Engineering X

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Methodology:
Global Engineering Capability Review

The Global Engineering Capability Review derived insights from:

- The Engineering Index 2019 (the Index);

- Forecasts of sectoral GDP growth; and

- Country case studies.

The methodologies used to create the Index, forecasts and case studies are discussed below.

Literature review for the Engineering Index 2019

As a first step in developing the methodology for the Index, The Economist Intelligence Unit (EIU) conducted a review of policy documents, academic literature, and other studies on measuring engineering strength across the world. The aim of this literature review was to identify existing frameworks, indicators and data sources for key aspects of engineering capability that could be used to develop this new benchmarking tool.

The EIU developed a framework for the Index based on the literature review and input from the Royal Academy of Engineering Programme Board and Lloyd's Register Foundation.

Engineering Index 2019

Adapting previous work conducted by the Centre for Economics and Business Research (CEBR), the Index measures **the extent to which countries are able to conduct key engineering activities in a safe and innovative way**. All indicators used in this Index are quantitative and were selected based on the following criteria:

- Data availability: All datasets are publicly available;

- Country coverage: Datasets cover at least 60% of countries;

- Relevance: Indicators measure the specific research question; and

- Indicator balance: Indicators are balanced across categories (i.e. no less than two indicators per category, and no more than five in any one category).

Index domains and focus areas

The Index 2019 focuses on six categories:

1 Knowledge: A measure of a country's contribution to and advancement of knowledge in engineering technology;

2. Labour force: The availability and diversity of engineers in the economy;

3. Engineering industry: The strength and sophistication of the engineering industry;

4. Infrastructure: The ability of infrastructure to support and demonstrate domestic engineering activities;

5. Digital infrastructure: The ability of digital infrastructure to support and demonstrate domestic engineering activities; and

6. Safety standards: Safety in engineering-intensive sectors.

Indicator list

Category	Category Description	Indicators	Source
Knowledge	A measure of contribution to and advancement of knowledge in engineering and technology.	• H index ranking (number of citations and number of papers in engineering) • R&D spending (% GDP) • Number of universities in the top 500 for engineering • Resident patent applications	Scimago, UNESCO, Times Higher Education, World Bank, OECD PISA
Labour force	Availability and diversity of engineers in the economy	• Availability of scientists and engineers • Graduates in engineering, manufacturing and construction programmes • Female graduates in engineering, manufacturing and construction programmes • Mean performance in science among 15-year olds • Mean performance in mathematics among 15-year olds	WEF, UNESCO
Engineering industry	Strength and sophistication of the engineering industry	• Medium to large companies in engineering fields, as a percentage of all medium to large companies in the country • Total value of engineering exports ($): Product: 84 – machinery, mechanical appliances, nuclear reactors, boilers; parts thereof. Product: 85 – electrical machinery and equipment and parts thereof; sound recorders and reproducers • Medium- and high-tech industry (including construction) (% manufacturing value added) • Economic Complexity Index	Orbis database, Trademap.org, World Bank (UNIDO), MIT
Infrastructure	Ability of infrastructure to support and demonstrate engineering activities	• Quality of infrastructure • Extent and quality of road network • Extent and quality of rail network • Quality of ports' infrastructure • Quality of air transport infrastructure	WEF, EIU Business and Environment Rankings
Digital infrastructure	Ability of digital infrastructure to support and demonstrate engineering activities	• Number of servers per 1 million people • Internet speed (average) • Digital Adoption Index	World Bank, Speedtest
Safety standards	Safety in engineering intensive sectors	• Number of injuries (fatal) per 100,000 in economic activities: mining and quarrying, manufacturing, electricity, water supply and construction. • UL Safety Index – safety outcomes	ILO, UL

Construction of the scores

Normalisation

Indicator scores are normalised and then aggregated across categories to enable a comparison of broader concepts across countries. Normalisation rebases the raw indicator data to a common unit so that it can be aggregated. All indicators in this model are normalised to a 0-100 scale, where 100 indicates the best performance and 0 represents the worst.

Indicators are transformed on the basis of a min/max normalisation, based on the following formula:

$x = (x - Min(x)) / (Max(x) - Min(x)) *100$

where Min(x) and Max(x) are, respectively, the lowest and highest values in the 99 countries, for indicators in which the highest/lowest-scoring countries among the 99 are representative of the highest/lowest-scoring countries globally.

Weightings

The role of weightings in an index is to reflect the importance attached to each category and/or indicator. As a default, equal weight was attached to each category of the Index and each indicator within each category.

Methodology for missing data

When designing the Index, The EIU made every effort to ensure data availability and minimise the impact of data gaps. Where data was missing, we developed the following standard approach for filling the gaps.

We first clustered countries by income level, according to World Bank classifications: high, upper-middle, lower-middle and low income. We then calculated the average score for each indicator by country income level (e.g. average number of servers / 1m people for upper-middle-income countries) and used this figure to fill in data gaps.

In some instances, this approach did not enable us to fill in all the data gaps. For the following seven indicators, a select number of countries had no data and were therefore left "unranked".

