مؤسسة محمد بن راشد آل مكتوم للمعرفة
MOHAMMED BIN RASHID AL MAKTOUM
KNOWLEDGE FOUNDATION

UNDP

GLOBAL KNOWLEDGE INDEX 2021

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FOREWORD

United Nations Development Programme

The Global Knowledge Index (GKI) continues to serve as a vital tool to monitor the knowledge status of countries in key areas including education, innovation and information and communications technology (ICT). Now covering 123 countries and 232 indicators, the 2021 GKI is helping to guide policymakers, researchers, civil society, and the private sector as they nurture knowledge-based societies and bridge knowledge gaps. In particular, the GKI shows how emerging trends in technology, learning and innovation are radically reshaping our societies. Countries must now leverage their knowledge infrastructure to open-up new opportunities in the form of jobs and livelihoods, driv-ing forward sustainable development. They must also utilise its immense potential to drive decisive climate action and spur new efforts to protect and restore our natural world. Crucially, the GKI is helping countries to identify how and where they must invest to build these cutting-edge, knowledge-based societies. Indeed, the GKI can also feed into key measurements such as UNDP's Human Development Index.

The GKI shows, for instance, how many countries in Africa need more support to address knowledge gaps in key areas like quality education, decent work, and regulatory frameworks, whilst highlighting new opportunities. Consider Mauritius, for example, where investments in ICT contribute to its strong performance on the Index. Indeed, many developing countries are demonstrating notable advances in key knowledge sectors. That includes Barbados in pre-university education; the Philippines in technical and vocational education and training; Lebanon in higher education; or Bahrain in ICT. The GKI also reflects the unprecedented wave of innovation and adoption of new technologies as countries and communities looked to find much-needed solutions to COVID-19. The United Nations (UN) is at the forefront of efforts to support this innovation surge -- everything from helping countries like Nigeria and Honduras to leverage the power of digital finance to support financial inclusion and sometimes lifesaving electronic cash transfers; to the 3-D printing of much-needed personal protective equipment for health workers, an effort assisted by the United Nations Development Programme's (UNDP) Accelerator Labs network. Indeed, the Labs are making a concerted effort to pool the world's collective intelligence to address persistent development challenges, part of efforts to help countries build knowledge-based societies.

As countries aim to build forward better from this devastating pandemic, the 2021 GKI reinforces the need for strategic South-South and triangular cooperation to narrow the gap between knowledge sectors, helping to scale-up development impact. It also recognises that 3.7 billion people remain trapped offline, unable to have their say in decisions that will affect their lives and livelihoods. Yet a worthwhile investment of $428 billion could achieve universal broadband connectivity by the end of the decade. The UN is also supporting global efforts to boost the digital capacity of vulnerable and marginalised groups, including women and persons with disabilities, so that they can play their role in shaping the future that they want.

I would like to express my sincere gratitude to His Highness Sheikh Mohammed bin Rashid Al Maktoum for his continued support to global efforts to create and sustain knowledge-based societies. I would also like to thank the many experts who contributed to the development of the Index. As we aim for the Global Goals, the UN and partners like the Mohammed bin Rashid Al Maktoum Knowledge Foundation will continue to support knowledge and scientific initiatives that are helping to both envision -- and create -- a greener, more inclusive, and more sustainable future for all.

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TABLE OF CONTENTS

GLOBAL KNOWLEDGE INDEX 2021

PREFACE

In light of various ongoing global developments—including successive scientific and technological revolutions, economic and social crises, and the health emergency induced by the spread of the COVID-19 pandemic—the race to develop knowledge to ensure competitiveness, achieve growth and sustain universal and equitable human development around the world has intensified.

The product of a joint initiative of the United Nations Development Programme (UNDP) and the Mohammed bin Rashid Al Maktoum Knowledge Foundation (MBRF) established in 2017, the Global Knowledge Index (GKI) represents a key contribution to our understanding and use of development indicators to assess contemporary knowledge and development conditions across the globe.

Given the increasing demand for indices—partly driven by the implementation of the 2030 Agenda—and the scarcity of reliable data to monitor progress in these vital areas, the GKI provides a reliable, practical and scientific tool with which to chart cognitive and developmental realities, and support effective policymaking.

The GKI comprises composite sub-indices that highlight the performance of six vital sectors: pre-university education; technical and vocational education and training; higher education; information and communications technology; research development and innovation; and the economy. It also features a composite enabling environment sub-index that captures the social, political, economic, health and environmental context across these sectors.

The previous edition of the GKI, released in 2017, has undergone a comprehensive review involving a high-level advisory board, including international experts drawn from a variety of fields directly related to the sectors of the Index. The aim of this review has been to develop the Index in line with recent changes in data type and availabil-ity. This updated version of the Index therefore employs the most recent data for 123 countries around the world available in international databases.

Full country profiles featuring interactive sectoral tables, the index's methodology and information about the variables in terms of definitions and sources can be found at www.knowledge4all.org.

SECTORAL INDICES

PRE-UNIVERSITY EDUCATION

TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING

HIGHER EDUCATION

RESEARCH, DEVELOPMENT AND INNOVATION

INFORMATION AND COMMUNICATIONS TECHNOLOGY

ECONOMY

ENABLING ENVIRONMENT

EXECUTIVE SUMMARY

INTRODUCTION

Profound contemporary global transformations—and their associated knowledge and technological revolutions—underline the central role of knowledge in achieving human development. Knowledge expands the opportunities available to individuals, empowering them to achieve socio-economic progress by developing their capabilities in a range of disciplines and sectors. It is broadly understood that no country can achieve its development goals without the support of suitable knowledge assets.

Nations around the world are racing to develop effective means and mechanisms to improve and leverage their human resources in a way that allows them to compete in a modern, globalized economy. This is especially relevant in the context of the Fourth Industrial Revolution, which emphasizes both knowledge economy and advanced technology. Therefore, countries must develop the knowledge and key skills amid an evolving environment that is driven by the intertwined effects of rapid change. While many consider only the economic effects of the Fourth Industrial Revolution, there is increasing global awareness of its profound effects on a range of areas from production, finance and business, to social, political, cultural and security systems.

Given the key relationship between knowledge and development, interest began to grow surrounding the means to measure and monitor related trends and conditions well before the concept of the Fourth Industrial Revolution arose. This is especially due to the complexity of the challenges related to achieving the sustainable development goals. The aim of such endeavours has been to chart the progress achieved toward development and humanitarian goals and identify related shortfalls. Knowledge indices are an important tool in this regard, as they allow for systematic and comprehensive assessments of the strengths and weaknesses of knowledge systems, and offer insights concerning the most appropriate means to achieve comprehensive human development.

The Global Knowledge Index (GKI) is one such instrument; by providing reliable data via its composite sectoral sub-indices, this methodological tool assists in measuring performance trends across the various elements of the knowledge system. It provides a comparison across regions and through times, highlights successful experiences, identifies the factors behind these successes, and helps direct efforts and resources to develop solutions to existing problems. As such, this tool promotes transparency by providing access to objective and accurate information, and facilitates information sharing on development policies and their outputs.

Reviewing indices: An evolutionary necessity

Indices evolve based on a process of development that is supported by periodic reviews. Such reviews are necessary to keep pace with scientific developments and ensure current challenges and concerns are reflected. Metrics and indices therefore need to be regularly updated to ensure they are both effective and sustainable. The review may investigate the structure of the index, its variables and/or the concepts upon which it is based. They are also conducted for objective reasons; for example, in response to the discontinuation of particular variables, the emergence of new variables and the presence of contextual factors that require an update to the pillars or sub-pillars of the index.

> *Development is dynamic; priorities and values shift. So should metrics. That is why the human development measurement toolkit has constantly evolved […]. The challenges we face, and the possibilities before us, have always been more complex, much more multidimensional and interconnected than a single metric—or even a handful of metrics, no matter how good—could ever capture on its own. Complexity requires more lenses. New metrics help construct them.*
>
> *Source: UNDP, 2020.*

Accordingly, in early 2021, a deep review was launched to reassess the structure of the GKI. This report represents the outcome of that review, including the most important changes and their justifications. It explains the methodological steps that were followed throughout the review and the various statistical treatments adopted to verify psychometric conditions.

About the GKI 2017

The GKI, launched at the end of 2017, sought to raise awareness of the need to create a composite index that meets the necessary methodological conditions to contribute to international efforts tracking and monitoring knowledge, and the extent to which it supports comprehensive and sustainable human development. It was built by a multidisciplinary team of academic researchers, in consultation with a broader consulting team comprising independent experts and those affiliated with specialized international bodies. The initiative was launched at a time when reliable data was scarce, national and international assessments offered widely varying indicators, and composite indices that examined interactions between different development sectors were lacking.

