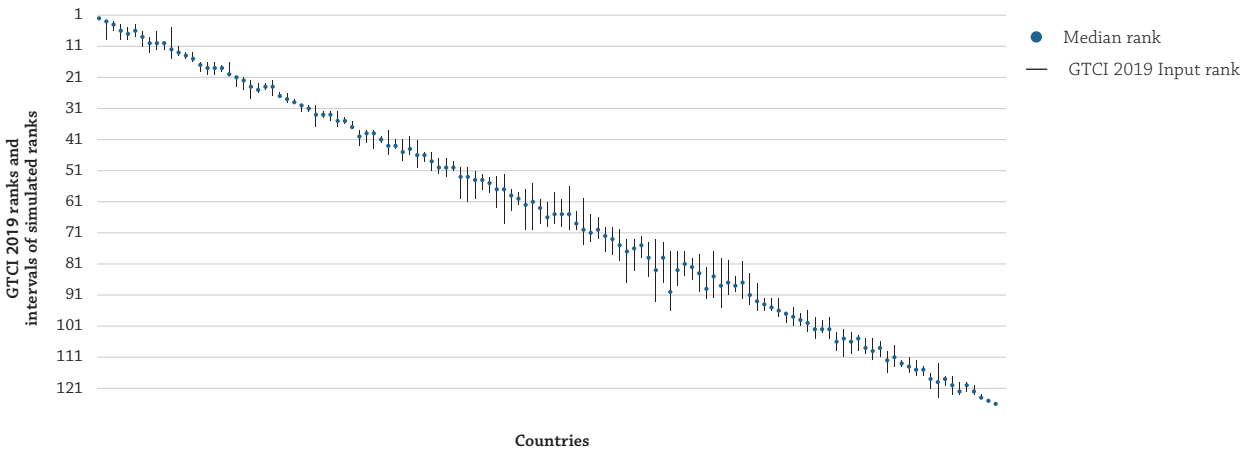
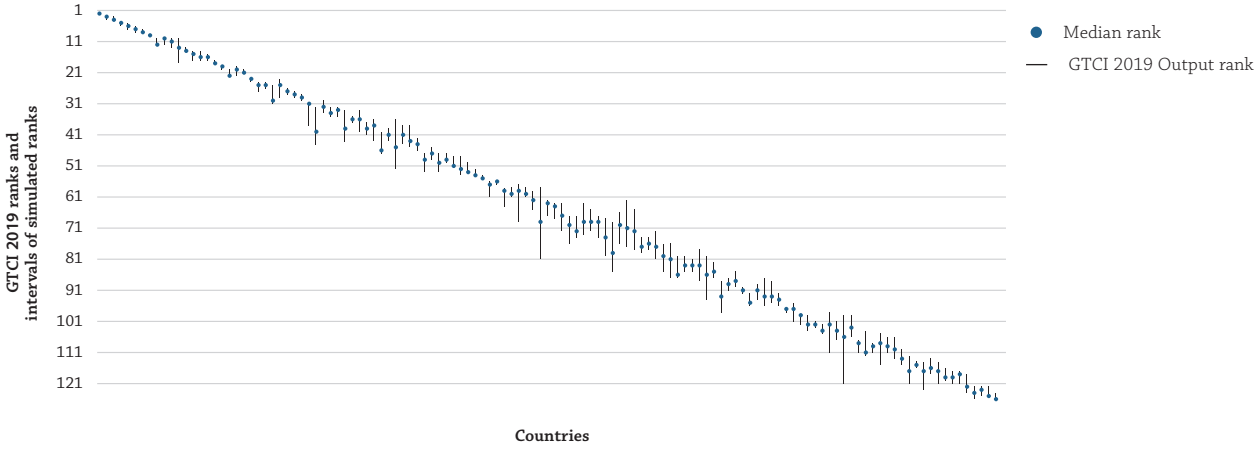


Figure 1c

Robustness analysis (Output rank vs. median rank, 90% confidence intervals)



