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## The global index of female entrepreneurship systems

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# **APPENDIX**

## **The Global Index of Female Entrepreneurship Systems**

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## APPENDIX 1: STRUCTURE AND DESCRIPTION OF FEMALE ENTREPRENEURSHIP INDEX 2024 COMPONENTS

Variable	Source	Webpage	Indicator Name	1st Period	2nd Period	Notes on 1st Period	Notes on 2nd Period
Economic freedom	The Heritage Foundation	<a href="https://indexdotnet.azurewebsites.net/index/download#">https://indexdotnet.azurewebsites.net/index/download#</a>	Business freedom	2019	2022		Puerto Rico: 2020 data
Property rights	The Heritage Foundation	<a href="https://indexdotnet.azurewebsites.net/index/download#">https://indexdotnet.azurewebsites.net/index/download#</a>	Property rights	2019	2022		Puerto Rico: 2020 data
Tertiary education	World Bank	<a href="https://data.uis.unesco.org/">https://data.uis.unesco.org/</a>	School enrollment, tertiary (% gross)	2019	2021	Venezuela: 2009 data for both periods Sudan: 2015 data for both periods Peru: 2017 data for both periods Puerto Rico: 2018 data for both periods Saudi Arabia: 2017 data for both periods Ecuador: 2020 Egypt: 2018 Ireland: 2020 Netherlands: 2018 Panama: 2020	Venezuela: 2009 data for both periods Sudan: 2015 data for both periods Peru: 2017 data for both periods Puerto Rico: 2018 data for both periods Saudi Arabia: 2017 data for both periods Angola: 2019 Guatemala: 2020 Iran: 2020 Japan: 2020 Kazakhstan: 2020 Russian Federation: 2019 Togo: 2020 United Arab Emirates: 2020
Quality of education	World Bank	<a href="https://www.wipo.int/publications/en/series/index.jsp?id=129">https://www.wipo.int/publications/en/series/index.jsp?id=129</a>	Education (Global Innovation Index 2.1)	2019	2022	Angola: 2022 data used for both periods Sudan 2012 data used for both periods Venezuela 2012 data used for both periods Macro region data available for Puerto Rico and Taipei,China	Sudan 2012 data used for both periods Venezuela 2012 data used for both periods Macro region data available for Puerto Rico and Taipei,China
Economy risk	Organisation for Economic Co-operation and Development	<a href="https://www.oecd.org/trade/topics/export-credits/arrangement-and-sector-understandings/financing-terms-and-conditions/country-risk-classification/">https://www.oecd.org/trade/topics/export-credits/arrangement-and-sector-understandings/financing-terms-and-conditions/country-risk-classification/</a>	Economy risk classification	2019	2022	Chile: 2014 data for both periods	Chile: 2014 data for both periods
Urbanization	World Bank	<a href="https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS">https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS</a>	Urban population (% of total population)	2019	2022	Taipei,China: 2020 data for both periods	Taipei,China: 2020 data for both periods
Infrastructure	World Bank	<a href="https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI">https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI</a>	Global Competitiveness Index 2nd pillar: infrastructure	2019	2019	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017
Corruption	Transparency	<a href="https://www.transparency.org/en/cpi/2022">https://www.transparency.org/en/cpi/2022</a>	Corruption Perceptions Index	2019	2022	Puerto Rico: 2014 data for both periods	Puerto Rico: 2014 data for both periods
Taxation	The Heritage Foundation	<a href="https://indexdotnet.azurewebsites.net/index/download#">https://indexdotnet.azurewebsites.net/index/download#</a>	Tax burden	2019	2022		Puerto Rico: 2020 data
Good governance	World Bank	<a href="https://www.worldbank.org/en/publication/worldwide-governance-indicators#home">https://www.worldbank.org/en/publication/worldwide-governance-indicators#home</a>	Government effectiveness	2019	2022		