The GKI is a composite index consisting of seven sub-indices that highlight the performance of six sectors (pre-university education; technical and vocational education and training (TVET); higher education; research, development and innovation (RDI); information and communications technology (ICT); and economy), and a composite index of enabling environment that measures the social, political and economic contexts of those sectors. The 2017 GKI was structured as follows:

- Pre-university education sub-index, comprising two pillars: knowledge capital and educational enabling environment.
- TVET sub-index, consisting of two pillars: formation and professional training, and features of the labour market.
- Higher education sub-index, consisting of two pillars: higher education inputs, and higher education outputs and quality.
- RDI sub-index, comprising three pillars: research and development, innovation in production, and societal innovation.
- ICT sub-index, consisting of two pillars: ICT inputs and ICT outputs.
- Economy sub-index, consisting of three pillars: knowledge competitiveness, economic openness, and financing and value added.
- Enabling environment sub-index, comprising three pillars: political and institutional, socio-economic, and health and environment.

These sectors are not isolated; rather, they are interactive and integrated systems. […] The complementary nature of the variables does not mean that some replace others […]. This highlights the importance of the optimal distribution of the various elements affecting knowledge performance, which justifies assigning equal weights to the different sectors that constitute the Index. Knowledge performance is not the simple sum of the performance of each sector but rather reflects how the sectors contribute to each other to achieve the highest level of knowledge effectiveness. The performance of each sector is thus interdependent.

Source: UNDP and MBRF, 2017.

The 2021 GKI

1) Review procedure

The methodology for reviewing the GKI included the following:

- Forming an expanded consulting team, comprising academics, specialists and experts from international organizations, divided into sectoral committees according to their fields of specialization.
- Providing these specialized committees with explanatory documents concerning the conceptual and methodological construction of their respective sectoral sub-indices.
- Collecting all the suggestions of advisory board members, and then categorizing them by subject (general structure, pillars or variables) and availability. All variables were considered and assessed according to their: relevance to the sectors in question; comparability; suitability for the current context (i.e., the 2030 Agenda, the Fourth Industrial Revolution); and potential to be updated at a later date.

Controversial issues were discussed to reach consensus. These interactions facilitated agreement on the structure of the sub-indices and their variables. Despite the many alternatives that were proposed and discussed between advisory board members, data unavailability necessitated a long-term, pragmatic view when adopting relevant variables to ensure they were sustainable and covered the largest possible number of countries. The following chapters will cover in detail the discussions that took place in relation to each sub-index and present its new, agreed structure.

2) Revised GKI structure 2021

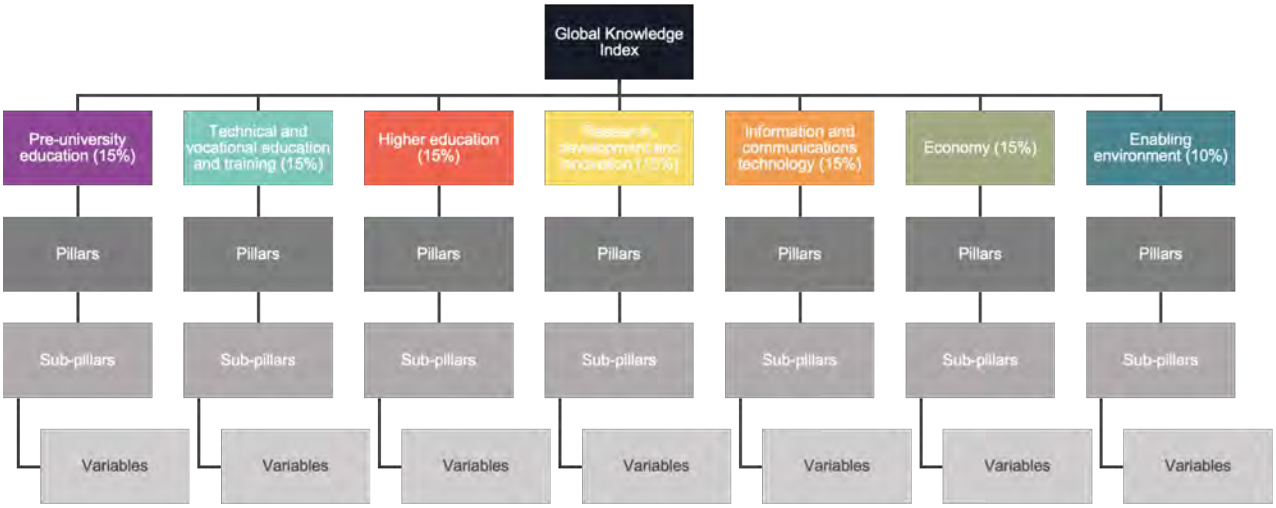
- Pre-university education sub-index, comprising two pillars: knowledge capital and educational enabling environment.
- TVET sub-index, covering two pillars: TVET components, and TVET labour market.
- Higher education sub-index, consisting of three pillars: inputs, learning environment, and outputs.
- RDI sub-index, including three pillars: inputs, outputs and impact.
- ICT sub-index, consisting of three pillars: infrastructure, access and usage.
- Economy sub-index, comprising three pillars: economic competitiveness, economic openness, and financing and domestic value added.
- Enabling environment, consisting of three pillars: governance, socio-economic, and health and environment.

STATISTICAL METHODOLOGY

As previously mentioned, the Global Knowledge Index (GKI) consists of seven sub-indices—pre-university education; technical and vocational education and training; higher education; research, development and innovation (RDI); information and communications technology (ICT); economy; and enabling environment—each of which was constructed in accordance with standard international methodologies for the design of composite indicators.[1]

The structure of the Index features a hierarchy comprising sectoral indices (referred to as sub-indices), pillars, sub-pillars and variables. Each of the six sub-indices has a weight of 15 percent, except for enabling environment, which is accorded a weight of 10 percent (Figure 1).

Figure 1: GKI structure



Selection of variables

The selection of variables included in the construction of each of the seven sub-indices was based on a clearly defined scientific methodology drawn from an extensive review of relevant local and international literature, as well as the experiences of, and concepts employed by, international organizations and agencies. It also relied on an intensive consultation process that engaged high-level advisory board members from different countries with a variety of different backgrounds and affiliations, all specialized in fields related to the sectors of the GKI. This process began with a mapping of the variables of the 2017 GKI that detailed the status of these variables (i.e. whether the variable is still reported or has been discontinued) but also assessed their methodologies and limitations. A complementary mapping exercise was undertaken to list variables capturing emerging trends that could potentially be included within the new structure of the index. Focus group meetings were also held to discuss the propositions and feedback from the advisory board, chaired by the core team members who prepared the report. Based on these discussions and focused workshops, final structures—including pillars, sub-pillars and variables— were produced.

A principal component analysis was used to confirm the consistency of the selected variables and the structure of their classification within the various sub-indices, further supporting the consistency of the broader conceptual context across the variables and sub-groups—for which the explained variance ratio in most cases exceeded 65 percent.[2]

The results of the in-depth correlation analysis and Cronbach's Alpha coefficient (exceeding 0.70 in most cases) confirmed the validity of the selection and classification of the variables. Furthermore, the correlation matrix for normalized variables was analysed to ensure that they followed the same direction as the composite index.

Data collection

The 155 variables employed in the 2021 GKI were drawn from over 40 international sources and databases including those of the United Nations Educational, Scientific and Cultural Organization (UNESCO); the World Bank; the International Telecommunication Union (ITU); the World Economic Forum (WEF); the International Monetary Fund (IMF); the Organisation for Economic Co-operation and Development (OECD); the International Labour Organization (ILO) and other United Nations agencies and international organizations. The collected data was reviewed multiple times to ensure no errors had occurred during data entry; consequently, data was processed on the assumption that it was error-free. Also, all variables were taken in relative terms, and for those not linked to other size-dependent variables—such as population or GDP—results were recalculated after adjusting for the effect of the size. Variables included are in the form of hard data, composite indicators and survey questions/responses.

The most recent data for each variable within the period 2011–2021 was used.[3] As a prerequisite, data employed in the construction of the sub-indices met certain statistical criteria. This applied to all sub-indices and for all countries. In cases where data for a variable were not available for at least half of the countries, these variables were excluded from the structure.