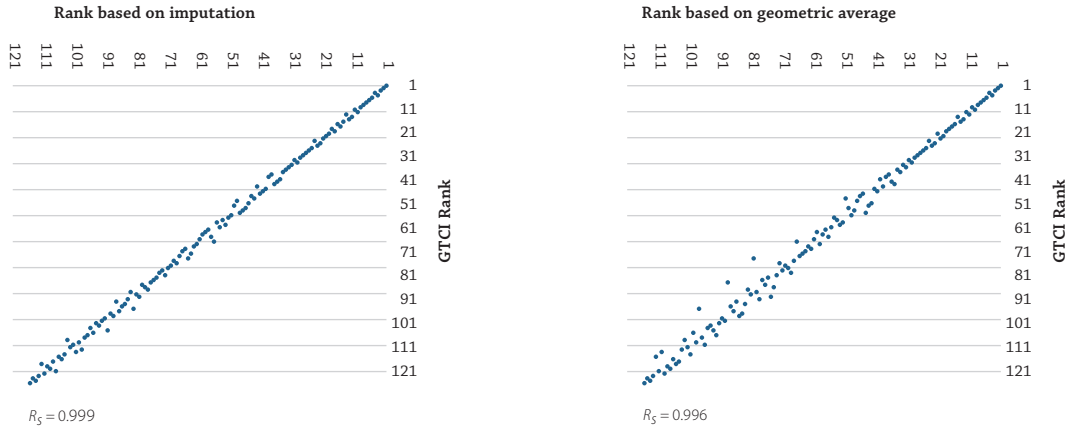
Source: European Commission Joint Research Centre (2019).

Notes: The Spearman rank correlation between the median rank and the GTCI 2019 rank is 0.999 (n = 125); between the median rank and the GTCI 2019 Output rank it is 0.998; and between the median rank and the GTCI 2019 Input rank it is 0.999. Median ranks and intervals are calculated over 4,000 simulated scenarios combining random weights, imputation versus no imputation of missing values, and geometric versus arithmetic average at the pillar level.

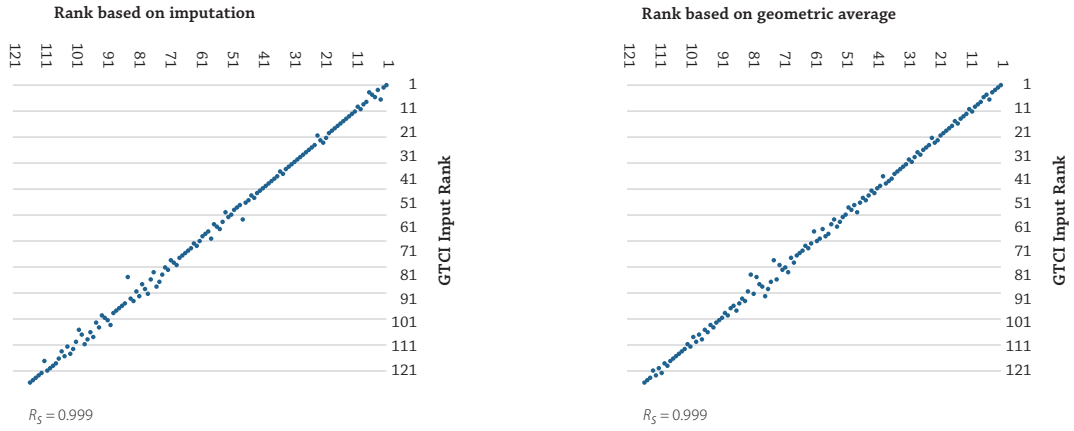
Figure 2

Sensitivity analysis: Impact of modelling choices

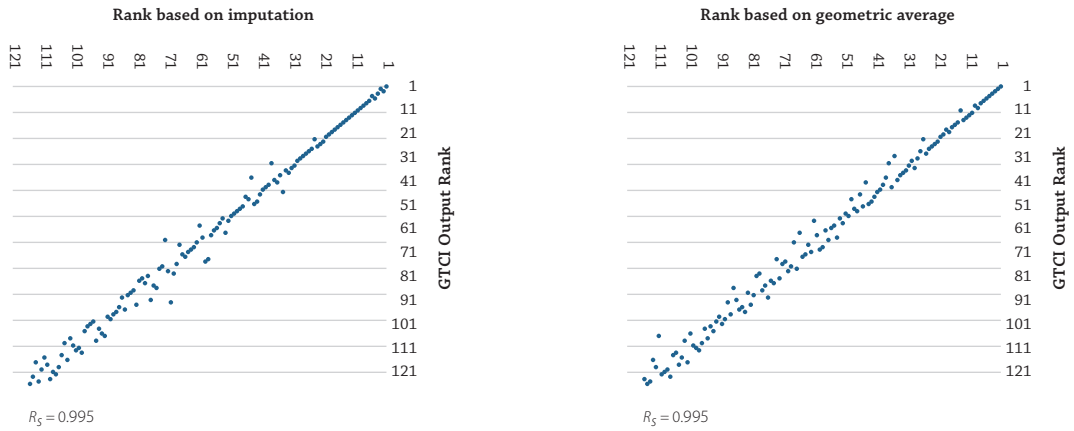
Global Talent Competitiveness Index 2019



GTCI Input Sub-Index 2019



GTCI Output Sub-Index 2019



Source: European Commission Joint Research Centre (2019).
Note: R_S represents the Spearman rank correlation coefficient (n = 125).