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Variable	Source	Webpage	Indicator Name	1st Period	2nd Period	Notes on 1st Period	Notes on 2nd Period
Tech absorption	United Nations Conference on Trade and Development	<a href="https://unctadstat.unctad.org/datacentre/dataviewer/US.FTRI">https://unctadstat.unctad.org/datacentre/dataviewer/US.FTRI</a>	Industry activity	2019	2021	Macro region data available for Puerto Rico and Taipei,China	No data for Puerto Rico and Taipei,China and no macro region data
Labor freedom	The Heritage Foundation	<a href="https://indexdotnet.azurewebsites.net/index/download#">https://indexdotnet.azurewebsites.net/index/download#</a>	Labor freedom	2019	2022		Puerto Rico: 2020 data
Staff training	World Bank	<a href="https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI">https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI</a>	Extent of staff training	2019	2019	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017
Regulation	World Bank	<a href="https://www.worldbank.org/en/publication/worldwide-governance-indicators#home">https://www.worldbank.org/en/publication/worldwide-governance-indicators#home</a>	Regulatory quality	2019	2022		
Market dominance	World Bank	<a href="https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI">https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI</a>	Extent of market dominance	2019	2022	Puerto Rico: 2014 data for both periods Belarus: 2021 Macro region data available for Sudan, Togo for 2017	Puerto Rico: 2014 data for both periods Taipei,China: 2019 Venezuela: 2019 Macro region data available for Sudan, Togo for 2017
Technology transfer	World Bank	<a href="https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI">https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI</a>	Innovation pillar	2019	2019	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017
Gross domestic expenditure on research and development	UNESCO	<a href="https://data.uis.unesco.org/index.aspx?queryid=74#">https://data.uis.unesco.org/index.aspx?queryid=74#</a>	Gross domestic expenditure on research and development as a percentage of gross domestic product	2019	2021	Angola: 2016 data for both periods Ecuador: 2014 data for both periods Jordan: 2016 data used for both periods Madagascar: 2017 data for both periods Morocco: 2010 data for both periods Puerto Rico: 2015 data for both periods Sudan: 2005 data for both periods Togo: 2014 data for both periods Venezuela: 2016 data for both periods Malaysia: 2018 Qatar: 2018 Saudi Arabia: 2020 Macro region data available for Dominican Republic; Lebanon; and Taipei,China	Angola: 2016 data for both periods Ecuador: 2014 data for both periods Jordan: 2016 data used for both periods Madagascar: 2017 data for both periods Morocco: 2010 data for both periods Puerto Rico: 2015 data for both periods Sudan: 2005 data for both periods Togo: 2014 data for both periods Malaysia: 2020 Australia: 2019 Brazil: 2020 Chile: 2020 Colombia: 2020 India: 2020 Indonesia: 2020 Iran: 2019 South Africa: 2020 Tunisia: 2019 Macro region data available for Dominican Republic; Lebanon; and Taipei,China