The methods used to identify and treat outliers, severe skewness and severe kurtosis are outlined below.

Data treatment

Skewness and kurtosis

A variable was considered to have severe skewness if its absolute skewness coefficient was above 2.25, while an absolute kurtosis coefficient above 3.5 indicated that the variable had severe kurtosis.[4] Such variables required statistical treatment before being employed.

Outliers

The value of a variable was considered an outlier if its instance fell outside the range of the specific data fence defined as follows:

$$\text{Lower bound} = \text{first quartile} - 1.5 \times \text{interquartile range}$$

$$\text{Upper bound} = \text{third quartile} + 1.5 \times \text{interquartile range}$$

By applying the rules for identifying outliers, severe skewness and/or severe kurtosis in the data of the variables, the team found 48 variables with outliers, skewness and/or sever kurtosis.

Variables with one to five outliers were Winsorized, whereby those values considered as outliers were assigned the second highest value (in the case of high values) or the second lowest value (in the case of low values) until the skewness and kurtosis were brought into acceptable ranges. In addition, variables with more than five outliers were treated using logarithmic or square root transformation. Table 1 shows the frequency distribution of these outlying variables according to the respective sub-index and the treatment used.

Table 1: Frequency distribution of GKI variables with outliers, skewness and/or kurtosis by sector and treatment

	Treatment			Frequency
	Winsorization	Transformation		
Sub-index		Logarithmic	Square root	
Pre-university education	5	-	-	5
Technical and vocational education and training	3	-	-	3
Higher education	5	-	-	5
Research, development and innovation	11	4	2	17
Information and communications technology	3	4	1	8
Economy	7	1	-	8
Enabling environment	2	-	-	2
Total	36	9	3	48

For example, in the pre-university education sub-index, within the variable 'net enrolment rate in primary education', outliers were identified and were treated using the Winsorization technique. Whereas in the information and communications technology sub-index, the two outlying variables, 'secure Internet servers per 1 million population' and 'international Internet bandwidth per user', were treated using square root and logarithmic transformations, respectively.

Normalization

The rescaling or min-max method was used for normalization, where the values of variables were normalized into the [0,100] range, in which higher values indicated better results. The normalization criterion depends on whether the variable is good (has a positive relation with the overall index) or bad (has a negative relation with the overall index).

The good variables were normalized using the following formula:

$$\text{Normalized value} = \frac{Country\ value - minimum\ sample\ value}{Maximum\ sample\ value - minimum\ sample\ value} \times 100$$

In the case of bad variables (i.e. those with an inverse relation), the formula was adjusted as follows:

$$\text{Normalized value} = \frac{Maximum\ sample\ value - country\ sample\ value}{Maximum\ sample\ value - minimum\ sample\ value} \times 100$$

For survey data or composite indices, the original series' ranges of values were retained in the form of minimum and maximum values—for instance, in the case of the [1,7] range for the World Economic Forum Executive Opinion Survey variables.

Index weighting

Weighting across the different components of the index (sub-indices, pillars and sub-pillars) was not unified; rather, it varied according to the nature of the components and their relative importance. Weightings identified for the seven constituent indices ranged from equal weighting and budget allocation to factor analysis. Equal weights were used in the absence of any clear evidence of a diversity of significance among variables, as well as in the absence of sound and complete information concerning the existence of causal relationships, or where a lack of consensus exists on a classical method for estimating weights.

The budget allocation process method was also used for weighting. A group of specialists and experienced experts were each given a budget consisting of 100 points to award to the variables. If the variable was believed

to have greater relative importance, it was allocated a greater number of points. Subsequently, the weights were calculated according to the average of the total points allocated to each variable.[5]

The weights were also assessed using factor analysis, which is based on aggregating the linked sub-indicators to form a single factor containing as much information as possible that is shared between the linked indicators. The weights produced by using both the budget allocation and factor analysis methods were consistent with each other and with the initial weight estimates, based on the intellectual and conceptual framework.

All sub-indices had equal weights across all hierarchies except for the research, development and innovation (RDI) sub-index, due to theoretical reasons outlined under the section on the RDI sub-index.

Index calculation

The 2021 GKI was calculated for 123 countries, using the most recent and reliable available data to calculate the variables for each country.

Owing to the lack of availability of data covering all the components for each country, and in view of the need to maintain a sufficient level of accuracy, the composite index was calculated in a bottom-up approach by applying a series of successive aggregations. Consequently, pillars were calculated using at least half of their sub-pillars, whereas sub-pillars required at least one variable. The availability of at least two thirds of the pillars was required to calculate the sub-index (sectoral index). The overall GKI is calculated only if data for all seven sub-indices are available.

The arithmetic aggregation formula was used to calculate all composite indicators of the Index. The composite indicator (CI) is calculated by aggregating its sub-components (SCj) as follows:

$$CI = \sum_{j=1}^{n} w_j \times SC_j$$

CI is the proposed composite indicator to be computed (sub-index, pillar or sub-pillar); wj is the relative weight of the sub-component SC (pillar, sub-pillar, or variable); and n is the number of sub-components aggregated to form the composite indicator.

PRE-UNIVERSITY EDUCATION

Introduction

Quality enhancement is a central issue in education policies around the world. Given the importance of human capital creation in achieving broader social development goals in a rapidly transforming world, it is vital that the outcomes of educational institutions remain closely aligned with the economic, social and cultural needs of countries. Hence, the performance of education systems must be continuously monitored and evaluated to ensure their development and capacity to provide quality education for all.

A growing body of literature exists concerning quality of education. Interest is no longer limited to ensuring all segments of society have equal access to education; today, the quality of education systems and the knowledge and skills they impart have also become major concerns. Global awareness regarding the importance of education quality was highlighted within the United Nations 2030 Agenda for Sustainable Development. Among the 17 goals of the Agenda is the goal to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", reflecting the understanding that obtaining a quality education "enables upward socioeconomic mobility and is a key to escaping poverty", and that bolder efforts are needed to achieve greater progress toward achieving universal education goals.[6]

In light of these global developments, it was necessary to focus attention on the adoption of systematic standards and tools that aid assessments of the quality of education systems and identify their strengths and weaknesses, therefore enabling the formulation of more effective educational policies based on reliable indicators.

> *Follow-up and review based on robust monitoring, reporting and evaluation policies, systems and tools are essential for the achievement of SDG4-Education 2030. Monitoring quality in education requires a multidimensional approach covering system design, inputs, content, processes and outcomes. As the primary responsibility for monitoring lies at the country level, countries should build up effective monitoring and accountability mechanisms, adapted to national priorities, in consultation with civil society.*
>
> *Source: UNESCO, 2016.*

In this context, the focus has shifted toward building indicators that are informed by international standards and specifications, and that support the monitoring of progress achieved by education strategies and programmes, allowing for comparisons over time in different locations or contexts. Such comparisons enable education planners and decision-makers to monitor changes in areas such as education quality and student performance. In particular, they draw attention to the effects of implemented reforms and identify emerging problems, thus highlighting individual education sub-systems that require improvement and further development.

The 2017 pre-university education sub-index

The 2017 pre-university education sub-index (spanning from pre-school education to the end of secondary education) comprised two interactive pillars: knowledge capital and educational enabling environment, with each containing several sub-pillars. The knowledge capital pillar is divided into three sub-pillars, of which two are quantitative in nature, indicating the extent to which children and young people have opportunities to attend school and complete the required years of schooling at different levels. The third relates to educational outcomes or outputs and focuses more on qualitative aspects of the education and learning process. The educational enabling environment is divided into three sub-pillars which are important for achieving quality educational outputs, according to international literature. These are expenditure on education, early childhood education, and school environment.

2021 pre-university education sub-index review

The pre-university education sub-index of the GKI was structured to act as a methodological tool for measuring performance in the various stages of the pre-university education system. Consultations with numerous experts established the significance and efficacy of this structure, while statistical analysis has revealed encouraging measures regarding the integrity, consistency and stability of its components. However, to ensure greater accuracy and structural suitability, the current review sought to enhance the sub-index in light of recent developments in the education arena. This section presents the outcomes of the review process, as well as the most important amendments applied to the previous structure of the pre-university education sub-index (2017) and their rationale. It also presents the psychometric measures and most prominent results that influenced the new structure of the sub-index.