Table 6

Country ranks and 90% confidence intervals for the GTCI 2019 and its Input/Output sub-indices

COUNTRY	GTCI 2019		INPUT SUB-INDEX		OUTPUT SUB-INDEX	
	RANK	INTERVAL	RANK	INTERVAL	RANK	INTERVAL
Switzerland	1	[1, 1]	1	[1, 1]	1	[1, 1]
Singapore	2	[2, 3]	2	[2, 8]	3	[2, 3]
United States of America	3	[2, 3]	4	[3, 8]	2	[2, 3]
Norway	4	[4, 4]	3	[2, 5]	6	[5, 7]
Denmark	5	[5, 7]	5	[4, 8]	7	[6, 7]
Finland	6	[5, 7]	8	[7, 12]	4	[4, 5]
Sweden	7	[5, 7]	6	[3, 7]	8	[8, 8]
Netherlands	8	[8, 8]	7	[5, 10]	9	[9, 11]
United Kingdom	9	[9, 12]	10	[9, 11]	15	[13, 16]
Luxembourg	10	[9, 14]	11	[4, 14]	16	[14, 16]
New Zealand	11	[10, 13]	9	[5, 11]	17	[16, 17]
Australia	12	[9, 13]	12	[10, 13]	13	[12, 13]
Iceland	13	[9, 14]	18	[16, 18]	5	[4, 6]
Germany	14	[10, 16]	14	[12, 15]	12	[9, 17]
Canada	15	[14, 16]	13	[12, 14]	14	[13, 16]
Ireland	16	[14, 16]	15	[15, 18]	10	[9, 11]
Belgium	17	[17, 18]	17	[15, 19]	18	[18, 19]
Austria	18	[17, 18]	16	[15, 19]	19	[19, 21]
United Arab Emirates	19	[19, 23]	19	[15, 19]	25	[24, 30]
Israel	20	[19, 20]	25	[21, 26]	11	[9, 12]
France	21	[20, 22]	22	[21, 27]	21	[19, 20]
Japan	22	[21, 23]	21	[20, 24]	22	[22, 23]
Estonia	23	[21, 24]	26	[25, 26]	20	[18, 21]
Qatar	24	[22, 27]	20	[20, 23]	30	[30, 37]
Czech Republic	25	[24, 26]	24	[22, 24]	28	[26, 28]
Malta	26	[24, 27]	23	[22, 25]	29	[27, 29]
Malaysia	27	[25, 27]	27	[25, 28]	23	[23, 26]
Portugal	28	[28, 29]	28	[27, 28]	32	[29, 33]
Slovenia	29	[29, 30]	33	[31, 34]	27	[25, 27]
Korea, Rep.	30	[29, 30]	34	[31, 36]	26	[22, 28]
Spain	31	[31, 32]	29	[29, 31]	39	[35, 42]
Chile	32	[32, 33]	32	[31, 33]	36	[34, 36]
Cyprus	33	[31, 33]	38	[37, 41]	24	[23, 25]
Costa Rica	34	[34, 36]	30	[29, 31]	48	[46, 52]
Lithuania	35	[34, 35]	35	[33, 35]	43	[37, 43]
Brunei Darussalam	36	[36, 39]	39	[37, 43]	31	[31, 43]
Latvia	37	[35, 38]	40	[39, 41]	34	[31, 34]
Italy	38	[36, 39]	41	[37, 45]	33	[31, 34]
Saudi Arabia	39	[39, 42]	37	[37, 42]	46	[46, 52]
Bahrain	40	[37, 44]	31	[29, 36]	59	[56, 68]
Slovakia	41	[38, 41]	42	[40, 43]	41	[38, 42]
Poland	42	[40, 42]	46	[44, 47]	38	[36, 40]
Azerbaijan	43	[43, 46]	48	[46, 51]	42	[35, 51]
Greece	44	[42, 47]	49	[46, 52]	45	[41, 45]
China	45	[43, 47]	45	[40, 49]	53	[51, 53]
Uruguay	46	[44, 53]	36	[34, 36]	83	[80, 84]
Mauritius	47	[44, 51]	44	[39, 45]	57	[57, 63]
Oman	48	[48, 58]	43	[40, 47]	74	[61, 76]
Russian Federation	49	[45, 52]	61	[54, 69]	37	[32, 39]
Trinidad and Tobago	50	[49, 55]	50	[47, 50]	55	[55, 60]
Montenegro	51	[47, 53]	59	[57, 61]	40	[39, 46]
Panama	52	[49, 60]	47	[44, 50]	67	[66, 73]
Hungary	53	[49, 54]	56	[52, 62]	50	[47, 50]
Bulgaria	54	[48, 54]	54	[51, 56]	52	[49, 52]
Croatia	55	[50, 55]	60	[56, 69]	47	[44, 48]
Kazakhstan	56	[54, 57]	58	[56, 63]	54	[53, 54]
Jordan	57	[57, 60]	55	[52, 57]	60	[57, 60]
Philippines	58	[52, 59]	66	[55, 69]	51	[47, 53]
Lebanon	59	[54, 64]	81	[76, 87]	35	[32, 42]
Argentina	60	[58, 62]	53	[50, 59]	68	[62, 72]
Armenia	61	[59, 63]	75	[72, 82]	49	[46, 49]
Botswana	62	[60, 68]	52	[49, 60]	80	[75, 86]
Ukraine	63	[57, 65]	84	[77, 89]	44	[37, 44]