Continued on the next page

Variable	Source	Webpage	Indicator Name	1st Period	2nd Period	Notes on 1st Period	Notes on 2nd Period
Scientific institutions	World Bank	<a href="https://www.wipo.int/publications/en/series/index.jsp?id=129">https://www.wipo.int/publications/en/series/index.jsp?id=129</a>	Average of scientific and technical articles/\$ billion purchasing power parity gross domestic product, and Quacquarelli Symonds university ranking, top 3	2019	2022	Angola: 2022 data for both periods Sudan: 2012 data for both periods, university ranking own calculation Venezuela: 2012 data for both periods, university ranking own calculation Macro region data available for Taipei,China and Puerto Rico university ranking own calculation	Sudan: 2012 data for both periods, university ranking own calculation Venezuela: 2012 data for both periods, university ranking own calculation Macro region data available for Taipei,China and Puerto Rico university ranking own calculation.
Availability of scientists	World Bank	<a href="https://www.wipo.int/publications/en/series/index.jsp?id=129">https://www.wipo.int/publications/en/series/index.jsp?id=129</a>	Researchers, full-time equivalent/million people	2019	2021	Armenia: 2008 data (headcount) data for both periods Peru: 2004 data (headcount) data for both periods Sudan: 2005 data (headcount) data for both periods Venezuela: 2009 data (headcount) data for both periods Israel: 2017 data for both periods Saudi Arabia: 2021 Belarus: 2021 No data available for: Dominican Republic; Puerto Rico; Taipei,China; and Lebanon	Armenia: 2008 data (headcount) data for both periods Peru: 2004 data (headcount) data for both periods Sudan: 2005 data (headcount) data for both periods Venezuela: 2009 data (headcount) data for both periods Australia: 2019 Burkina Faso: 2019 Israel: 2017 data for both periods No data available for: Dominican Republic; Puerto Rico; Taipei,China; and Lebanon
Venture capital	World Bank	<a href="https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI">https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI</a>	Venture capital	2019	2019	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017
Business strategy	World Bank	<a href="https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI">https://prosperitydata360.worldbank.org/en/dataset/WEF+GCI</a>	Business dynamism	2019	2019	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017	Puerto Rico: 2014 data for both periods Macro region data available for Sudan, Togo, Belarus for 2017
Economic complexity	Atlas (Harvard)	<a href="https://atlas.cid.harvard.edu/rankings">https://atlas.cid.harvard.edu/rankings</a>	Economic Complexity Index	2019	2021	Sudan: 2022 data for both periods Taipei,China: 2020 data for both periods Puerto Rico: 2023 data for both periods Luxembourg: No data --> avg of Belgium and Netherlands	Sudan: 2022 data for both periods Taipei,China: 2020 data for both periods Puerto Rico: 2023 data for both periods Luxembourg: No data --> avg of Belgium and Netherlands
Depth of capital market	IESE	<a href="https://blog.iese.edu/vcpeindex/">https://blog.iese.edu/vcpeindex/</a>	Capital market	2019	2022	Macro region data available for Iran, Puerto Rico, Sudan, Togo for 2021	Macro region data available for Iran, Puerto Rico, Sudan, Togo for 2021

Source: Authors' compilation.

## APPENDIX 2: DESCRIPTION OF INDIVIDUAL AND INSTITUTIONAL VARIABLES IN FEMALE ENTREPRENEURSHIP INDEX 2024

Pillar Name	Description
Opportunity perception	Refers to the entrepreneurial opportunity perception potential of the population, and weights this against the freedom of the economy and property rights.
Startup skills	Captures the perception of startup skills in the population and weights this aspect with the quality of education.
Risk acceptance	Captures the inhibiting effect of fear of failure of the population on entrepreneurial action, combined with a measure of the economy's risk.
Networking	Combines two aspects of networking: (i) a proxy of the ability of potential and active entrepreneurs to access and mobilize opportunities and resources and (ii) the ease of access to reach each other.
Cultural support	Combines how positively a given economy's inhabitants view entrepreneurs in terms of status and career choice and how the level of corruption in that economy affects this view.
Opportunity startup	Captures the prevalence of individuals who pursue potentially better-quality opportunity-driven startups (as opposed to necessity-driven startups) weighted with the combined effect of taxation and government quality of services.
Technology absorption	Reflects the technology intensity of an economy's startup activity combined with an economy's capacity for firm-level technology absorption.
Human capital	Captures the quality of entrepreneurs as weighing the percentage of startups founded by individuals with higher than secondary education with a qualitative measure of the propensity of firms in a given economy to train their staff combined with the freedom of the labor market.
Competition	Measures the level of the product or market uniqueness of startups combined with the market power of existing businesses and business groups as well as with the effectiveness of competitive regulation.
Product innovation	Captures the tendency of entrepreneurial firms to create new products weighted by the technology transfer capacity of an economy.
Process innovation	Captures the use of new technologies by startups combined with gross domestic expenditure on research and development and the potential of an economy to conduct applied research.
High growth	Represents a combined measure of (i) the percentage of high-growth businesses that intend to employ at least 10 people and plan to grow more than 50% in 5 years, (ii) the availability of venture capital, and (iii) business strategy sophistication.
Internationalization	Captures the degree to which an economy's entrepreneurs are internationalized, as measured by businesses' exporting potential weighted by the level of economic complexity of the economy.
Risk capital	Combines two measures of finance: (i) informal investment in startups and (ii) a measure of the depth of the capital market. Availability of risk capital is to fulfill growth aspirations.