Discussions with the advisory board centred on the following:

- Emphasizing the need to link education indicators with the indicators contained within the sustainable development goals (SDGs).
- How to measure equity and inclusiveness.
- How to reconcile two primary concerns: accounting for key variables, and ensuring that a sufficient number of countries are included to calculate pillar and sub-pillar values.
- The need to include variables relating to the educational process, while recognizing the absence of reliable information on this dimension and the consequent barriers to objective measurement.
- The varied views regarding the significance of the pupil–teacher ratio variable; while some experts view this variable as an important factor in gauging the quality of the teaching and learning process, others view it in relative terms, citing studies that show weak correlation between the number of pupils in the classroom and their academic attainment.

The revised structure and its justification

In light of the inherent difficulties of the review and amendment process—most notably the issue of data availability—the amendments focused on the following aspects:

At the pillar level, it was decided to maintain the two pillars under the same names: knowledge capital and educational enabling environment. The focus on measuring knowledge capital as one of the main outcomes of educational systems was emphasized, along with the need to include relevant contextual variables that directly impact the value and quality of educational outputs; namely, all inputs and processes that enable students to reach the desired goals. The sub-pillars were also retained and refined, and their variables reconsidered in light of changes in global data.

Therefore, the final structure of the sub-index comprises the following pillars:

The knowledge capital pillar

The knowledge capital pillar retained its existing sub-pillars: enrolment, completion and outcomes:

- The enrolment sub-pillar: employs ratios as a preliminary indicator of the extent to which countries are able to provide access to education institutions at all levels, from pre-school education to the end of secondary education. This sub-pillar includes three variables:
  - net enrolment rate in primary education;
  - net enrolment rate in lower secondary education; and
  - net enrolment rate in upper secondary education.

  The variable ‘out-of-school children and adolescents of primary and lower secondary school age’ has been omitted owing to significant high inverse correlation with the variable, ‘net enrolment rate in primary and secondary education’.

- The completion sub-pillar: Two important aspects were taken into consideration when selecting the variables for this sub-pillar: a legislative aspect related to compulsory education, and a realistic aspect related to actual completion. The previous variables related to graduation rates—which the UNESCO Institute for Statistics no longer calculates—were replaced by two variables that indicate the extent of secondary school completion. The secondary stage was chosen because it is the last stage of pre-university education; hence reaching this stage necessarily means that the previous stages were completed. The variables in this sub-pillar are as follows:
  - number of years of compulsory primary and secondary education guaranteed in legal frameworks;
  - completion rate in upper secondary education; and
  - gross intake ratio to the last grade of lower secondary education.

- Within the outcomes sub-pillar, the 'assessment of 8th grade achievement in mathematics and science' variable was omitted, while the variable, 'assessment of 15-year-old students in mathematics, science and reading', was retained. One other variable was added that relates to student learning: 'learning-adjusted years of schooling'.

A global learning metric could help bring learning centerstage, making it more salient. Such a metric would use an internationally comparable scale to consistently track progress and identify gaps across contexts. It would enable comparisons across children, households, schools and locations. Beyond its technical dividends, a global metric would motivate action and generate accountability for learning. By showing what is possible, it could point to what countries should be aspiring to—and create pressure to meet those aspirations. By benchmarking learning gaps among disadvantaged groups, a global metric could also create pressures for social mobility within countries. Furthermore, comparable learning data could increase the effectiveness of global research, international partnerships, and global aid for learning. Such data could also help countries develop their capacity for analyzing results to drive policy.

Source: World Bank, 2018.

The educational enabling environment pillar

It was agreed to retain the two sub-pillars of expenditure and early learning, and expand the scope of the third sub-pillar to become 'resources' and include other variables that relate more closely to the learning environment. Further, recognizing the increasing significance of equity and inclusiveness in international charters, and their close connection with the right to education, it was decided to include this dimension separately under a fourth sub-pillar. Below is a detailed description of the sub-pillars and their rationale:

- With regard to the expenditure sub-pillar, higher rates of enrolment in education entail increased expenditure on education, as this requires the construction of school buildings, the preparation of teachers, the provision of educational devices and aids, and other necessary services. As such, countries must spend on education to ensure its continuity and improve its internal and external efficiencies. Expenditure on education is often measured as a percentage of a country's budget or GDP. Given that expenditure on education and educational institutions in general does not accurately indicate the amounts that reach the educational process—and particularly students—the variable, 'current expenditure as a percentage of total expenditure in public institutions', was replaced with two variables relating to student spending. Accordingly, the expenditure sub-pillar includes four variables relating to different integrated aspects of government spending, as follows:

  - government expenditure on primary education (% GDP);
  - government expenditure on secondary education (% GDP);
  - government funding per primary student (% GDP per capita); and
  - government funding per secondary student (% GDP per capita).

- Concerning the resources sub-pillar, the human capital entrusted with the task of teaching is a key factor that is no less important than expenditure on education. Without highly qualified and well-trained education cadres, education goals and curricula cannot be effectively translated into reality and will remain largely theoretical. While we are certain that a proper approach to measuring this factor requires a number of variables in relation to teachers' preparation, continuous training and professional self-development, given the scarcity of data, only two variables were added in relation to the availability of trained teachers:

  - pupil–trained teacher ratio in primary education (headcount basis); and
  - pupil–trained teacher ratio in secondary education (headcount basis).

  It was suggested to add a number of variables relating to school management, including qualification and independence of school principals—such as ones that give insights on the 'percentage of principals who report on representation of teachers and department heads in the school management team', or 'percentage of principals with significant responsibility for the majority of school tasks', and 'percentage of principals who participated in at least one professional development activity in the 12 months preceding the survey', etc. However, despite their importance, these variables were not included due to the lack of reliable data or the low number of countries for which such data is available.

The professionalisation of teachers implies four dimensions of training: academic (erudite knowledge), didactic (capacity to transform erudite knowledge into knowledge to be taught), pedagogical (offer situations that are motivating and conducive to learning) and personal (behaviour, ability to listen, empathy, etc.), to which the research dimension (innovation, changing reality) can be added. This professionalisation is constantly developing, continues throughout the teacher's career and should benefit from appropriate supervision.

Source: UNESCO IIEP, 2015.

As for educational resources, the interactions that take place in the classroom, and the educational and assessment practices that are employed, are considered key factors in the success of the teaching and learning process. Examining pedagogical practices necessarily entails shedding light on the process of transferring knowledge, managing the classroom, motivating learners and catering both to individual differences and the different needs of learners. Hence, there was a need to include variables such as 'classroom hours allocated for extracurricular modules' and 'the existence of, or time allocated for, integrative modules within the school (STEAM courses, interdisciplinary courses, and project-based modules)'.

However, given the limited availability of data, the main change was to include the use of technology in the educational process, in light of the spread of information and communications technology (ICT) and their diverse uses both in and outside the classroom environment to enhance education.[7] Studies have shown a correlation between the use of ICT in school systems and improved levels of reading, mathematics and science proficiency among students. There has been increasing interest in integrating technological media in the teaching and learning process, and it has become a basic requirement in educational system reform projects, especially in light of the spread of COVID-19 and the physical restrictions imposed on schools.

First, it was sought to adopt a set of variables relating to strategies for integrating educational technologies into curricula, training teachers on using such technologies, the equipment available in schools, and availability of digital learning materials. However, given the lack of data from reliable sources on these dimensions, only four variables about the availability of computers and Internet connections in schools were included. Thereafter, based on the high correlation revealed between the availability of computers and the availability of Internet connections, only the following two variables were included:

- schools with access to computers in primary education for pedagogical purposes (%); and
- schools with access to computers in secondary education for pedagogical purposes (%).

The early learning sub-pillar was adopted as an alternative name to "early childhood education"—as in the previous index—based on agreement among the consulting team that it more effectively highlights the concept of learning (rather than that of programmes) and its role in building children's personalities and preparing them cognitively, emotionally and socially for learning in the subsequent stages of education. Since 2011, the World Bank Education Strategy 2020[8] has stressed the need to encourage early childhood learning and to ensure continuity both inside and outside the formal schooling system. UNESCO has also called for investments in early childhood development programs that include education and health, as early stimulation of intellectual development has positive long-term effects on education outcomes and future life pathways. "Research results demonstrate that early interventions for young children are essential not only for their own well-being: They also have sustainable, long-term effects on the development of human capital, social cohesion and economic success. […] It is now well understood that intervening earlier requires fewer resources and less effort; at the same time, it is more effective".[9]

This also reflects global trends and the Sustainable Development Goals. Hence, based on the above, the existing variables were reconsidered, replaced and enhanced by the addition of further variables. The agreed variables are as follows:

- gross enrolment ratio in early childhood education;
- proportion of children aged 24–59 months who are developmentally on track in terms of health, learning and psychosocial well-being;
- proportion of children under five years experiencing positive and stimulating home learning environments; and
- pupil-trained teacher ratio in pre-primary education (headcount basis).