Table 6 *(continued)*

Country ranks and 90% confidence intervals for the GTCI 2019 and its Input/Output sub-indices

COUNTRY	GTCI 2019		INPUT SUB-INDEX		OUTPUT SUB-INDEX	
	RANK	INTERVAL	RANK	INTERVAL	RANK	INTERVAL
Kuwait	64	[61, 74]	57	[51, 67]	82	[79, 84]
Colombia	65	[64, 67]	65	[59, 68]	65	[62, 71]
Thailand	66	[64, 68]	63	[60, 68]	73	[65, 75]
Indonesia	67	[65, 75]	64	[57, 67]	72	[68, 84]
Serbia	68	[63, 69]	76	[71, 78]	56	[55, 56]
Romania	69	[65, 73]	71	[68, 76]	61	[58, 64]
Mexico	70	[66, 72]	70	[65, 72]	70	[66, 73]
South Africa	71	[66, 75]	73	[69, 79]	58	[57, 60]
Brazil	72	[71, 75]	62	[59, 67]	86	[81, 86]
Rwanda	73	[69, 87]	51	[49, 59]	100	[100, 102]
Turkey	74	[69, 76]	72	[68, 77]	75	[64, 77]
Albania	75	[71, 79]	67	[63, 69]	85	[79, 93]
Georgia	76	[71, 76]	74	[72, 86]	64	[62, 67]
Mongolia	77	[71, 81]	82	[76, 84]	62	[57, 80]
Namibia	78	[77, 83]	68	[59, 74]	94	[87, 94]
Peru	79	[76, 80]	83	[78, 85]	66	[66, 75]
India	80	[75, 80]	79	[73, 86]	77	[73, 77]
Tajikistan	81	[80, 84]	91	[83, 93]	71	[67, 79]
Sri Lanka	82	[79, 84]	88	[79, 90]	79	[75, 84]
Bhutan	83	[80, 96]	69	[64, 73]	102	[97, 110]
Tunisia	84	[78, 87]	95	[91, 97]	63	[61, 66]
Kenya	85	[83, 90]	87	[78, 94]	89	[84, 89]
Bosnia and Herzegovina	86	[85, 92]	92	[86, 95]	81	[79, 86]
Ecuador	87	[84, 90]	90	[79, 91]	88	[86, 90]
Guatemala	88	[85, 93]	77	[73, 84]	96	[96, 97]
Moldova	89	[81, 90]	93	[91, 95]	78	[71, 80]
Dominican Republic	90	[86, 92]	85	[81, 91]	90	[89, 91]
Lao PDR	91	[88, 96]	80	[76, 95]	97	[94, 100]
Viet Nam	92	[84, 94]	89	[84, 89]	93	[86, 95]
Gambia	93	[86, 105]	78	[72, 92]	104	[98, 120]
Ghana	94	[91, 96]	86	[76, 91]	99	[98, 103]
Kyrgyzstan	95	[90, 95]	101	[98, 102]	76	[73, 78]
Egypt	96	[92, 97]	100	[97, 104]	84	[77, 87]
Iran, Islamic Rep.	97	[90, 97]	104	[101, 110]	69	[64, 71]
Honduras	98	[97, 100]	99	[95, 102]	98	[98, 101]
Nigeria	99	[97, 105]	108	[104, 111]	87	[87, 97]
Morocco	100	[97, 101]	96	[96, 99]	105	[98, 105]
Paraguay	101	[98, 102]	98	[96, 100]	103	[100, 106]
Senegal	102	[100, 104]	97	[94, 100]	106	[106, 110]
Nicaragua	103	[101, 108]	94	[91, 95]	117	[113, 120]
Zambia	104	[99, 104]	102	[97, 104]	101	[101, 104]
Algeria	105	[101, 105]	111	[106, 113]	91	[91, 95]
El Salvador	106	[106, 108]	106	[103, 108]	112	[109, 114]
Cambodia	107	[107, 112]	103	[102, 108]	120	[116, 120]
Pakistan	108	[103, 110]	114	[111, 116]	95	[91, 95]