Source: Acs, Autio, and Szerb (2019).

### APPENDIX 3: INDEX CONSTRUCTION

The Female Entrepreneurship Index (FEI) scores for all the economies are calculated according to the following nine points (Acs, Autio, and Szerb 2019, pp. 40–44).

1. **Selection of indicators.** Selection starts with indicators that are sourced directly from the original data for each economy involved in the analysis. These indicators can be at the individual level (personal or business) from the Global Entrepreneurship Monitor (GEM) Adult Population Survey or (APS) at the institutional/environmental level from various other sources. Altogether, 16 individual indicators and 23 institutional indicators are used.
2. **Calculation of variables.** In most cases, the indicators are also used as variables. However, two cases in the individual variables and eight cases in the institutional variables contain two or three indicators. The computation of these variables is as follows:

$$\text{Carrier Status}_i = \text{Carrier}_{i,l} * \text{Status}_{i,l} \quad (1a)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$\text{Informal Investment Mean}_i = \text{Business Angel}_{i,l} * \text{Informal Investment}_{i,l} \quad (1b)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$\text{Freedom}_i = \text{Economic Freedom}_{i,l} * \text{Property Rights}_{i,l} \quad (1c)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$\text{Education}_i = \text{Tertiary Education}_{i,l} * \text{Quality of Education}_{i,l} \quad (1d)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$\text{Connectivity}_i = \text{Urbanization}_{i,l} * \text{Infrastructure}_{i,l} \quad (1e)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$\text{Governance}_i = \text{Taxation}_{i,l} * \text{Good Governance}_{i,l} \quad (1f)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$\text{Labor Markt}_i = \text{Labor Freedom}_{i,l} * \text{Staff Training}_{i,l} \quad (1g)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$\text{Competitiveness}_i = \text{Regulation}_{i,l} * \text{Market Dominance}_{i,l} \quad (1h)$$

for all  $l = 1, 2$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$Science_i = Gerd_{i,l} * Scientific\ Institutions_{i,l} * Availability\ of\ Scientists_{i,l} \quad (1i)$$

for all  $l = 1, 2, 3$  the number of individual indicators

$i = 1 \dots k$ , the number of economies

$$Finance\ and\ Strategy_i = Venture\ Capital_{i,l} * Busienss\ Strategy_{i,l} \quad (1j)$$

for all  $l = 1, 2$  the number individual indicators

$i = 1 \dots k$ , the number of economies

- 3. Construction of pillars.** All pillars are calculated from the variables using the interaction variable method—that is, by multiplying the individual variable with the proper institutional variable.

$$z_{i,j} = IND_{i,j} * INS_{i,j} \quad (2)$$

for all  $j = 1 \dots p$ , the number of individual, institutional variables, and pillars

$IND_{i,j}$  is the original score value for economy  $i$  and variable  $j$  individual variable

$INS_{i,j}$  is the original score value for economy  $i$  and variable  $j$  institutional variable

$z_{i,j}$  is the calculated pillar value for economy  $i$  and pillar  $j$

- 4. Capping.** All index building is based on a benchmarking principle. We selected the 95th percentile score adjustment, meaning that any observed values higher than the 95th percentile are lowered to the 95th percentile. For the 128 economies in the dataset, we use the benchmarks values from the full dataset.
- 5. Normalization.** Pillar values were first normalized to a range from 0 to 1, according to equation (3):

$$x_{i,j} = \frac{z_{i,j}}{\max z_{i,j}} \quad (3)$$

for all  $j = 1 \dots p$ , the number of pillars

where  $x_{i,j}$  is the normalized score value for economy  $i$  and pillar  $j$