- For the equity and inclusiveness sub-pillar it was determined that, in line with the principle of the sustainable development agenda of 'leaving no one behind', equity and inclusiveness should be given special attention. Initially, they were considered for inclusion in a third pillar in the pre-university education sub-index. There was also an agreement regarding the disparities and inequalities that require attention in terms of quantity (enrolment and completion rates) and quality (attainment). A number of significant variables were suggested in relation to the differences between students in reading, mathematics and science scores by gender, location, immigration, disability, and guaranteed level of inclusion in primary and secondary education for students with disabilities.

  However, in view of the scarcity of data and the difficulty of measuring aspects of equity in education beyond the issue of parity, this dimension was integrated into the educational enabling environment pillar. As for the variables that were considered, three main dimensions were taken into account: gender, location and wealth:
  - completion rate in upper secondary education, gender parity;
  - completion rate in upper secondary education, wealth parity; and
  - completion rate of upper secondary education, location parity.

It is very important that education systems reach all children regardless of gender, race, ability or background, not only through access to education, but through access to quality education.

Source: Arab Campaign for Education for All – ACEA, 2021. [in Arabic].

It must be noted that, given the important role of large-scale, national and international indicators in tracking the development of the learning system, and related accountability and governance measures, the revision focused on defining variables that measure or approximate these issues. Reference was made to the World Bank's Systems Approach to Achieve Learning for All,[10] and to SDG indicator 4.1.6: Administration of a nationally representative learning assessment (a) in Grade 2 or 3; (b) at the end of primary education; and (c) at the end of lower secondary education. However, the countries for which this data is available were not sufficient to allow broad coverage.

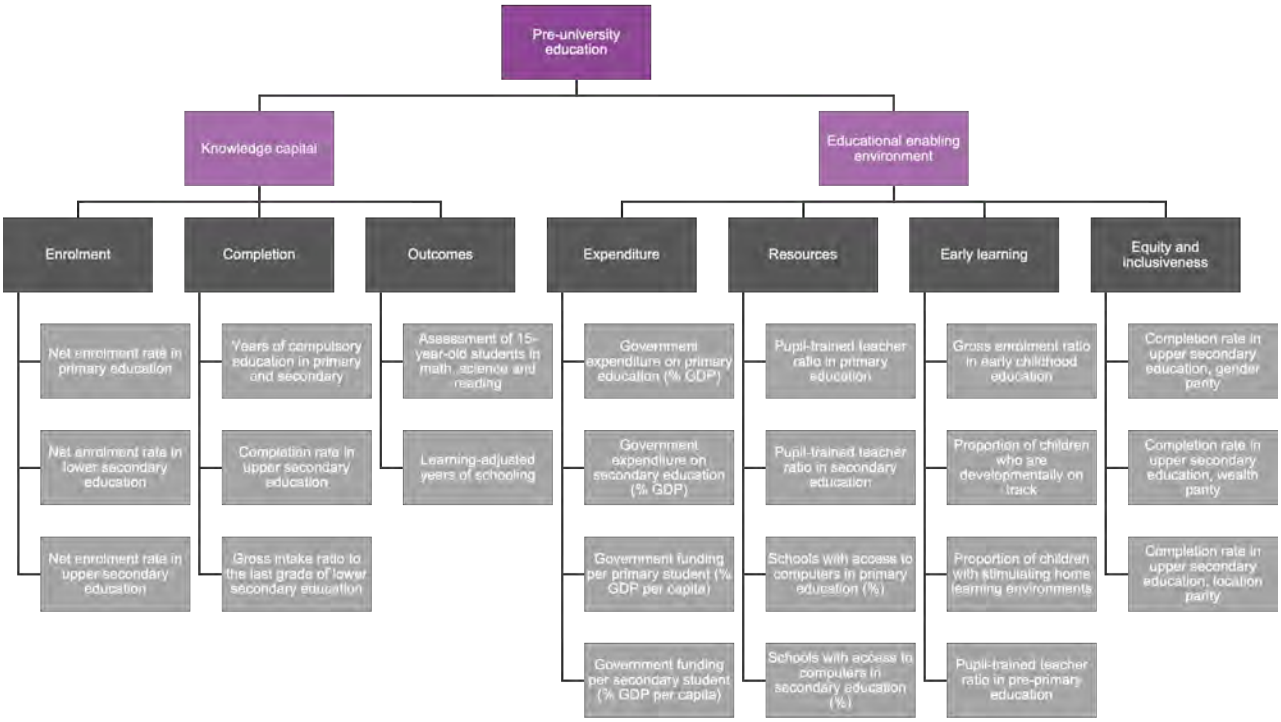
The final amendments to the pre-university education sub-index emphasize a systemic approach that places the educational system within a set of internal and external factors that ultimately determine its quality and the quality of its outcomes. This is fully consistent with UNESCO's approach,[11] which identified four main components for education systems analysis and quality measurement:

- Contextual indicators: these provide information on contextual factors affecting learning, which are often difficult to measure because they relate to qualitative issues, surveys and classroom observations.
- Indicators of favourable inputs for education: these mainly measure the deployment and use of resources to facilitate learning. They indicate whether the planned financial, material and human resources are being delivered in the prescribed quantities at all levels of the system.
- Teaching and learning indicators: these measure how the activities of educational programmes are implemented, including the practical implementation of specific educational arrangements, such as application of standards, quality of teaching, time spent on a task, school climate, and educational supervision. Similar to contextual indicators, process indicators address qualitative issues and are measured through surveys, educational observations, inspection reports and self-evaluations.
- Outcome indicators: these measure the impact of education policies and the extent to which they achieve the desired goals. They are measured using the results of national examinations, international assessments and surveys.

While indicators are developed year to year, their importance is underlined as a key contributor to the process of developing effective educational policies aimed at achieving development goals in all dimensions. At the same time, a number of challenges are highlighted in relation to the ability to benefit from these indicators in raising educational performance and improving the quality of its outputs. These challenges include, most notably:

- Collecting comparable data, which requires developing systematic surveys and enhancing the use of international classifications to ensure comprehensiveness and the standardization of concepts and sources.
- The processing methods, including correction, auditing, building statistical models, and preparing national, regional and international estimates.
- The ability to interpret data and turn them into qualitative guidelines for reform and development purposes.
- Securing channels of cooperation that help achieve integration between the indicators offered by various education stakeholders, so as to enhance the opportunities to benefit from them and avoid both duplication and wasted efforts.

Figure 2: Structure of the pre-university education sub-index



Introduction

Given the rapid developments in education and training, it is important to form a clear understanding of the various factors and variables that positively and negatively affect the nature and quality of these areas that contribute either directly or indirectly to the provision of skilled labour and qualified human capital. Given the strategic importance of countries' technical and vocational education and training (TVET) systems in building productive and cohesive communities, the use of indicators to track and monitor their strengths and weaknesses is vital, not least to provide data to inform decision makers concerned with education, training and employment policymaking. The provision of these types of data allows decision makers to compare their achievements with other countries, thus contributing to the enrichment of national experiences.

The Fourth Industrial Revolution, and the transition to green and digital economies, have created significant disparities between countries. Therefore, new sustainable approaches and methods are required to meet contemporary challenges and keep pace with relevant transformations.[12]

Various indices and indicators can play significant roles in this respect and the GKI must therefore adapt to developments by enhancing its methodology and expanding its sub-indices—particularly in the area of continuous education and training, which constitutes a key link between education systems and labour markets. The revised GKI also seeks to include new variables, where data is available in an accurate and internationally recognized scientific manner. These new variables depend mainly on values and goals such as quality, equal opportunities and equality that 2030 global education agendas seek to devote and disseminate.

One of the most important factors undermining the effectiveness of education and training programmes is the absence of rigorous, periodic statistics that enable proactive policymaking.