Uganda	109	[107, 112]	105	[102, 109]	118	[115, 119]
Lesotho	110	[108, 120]	109	[105, 110]	115	[113, 122]
Tanzania, United Rep.	111	[110, 113]	107	[104, 109]	119	[116, 120]
Venezuela, Bolivarian Rep.	112	[106, 113]	117	[112, 123]	92	[88, 93]
Cameroon	113	[108, 113]	113	[110, 115]	107	[103, 111]
Liberia	114	[114, 121]	110	[108, 115]	123	[121, 124]
Malawi	115	[114, 118]	112	[111, 113]	121	[117, 123]
Mali	116	[114, 116]	115	[113, 116]	114	[113, 115]
Ethiopia	117	[113, 121]	116	[115, 120]	116	[112, 117]
Bangladesh	118	[117, 121]	118	[116, 119]	113	[111, 120]
Madagascar	119	[116, 120]	120	[118, 122]	110	[105, 110]
Nepal	120	[115, 120]	121	[118, 121]	108	[107, 110]
Zimbabwe	121	[116, 121]	122	[119, 122]	111	[105, 112]
Mozambique	122	[122, 123]	119	[116, 122]	125	[123, 125]
Burundi	123	[123, 124]	123	[122, 123]	122	[121, 125]
Congo, Dem. Rep.	124	[122, 124]	124	[124, 124]	109	[104, 114]
Yemen	125	[125, 125]	125	[125, 125]	124	[121, 124]

Source: European Commission, Joint Research Centre (2019).

very high Cronbach's alpha value of 0.97, well above the recommended 0.70 threshold for a reliable aggregate).

Points that call for possible refinements of the GTCI framework were also identified. These refinements mainly concern five out of the 68 variables, namely 1.3.1 Ease of hiring, 1.3.2 Ease of redundancy, 2.2.5 Gender earnings gap, 3.1.3 Tertiary education expenditure, and 3.2.2 Prevalence of training in firms. Although conceptually enriching the GTCI framework, and in most cases the statistical impact of these variables reaches the second aggregation level (the GTCI pillars), their impact on the GTCI ranking is low and can explain only a small (negligible) amount of variation in the GTCI scores. It is recommended that the GTCI development team delve into the formulation of these five indicators and to carefully monitor how they behave in the coming releases of the index, and eventually to fine-tune the GTCI framework in this respect.

On the whole, the analysis of the correlations at the sub-pillar level reveals that the statistical structure of the GTCI is coherent with its conceptual framework, given that sub-pillars correlate strongly with their respective pillars. Furthermore, all pillars correlate strongly and fairly evenly with the GTCI itself, which indicates that the framework is well balanced.