$\max z_{i,j}$  is the maximum value for pillar  $j$

- 6. Average pillar adjustment.** The different averages of the normalized values of the indicators imply that reaching the same indicator values requires different effort and resources. Since we want to apply the FEI for public policy purposes, the additional resources for the same marginal improvement of the indicator values should be the same for all indicators. Therefore, we need a transformation to equalize the average values of the components. Equation (4) shows the calculation of the average value of pillar  $j$ :

$$\bar{x}_j = \frac{\sum_{i=1}^n x_{i,j}}{n} \quad \text{for all } j \quad (4)$$

We want to transform the  $x_{i,j}$  values such that the potential minimum value is 0 and the maximum value is 1:

$$y_{i,j} = x_{i,j}^k \quad (5)$$

where k is the “strength of adjustment,” the k-th moment of  $x_j$  is exactly the needed average,  $\bar{y}_j$

We have to find the root of the following equation for k:

$$\sum_{i=1}^n x_{i,j}^k - n\bar{y}_j = 0 \quad (6)$$

It is easy to see, based on previous conditions and derivatives, that the function is decreasing and convex, which means it can be solved quickly using the well-known Newton-Raphson method with an initial guess of 0. After obtaining k, the computations are straightforward. Note that if

$$\bar{x}_j < \bar{y}_j \quad k < 1$$

$$\bar{x}_j = \bar{y}_j \quad k = 1$$

$$\bar{x}_j > \bar{y}_j \quad k > 1$$

then k is thought of as the strength (and direction) of adjustment. The adjusted pillar values are calculated for all the 2017–2022 time period. These values and this distribution are applied for the 128 economies in the FEI 2024 edition. It means the average adjusted pillar values of the economies that participated in the 2017–2022 GEM cycle are exactly the same in the 2017–2022 dataset and in the 2024 FEI edition.

7. **Penalizing.** After these transformations, the Penalty for Bottleneck (PFB) methodology was used to create indicator-adjusted PFB values. We define our penalty function as follows:

$$h_{(i),k} = \min y_{(i),k} + (1 - e^{-y_{(i),k} - \min y_{(i),k}}) \quad (7)$$

where  $h_{i,j}$  is the modified, post-penalty value of pillar j in economy i

$y_{i,j}$  is the normalized value of index component j in economy i

$y_{min}$  is the lowest value of  $y_{i,j}$  for economy i

$i = 1, 2, \dots, n$  = the number of economies

$j = 1, 2, \dots, p$  = the number of pillars

8. **The pillars are the basic building blocks of the subindex** (entrepreneurial attitudes, entrepreneurial abilities, and entrepreneurial aspirations). The value of a subindex for any economy is the arithmetic average of its PFB-adjusted pillars for that subindex, multiplied by 100. The maximum value of the subindices is 100, and the potential minimum is 0, both of which reflect the relative position of an economy in a particular subindex.

$$ATT_i = 100 \sum_{j=1}^5 \frac{h_j}{5} \quad (8a)$$

$$ABT_i = 100 \sum_{j=6}^9 \frac{h_j}{4} \quad (8b)$$

$$ASP_i = 100 \sum_{j=10}^{14} \frac{h_j}{5} \quad (8c)$$

where  $h_{i,j}$

is the modified, post-penalty value of pillar  $j$  in economy  $i$

$i = 1, 2, \dots, n$  = the number of economies

$j = 1, 2, \dots, p$  = the number of pillars

9. **The super index**, the FEI, is simply the average of the three subindices. Since 100 represents the theoretically available limit, the FEI points can also be interpreted as a measure of the efficiency of the entrepreneurship resources.

$$FEI_i = 1/3(ATT_i + ABT_i + ASP_i) \quad (9)$$

where  $i = 1, 2, \dots, n$  = the number of economies

**Missing variables and data imputations.** Since the individual data are provided by the GEM, participation in the GEM survey determines the potential list of economies and sample size. However, there is another potential limitation—that is, the availability of institutional data. The World Economic Forum ceased the publication of the Global Competitiveness Report (GCR) after 2020. However, a significant portion of the GCR indicators used in the Global Entrepreneurship Index are derived from expert opinion surveys. There are no other international datasets that ask these specific questions and are available for as many economies as the GCR. Therefore, we decided to use the latest available data (2019). If a specific institutional variable was not available for a given economy, the missing value was substituted with the macro-regional data.