> *To effectively promote youth employability, it is particularly important that ALMPs [active labour market policies] are designed and oriented to meet labour market needs. This requires a participatory approach and can only succeed if employers are actively involved. […] Work experience can have a particularly positive impact on youth employability and can provide an initial link between young people and the labour market. However, the majority of companies in AMCs [Arab Mediterranean countries] are SMEs that have a very limited capacity to deliver training. […] Educational and training systems in AMCs often lack information about current labour market needs. […] While there are a multitude of initiatives to enhance this involvement, they function mainly as projects, and mechanisms for the systematic involvement of the private sector are not yet in place in most AMCs.*
>
> *Source: European Training Foundation, 2015.*

The GKI considers TVET to be an essential sector that combines training and qualifications of the human capital at the professional level and one of the most critical sectors linked to the labour market. Meeting labour market requirements and integrating them into academic courses and curricula is a complex process that is subject to the fluctuations of the economy, competitiveness and international conditions. Professions come and go rapidly, making it difficult to respond quickly to changing requirements. Proactive policy adoption is therefore required based on a long-term vision, rather than economic fluctuations.

The TVET sector is also important in the context of steady demographic growth—particularly among children and youth—which directly affects public spending and the role of the state, especially in countries with limited financial resources. Rising numbers of young people who are not in education, employment or training (NEET) could create social crises, aggravating social marginalization and exclusion, and fostering a sense of injustice among groups that are meant to be at the heart of development efforts. The provision of education and employment has become increasingly difficult and complex as lifestyles change, giving the impression that one segment of society is less fortunate than another in terms of their education, health or social rights.[13]

Some hasty diagnoses attribute the problem to the inability of education and training systems to meet the requirements of the labour market. Such conclusions require careful, objective scrutiny. International indicators in this regard prove beyond doubt that the problem is greater and deeper than previously thought. For example, the European Training Foundation[14] concludes that many countries do not have sufficient systematic arrangements to determine the skills that are in demand in local, national or international labour markets. This is one of the factors that must be addressed urgently, as it undermines the ability of education and training programmes to identify and adapt to the knowledge, skills and attitudes that citizens need to enter and advance within rapidly changing labour markets.

A careful reading of the results of studies and reports of international organizations shows a lack of balance between education and training systems and the labour market, leading to negative impacts on the TVET sector, which is often identified as the source of the problem. However, a deeper examination of the inputs and outputs of this sector, which is ineffective in many countries, confirms that this situation is not necessarily attributed to the nature of the outputs of the TVET sector alone, but goes deeper, as highlighted by international studies that look more closely at the realities of the labour market.[15]

The 2017 TVET sub-index

The TVET sub-index of the 2017 GKI featured two main pillars: 1) formation and professional training; and 2) features of the labour market.

- The formation and professional training pillar comprised two sub-pillars: continuous training and educational structure. While the continuous training sub-pillar measured the extent of staff training, local availability of specialized training services and percentage of firms offering formal training, the educational structure sub-pillar focused on expenditure, enrolment and pupil–teacher ratio.
- The second pillar of the TVET sub-index, features of the labour market, consisted of two sub-pillars. The first, qualifications of human capital, comprised variables on poor work ethic in the labour force, availability of skilled employees and technicians per thousand labour force. The second sub-pillar, structure of the labour market, comprised two variables: restrictive labour regulations and labour freedom.

These integrated variables draw a dynamic picture of the TVET system in a given country and provide a general framework for diagnosing its status, strengths and weaknesses compared to other countries.

2021 TVET sub-index review

Based on the knowledge accumulated since the first edition of the GKI, which was refined and enriched through extensive consultations with subject-matter experts, a new draft of the TVET sub-index was proposed, taking into consideration the rapid developments in this sector in terms of its relationship with the labour market and the productive environment in general.

The previous version of the TVET sub-index was reviewed through lengthy discussions among a specialized group of independent consultants and experts from relevant international organizations. The focus of discussions was as follows:

- Adopting internationally recognized levels of learning at the primary, secondary and higher levels.
- The need to include variables to measure the qualification of human capital within the labour market and the efficacy of the labour market's response to the requirements and needs of employers.
- The need to make a distinction between professional qualifications in general and those relating to the three economic sectors—i.e. primary, secondary and tertiary, where the qualifications of the secondary (manufacturing) sector are often prioritized over those of the primary (agriculture) and tertiary (services) sectors.
- The requirement for variables that measure equity and inclusiveness, both to track the dynamics of their integration in training and support efforts to combat poverty among productive workforces.
- Given the essential role of the labour market in creating demand for qualified labour, the need to add a pillar to measure this critical dimension and assist in identifying the economic dynamics that create a competitive structure for education and professional training.
- The need to adopt variables to measure quality in TVET.
- The possibility of adding new variables to measure the digitization of the TVET sector or its openness to the sustainable development goals or entrepreneurship.

As such, the review of the TVET sub-index for 2021 accounted for important variables for which data was unavailable when the GKI was created in 2017. Nevertheless, the persistent lack—or poor quality—of data for some of these variables ultimately precluded them from the new sub-index. These included some related to training, such as 'participation rate in non-formal job-related training', or digital skills, such as 'percentage of young people and adults who have sent emails with attached files' or 'percentage of young people and adults who have written a computer programme using a specialized programming language'. Others related to labour market requirements, such as 'percentage of workers who need reskilling for at least one month' or 'percentage of employers who retrain existing employees in response to changing skills needs'; labour market structure and digitalization, such as 'share of technical and vocational education and training jobs at risk of automation'; or equity, such as 'skills employment gender gap'.

The revised structure of 2021 TVET sub-index

The revised structure of the sub-index followed the same methodological foundations as the 2017 version, with some enhancement in relation to aspects that are considered important for building a knowledge society. There was an urgent need to produce a balanced vision of this sector based on the basic rights to education and training, as one of the pillars of the 2030 Sustainable Development Agenda. Therefore, quantitative variables such as enrolment and completion were linked to qualitative variables, as is the case for extent of staff training and quality of vocational training.

The structure of the economy, especially in terms of its relation to contemporary and knowledge transformations, has an essential role in this approach. Therefore, the new sub-index measures the extent to which national economies are able to diversify their offerings and modernize their structures to ensure both their positive interaction with education and training systems, and their positive contribution to the development of human capital. There are three main factors that affect the structure of the economy and the dynamics of social systems today: the environment of the economy, the structure of the labour market and qualifications. These factors are all interconnected and enable societies to respond to challenges, including most notably the integration of young people into their economies.[16]

The revised TVET sub-index 2021 also measures efficiency in training by adding the variable, 'participation rate in formal and non-formal education training'. It is a variable that combines both competences and skills and treats both sexes equally, despite the gaps between them resulting from the rapid development of some economies.

The principle of equality is also established in the TVET sub-index 2021, which measures equality between the two sexes in terms of the availability of qualified labour. The principles of equity and social integration have also been included in the form of a new variable that emphasizes the role of inclusion in education and training, and its contribution to fighting poverty and social marginalization, especially among the productive workforce.

In addition, the review identified indicators to capture the dynamics between the structure of training and the labour market in a way that enables the evaluation of the education and training system based on its ability to respond positively to the determinants and constraints of the labour market, such as unemployment and qualification.

Data availability and source quality represented determining factors in the adoption of new variables. Hence, the 2021 version of TVET sub-index remains both realistic and credible.

Thus, the final structure of the TVET sub-index for 2021 comprises two pillars:

The TVET components pillar

This pillar monitors the structures of TVET institutions, the qualifications they provide, and their ability to diversify their educational offerings and make them available to various segments of society—especially females. This relates primarily to factors including enrolment and graduation ratios at all levels, as well as the nature and size of the human resources working in the sector—especially trainers and teachers—and the ability to leverage continuous training programmes to achieve improvements in quality. This pillar is divided into three sub-pillars:

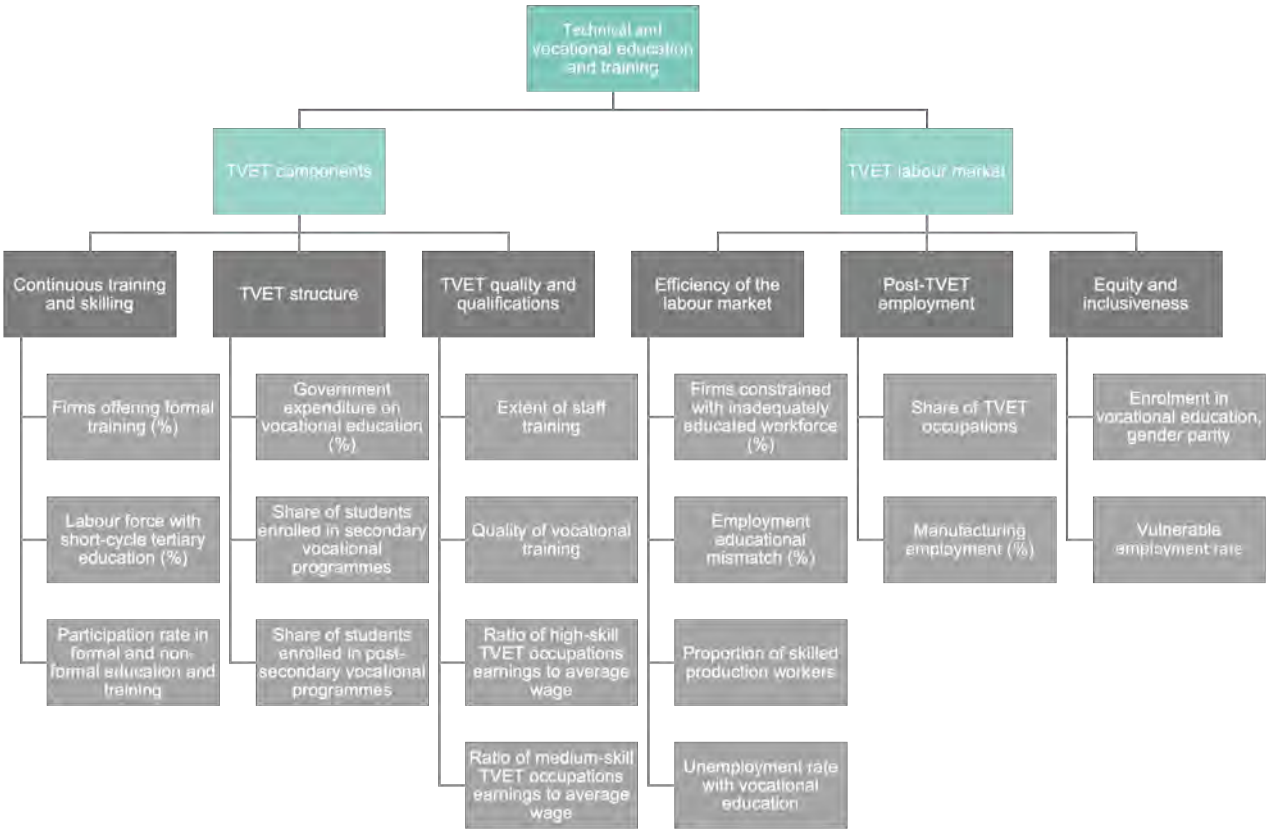
- The first sub-pillar is continuous training and skilling. It is measured through the following variables: percentage of firms offering formal training; labour force participation rate with short-cycle tertiary education; and participation rate of youth and adults in formal and non-formal education and training.
- The second sub-pillar focuses on TVET structure. It is measured through the following three variables: government expenditure on secondary, post-secondary and non-tertiary vocational education (%); share of students enrolled in secondary education enrolled in vocational programmes; and share of students in post-secondary non-tertiary education enrolled in vocational programmes.
- The third and final sub-pillar focuses on TVET quality and qualifications and is measured through the following variables: extent of staff training; quality of vocational training; mean nominal monthly earnings for high-skill TVET occupations relative to total average wage; and mean nominal monthly earnings for medium-skill TVET occupations relative to total average wage.

The TVET labour market pillar

The labour market pillar monitors the realities of the employment system in relation to TVET as an integral part of the economy as a whole. It is measured through three sub-pillars, and offers a picture of conditions in the labour market and the extent to which the principles of efficiency, equity and inclusiveness are respected.

- The first sub-pillar, efficiency of the labour market, comprises four variables: percent of firms identifying an inadequately educated workforce as a major constraint; proportion of employees who are over or under-educated; proportion of skilled production workers; and unemployment rate among individuals with upper secondary, post-secondary non-tertiary, and short-cycle tertiary education.
- The second sub-pillar, post-TVET employment, is measured through the following variables: share of TVET occupations; and manufacturing employment as a proportion of total employment.
- The last sub-pillar is equity and inclusiveness. It is measured through three variables: gender parity among 15- to 24-year-olds enrolled in vocational education; and vulnerable employment as a percentage of total employment.

Figure 3: Structure of the TVET sub-index



HIGHER EDUCATION

Introduction

Higher education plays a key role in driving knowledge and innovation by producing human capital with the qualifications and skills necessary to meet the needs of industries that drive the global knowledge economy. Hence, it was imperative that higher education be included as a core sub-index under the Global Knowledge Index. For the purpose of this Index, higher education will consider ISCED 5 to ISCED 8 programmes (short-cycle tertiary education, bachelor's or equivalent level, master's or equivalent level and doctoral or equivalent level) offered by public and private tertiary education institutions, as per the UNESCO International Standard Classification of Education (ISCED) 2011.[17]

Higher education is a major foundation of economic competitiveness and plays a vital role in achieving human development. The importance of this sector is demonstrated by its designation as one of the key focus areas of the UN 2030 Agenda for Sustainable Development. SDG 4 calls for the provision of inclusive and equitable quality education, including tertiary education, that is free of gender disparities, as a prerequisite for achieving development and full social participation.[18]

According to the World Bank,[19] higher education is essential to achieving growth, alleviating poverty and promoting prosperity. It is a key requirement for fostering employability in the industries that drive the global knowledge economy. As such, having a quality higher education system in place is a strategic necessity for broadening youth skillsets and achieving knowledge societies. This is, however, conditional on the provision of a conducive and productive labour market that can accommodate human capital with higher skills. It also requires balanced coordination between industrial and social institutions.

The higher education sector has demonstrated its ability to keep pace with development and adapt at all levels; but it now faces various challenges associated with the acceleration of globalization. It is particularly important that stakeholders consider these developments. Failure to do so may lead to a decline in the quality and effectiveness of the sector, and undermine a country's ability to conduct research and generate knowledge in various fields, thereby threatening national development and knowledge capital formation.

The role of higher education in human development, knowledge creation and innovation is widely acknowledged. This role extends beyond driving economic growth; it also serves to nurture societal values and a sense of citizenship, stimulate community involvement, and strengthen the foundations of democracy and justice. Higher education therefore influences quality of life and shapes the behaviour of individuals in society. Despite its importance, measuring the quality of higher education is a challenge. Given the importance of measures to ensure the quality of higher education, the OECD's 'Assessment of Higher Education Learning Outcomes'[20] highlights the lack of tools to compare the quality of education and learning in higher education at the international level. It points out that the few available studies focus on national-level comparisons. UNESCO observes that international university rankings use the research outputs of well-reputed institutions as a standard for measurement, representing a key limitation to the utility and relevance of such systems. Furthermore, these rankings do not evaluate the success of a higher education system in the context of the broader enabling environment in the reference country and therefore cannot be considered appropriate measures of development.[21]

Numerous attempts have been made to amend this deficiency, including through accreditation of higher education institutions and their programmes according to certain performance standards. However, they do not consider the status of higher education as a whole in any given country, as their scope has remained limited to specific programmes or institutions. In contrast to ranking or accreditation, the higher education sub-index seeks to examine the status of the sector across countries, analyse its performance, and identify areas for improvement and corrective intervention. An index can also be a useful reference tool for decision makers and stakeholders in evaluating the progress of education systems over time. Since 2017, the GKI's higher education sub-index has attempted to fill this gap by assessing the status of higher education at the country level.

The 2017 higher education sub-index

The 2017 higher education sub-index comprised two main pillars: the higher education inputs pillar, and the higher education outputs and quality pillar. The inputs had three sub-pillars: expenditure, enrolment and human resources. The higher education outputs and quality pillar had four sub-pillars: two measured the outputs in terms of graduation rates and post-graduation employment rates, and a further two measured the quality of the higher education system in terms of quality of universities and competency of students. The sub-index contained 16 variables, with seven variables for the inputs pillar and nine for the outputs and quality pillar.

Two criteria were adopted to determine the weighting of the 2017 higher education sub-index to 1) give equal weights to different variables within each sub-pillar and 2) accord greater weight to the output and quality pillar – as studies of higher education indicators have recommended.[22]

2021 higher education sub-index review

The review of the higher education sub-index began with a critical examination of the 2017 version, while acknowledging the limited ability to assess the different dimensions or provide an exhaustive list of indicators and variables—for a variety of reasons. This is especially true in the case of composite indices where limitations are imposed by the number of variables, the agreed structure for different hierarchies in the composite index, or the availability of data.