Mean score in science performance among 15-year-olds: Armenia, Azerbaijan, Bahrain, Bangladesh, Benin, Bosnia and Herzegovina, Burundi, Ecuador, Egypt, El Salvador, Ethiopia, Ghana, Guyana, Honduras, India, Iran, Kuwait, Laos, Madagascar, Mauritius, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Nigeria, Oman, Panama, Philippines, Rwanda, Saudi Arabia, Serbia, South Africa, Sri Lanka, Ukraine	35 countries
Mean score in mathematics performance among 15-year-olds: Armenia, Azerbaijan, Bahrain, Bangladesh, Benin, Bosnia and Herzegovina, Burundi, Ecuador, Egypt, El Salvador, Ethiopia, Ghana, Guyana, Honduras, India, Iran, Kuwait, Laos, Madagascar, Mauritius, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Nigeria, Oman, Panama, Philippines, Rwanda, Saudi Arabia, Serbia, South Africa, Sri Lanka, Ukraine	35 countries
Extent and quality of rail network: Benin, Burundi, Ethiopia, Madagascar, Mozambique, Nepal, Rwanda	7 countries
Extent and quality of road network: Benin, Burundi, Ethiopia, Madagascar, Mozambique, Nepal, Rwanda	7 countries
Quality of air transport infrastructure: Benin, Burundi, Ethiopia, Madagascar, Mozambique, Nepal, Rwanda	7 countries
Quality of ports' infrastructure: Benin, Burundi, Ethiopia, Madagascar, Mozambique, Nepal, Rwanda	7 countries
Number of injuries (fatal) per 100,000 in economic activities (mining and quarrying, manufacturing, electricity, water supply and construction): Benin, Burundi, Ethiopia, Madagascar, Mozambique, Nepal, Rwanda	7 countries

For the category scores (which were weighted averages of each indicator), countries that had data for less than 80% of indicators were also left unranked and received a score of "N/A".

Labour force: Armenia, Azerbaijan, Bahrain, Bangladesh, Benin, Bosnia and Herzegovina, Burundi, Ecuador, Egypt, El Salvador, Ethiopia, Ghana, Guyana, Honduras, India, Iran, Kuwait, Laos, Madagascar, Mauritius, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Nigeria, Oman, Panama, Philippines, Rwanda, Saudi Arabia, Serbia, South Africa, Sri Lanka, Ukraine	35 countries
Infrastructure: Benin, Burundi, Ethiopia, Madagascar, Mozambique, Nepal, Rwanda	7 countries
Safety standards: Benin, Burundi, Ethiopia, Madagascar, Mozambique, Nepal, Rwanda	7 countries

Forecasting GDP growth

This section provides an overview of the steps taken to obtain sectoral GDP forecasts for 20 priority countries selected in partnership with Engineering X Programme Board and the EIU.

Sectors

The following six sectors were selected based on International Labor Organisation (ILO) classifications.

- *Agriculture*: Crop and animal production, hunting and related service activities, forestry and logging, and fishing and aquaculture.

- *Construction*: General construction and specialised construction activities for buildings and civil engineering works. This includes new work, repairs, additions and alterations, the erection of prefabricated buildings or structures on the site, and constructions of a temporary nature.

- *Manufacturing*: Physical or chemical transformation of materials, substances or components into new products.

- *Mining and utilities*:

  – *Mining and quarrying*: Extraction of minerals occurring naturally as solids (coal and ores), liquids (petroleum) or gases (natural gas).

  – *Electricity, gas and water supply*: The activity of providing electric power, natural gas, steam, hot water and the like through a permanent infrastructure network of lines, mains and pipes, as well as the operation of electric and gas utilities.

- *Trade, transportation and business administration*:

  – *Trade*: Wholesale and retail trade of any type of good and the rendering of services incidental to the sale of these goods.

  – *Transportation*: Provision of passenger or freight transport by rail, pipeline, road, water or air, and associated activities such as cargo handling, rent of transport equipment, and postal or courier activities.

  – *Accommodation and food*: Provision of short-stay accommodation for visitors and other travellers, and the provision of complete meals and drinks fit for

immediate consumption.

  – *Business and administrative services*: A variety of activities that support general business operations.

- *Public administration and other services*:

  – *Public administration*: Activities of a government nature, normally carried out by the public administration, including the enactment and judicial interpretation of laws and their pursuant regulation, the administration of programmes, legislative activities, taxation, national defence, public order and safety, immigration services, foreign affairs and compulsory social security activities.

  – *Community*: Education at any level or for any profession, oral or written, as well as by radio, television or other means of communication. This also includes the provision of health and social work activities, and activities that meet varied cultural, entertainment and recreational interests of the general public.

  – *Other services and activities*: A residual category that includes the activities of membership organisations, the repair of computers and personal and household goods, and a variety of personal service activities.

Produce GDP forecast by sector from 2019 to 2023

Our GDP forecasts use 2018 as the start year. To forecast GDP in five years across each sector, The EIU developed two economic models:

1. An econometric time series model that considers the relationship between current and historical sectoral GDP values; and

2. Linear estimates projected using moving averages of the last five years.

Using two models enables comparison and validation of results from both approaches.

Country case studies

In order to supplement desk research on each of the countries for which case studies were developed, The EIU conducted a total of **30 interviews (five per country)** between July and October 2019 with country experts.

Experts were identified based on recommendations from the Royal Academy of Engineering and The EIU's own outreach. Experts represented a wide array of backgrounds, depending on the topic in question. These include (but are not limited to):

- Academia;
- Business / industry;
- Non-governmental organisations;
- International organisations (e.g., UNICEF or the World Bank); and
- News media.

Twenty-eight interviews were conducted over the phone. For the remaining two interviews, interviewees provided written responses to interview questions.