The GTCI and both sub-index country ranks are relatively robust to methodological assumptions related to the estimation of missing data, weighting, and aggregation formula. It is reassuring that for a large majority of the countries included in the GTCI, the overall rank and those in the Input and Output sub-indices are the result of the underlying data and not of the modelling choices. Consequently, inferences can be drawn for most countries in the GTCI, although some caution may be needed for a few countries.[14] Note that perfect robustness would have been undesirable because this would have implied that the GTCI components are perfectly correlated and hence redundant, which is not the case for the GTCI 2019. In fact, one way in which the GTCI helps to highlight other components of human capital and talent competitiveness is by pinpointing the differences in rankings that emerge from a comparison between the GTCI and each of the six pillars: the GTCI ranking differs from any of the six pillar rankings by 10 positions or more for at least one-third (up to almost 60%) of the countries. This outcome both evidences the added value of the GTCI ranking and points to the importance of taking into account the individual pillars, sub-pillars, and variables on their own merit. By doing so, country-specific strengths and bottlenecks in human capital and talent competitiveness can be identified and serve as an input for evidence-based policymaking.

The auditing conducted herein has shown the potential of the Global Talent Competitiveness Index 2019, subject to some minor hints for future releases, for reliably identifying weaknesses and best practices and ultimately monitoring national performance in human capital and competitiveness issues around the world. Readers and policy analysts should hence go beyond the overall GTCI scores and ranks and duly take into account the individual indicators and pillars on their own merit. By doing so, country-specific strengths and challenges in attracting, developing, and retaining talent can be identified and serve as an input for data-informed policy analysis. The Global Talent Competitiveness Index cannot possibly serve as the ultimate and definitive yardstick of monitoring progress and performance on talent and competitiveness. Instead, the GTCI best represents an ongoing attempt by INSEAD to contribute to policy discussions on the very many challenges that national systems face in a world that is increasingly dependent on talent, continuously adapting the GTCI framework to reflect improved and new data sources and the theoretical advances on how to leverage talent as a tool for competitiveness.

ENDNOTES

1 The JRC analysis was based on the recommendations of the OECD & EC JRC (2008) *Handbook on Constructing Composite Indicators* and on more recent research from the JRC. The JRC auditing studies of composite indicators are available at http://composite-indicators.jrc.ec.europa.eu/ (all audits were carried out upon request of the index developers).

2 OECD & EC JRC (2008).

3 Compared to last year, eight new countries were added in the GTCI 2019: Brunei Darussalam, Burundi, Cameroon, Democratic Republic of Congo, Liberia, Nigeria, Tajikistan, and Zambia, while two countries are not included this year: Bolivia and the Former Yugoslav Republic of Macedonia.

4 Groeneveld & Meeden (1984) set the criteria for absolute skewness above 1 and kurtosis above 3.5. The skewness criterion was relaxed herein to account for the small sample (125 countries).

5 Only in one of the 14 sub-pillars is there a second principal component with an eigenvalue slightly above the 1.0 threshold: 2.2 Internal Openness (eigenvalue of 1.07). However, this eigenvalue is not statistically higher than 1.0 according to the bootstrapping hypothesis testing. This suggests that relevant information is not lost when directly aggregating the variables into the Internal Openness sub-pillar.

6 See Nunnally (1978).

7 See Becker et al. (2017) and Paruolo et al. (2013) for discussions on why the weights assigned to the variables do not necessarily coincide with the variables' importance in an index.

8 If the five variables that were not found to be sufficiently influential at the index level—1.3.1 Ease of hiring, 1.3.2 Ease of redundancy, 2.2.5 Gender earnings gap, 3.1.3, Tertiary education expenditure, and 3.2.2 Prevalence of training in firms—were deleted from the GTCI framework, the differences with the current GTCI ranking would be three positions or less for about 85% of the countries.

9 Saisana et al. (2005), (2011); Saisana & Saltelli (2011); Saltelli et al. (2008); Vértesy (2016); Vértesy & Deiss (2016).

10 The Expectation-Maximization (EM) algorithm (Little & Rubin, 2002) is an iterative procedure that finds the maximum likelihood estimates of the parameter vector by repeating two steps: (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. (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.

11 Munda (2008).

12 Saltelli & Funtowicz (2014).

13 As already mentioned in the uncertainty analysis, about 89% of the simulated median ranks for the GTCI and 97% for the Input sub-index are less than two positions away from the reported 2019 rank—this percentage drops only to 84% in the Output sub-index.

14 Caution is needed when drawing inference on the relative standing of the following countries vis-a-vis other countries because of the very wide range of the confidence intervals, of almost 20 positions or more: Gambia's rank in the GTCI—with a rank confidence interval range of [86, 105], and in the Input and Output sub-indices with a confidence interval range of [72, 92] and [98, 120], respectively—and Mongolia's rank in the Output sub-index [57, 80].

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