Revisions to the 2017 higher education sub-index

1. The higher education sub-index now considers all four different levels of tertiary education, namely ISCED 5, ISCED 6, ISCED 7 and ISCED 8 (listing them: i.e. short higher education programmes, a bachelor's degree or equivalent, a master's degree or equivalent, and a doctoral degree or equivalent).
2. A third pillar on the learning environment in higher education institutions was added alongside the inputs and the outputs pillars.
3. The variable on university ranking was omitted, as this is identified in the literature as a problematic measure that does not adequately assess the quality of higher education institutions and therefore should not be considered in a development context.
4. Measures related to the equity and inclusiveness of higher education were added, to identify whether a given country makes higher education accessible to all students regardless of their backgrounds.
5. The sub-pillar on university quality was changed to university impact and the 'competency of students' sub-pillar was removed.

Limitations

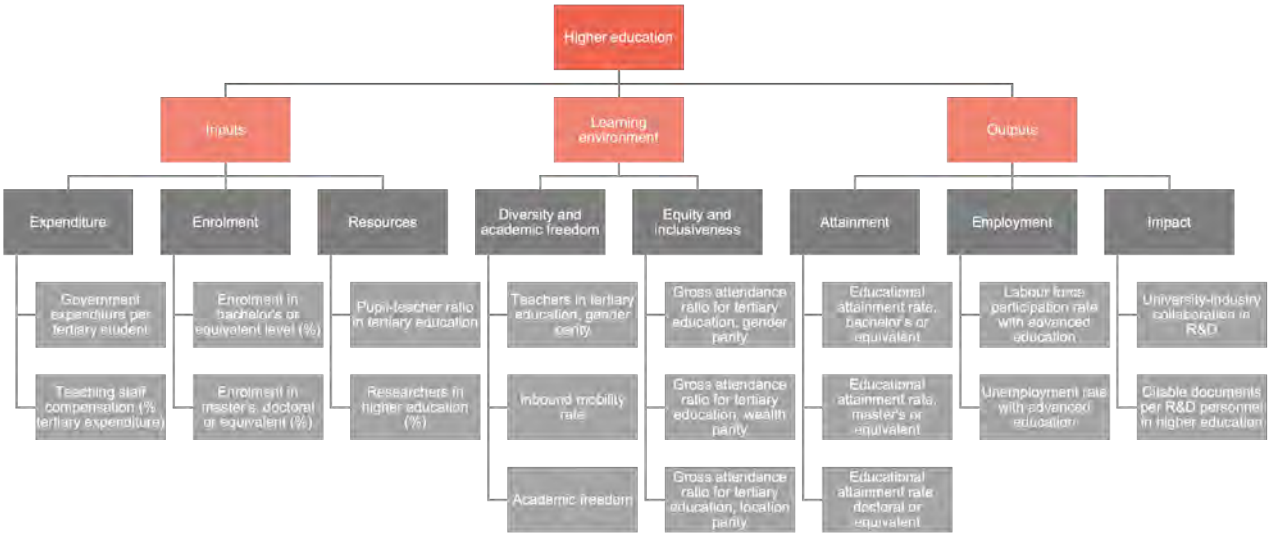
Since the inception of the GKI in 2017, the higher education sub-index has faced a number of challenges and limitations, some of which persist. The main challenge relates to poor data coverage and availability, especially with regard to indicators related to the quality of higher education. Some data employed in the 2017 version no longer exist, which posed another challenge. Higher education is different from other levels of education, in that substantial funding that comes from students themselves (either directly, via personal or family contributions, or indirectly via loan programmes). For countries where private higher education institutions are dominant, government expenditure does not capture investment in post-secondary education. Unfortunately, data on household contributions to higher education was only available for few countries.

Furthermore, the COVID-19 pandemic has affected the sector's mission as it relates to teaching, research and service.[23] It was suggested that a variable be added on the learning capabilities of higher education systems in different countries. This was supported by the fact that higher education institutions have raced to develop solutions to ensure the continuity in response to the disruption to campus- and classroom-based learning during the pandemic. Thus, higher education services have migrated from traditional to virtual, blended or other forms of delivery. This makes the development of new methods of course delivery—including online teaching models and virtual systems—a vital capability for universities. Variables on online higher education and open universities were also suggested, the rationale being to examine whether higher education systems offer further opportunities for increased knowledge building among larger segments of societies. Therefore, 'distance education' was proposed as a sub-pillar, with variables covering open universities and online or virtual learning, and the availability, enrolment and graduation rates related to these programmes. However, poor data quality and availability have undermined this important enhancement to the sub-index.

The revised structure and its justification

While the structure of the 2017 higher education sub-index suited the data available at the time, it has been revised in light of the global changes that have occurred since and the availability of new variables. As such, the new higher education sub-index was able to bridge several caveats. It was decided that measuring the sub-index through its inputs and outputs, while straightforward, would not fully capture critical dimensions related to the context of higher education; this is a common limitation related to building composite indices, as the composition does not entirely reflect what is being measured. However, this limitation was partly mitigated by the data employed in the current version, and through assessments of the openness of the sector and its attention to equity issues. The current higher education sub-index therefore considers internal and contextual characteristics of higher education systems through a pillar that studies the learning environment in higher education institutions. Consequently, the 2021 higher education sub-index has three sub-pillars: inputs, learning environment and outputs. Under these pillars, three sub-pillars assess inputs (expenditure, enrolment and resources); two sub-pillars assess the learning environment (diversity and academic freedom, and equity and inclusiveness); and three sub-pillars assess outputs (attainment, employment and impact).

Figure 4: Structure of the higher education sub-index



The higher education inputs pillar

The inputs of higher education are those factors that enable systems to achieve their objectives. They come from different sources including fiscal and human. With regard to the expenditure sub-pillar, the variable related to government expenditure per tertiary student was preserved and a variable on teaching staff compensation was added. Three variables (on initial household funding per tertiary student—as there is a noticeable increase in families' share in funding their children's higher education—private higher education funding and university teachers' mean monthly earnings) were also considered but dropped, as data on these variables are not widely available.

For the second sub-pillar on enrolment, two variables were considered relating to enrolment in bachelor's or equivalent level (%) and the enrolment in master's, doctoral or equivalent (%).

Some variables were considered for inclusion in the resources sub-pillar, relating to the number of think tanks affiliated to higher education institutions; open universities; and virtual universities. However, again, sufficient data were not available to support these variables. Therefore, the sub-pillar currently only comprises pupil–teacher ratio in tertiary education and a variable on researchers in higher education retained from the previous version of the index. While this variable could also be considered an output of the system, it is nonetheless a resource available to higher education institutions and is considered an input the index.

The learning environment in higher education institutions pillar

The aim of the learning environment pillar is to provide an indication of the learning and teaching climate that students and instructors experience in higher education institutions. The learning environment pillar is a new addition to the index. Initially, many variables were suggested, including: online teaching; COVID-19 management; female-to-male ratio of teachers in higher education; parity indices; international student mobility rates; and others. Subsequent discussions identified a concise perspective of what learning environment means at higher education institutions: it is an environment that respects and celebrates diversity; has equity concerns as a core focus; and is open and transparent, and maintains academic freedom. These three main features made up the sub-pillars of the learning environment. Therefore, three themes were suggested: equity and inclusiveness, diversity and academic freedom—with diversity and academic freedom grouped in one sub-pillar and equity and inclusiveness grouped in another.

For the equity and inclusiveness sub-pillar, three variables were adopted: gross attendance ratio for tertiary education, gender parity; gross attendance ratio for tertiary education, wealth parity; and gross attendance ratio for tertiary education, location parity. Taken together, these three variables relate to the composition of students in higher education institutions by their gender, location and wealth and provide a good indicator for equity in the sector.

In the second sub-pillar, the first theme on diversity was measured through two variables: the inbound mobility rate and the teachers in tertiary education, gender parity. The second theme on academic freedom reflects issues of freedom and openness and is measured through the Academic Freedom Index. A higher education sector is responsive to issues of diversity and freedom if it considers a balanced representation of male and female teachers, opens its doors to both sexes from abroad, and maintains an atmosphere of freedom of expression, freedom in teaching and research, institutional autonomy, academic exchange and campus integrity.

The higher education outputs pillar

The outputs pillar aims to provide an assessment of the outcomes and impact of the system and its contribution to the economic and social development of its graduates. The outputs pillar consists of three sub-pillars: attainment, employment and impact.

The attainment sub-pillar comprises three variables: educational attainment rate, bachelor's or equivalent; educational attainment rate, master's or equivalent; and educational attainment rate, doctoral or equivalent.

The employment sub-pillar was the subject of extensive discussion, the key aspect of which was the understanding that employment is less directly related to higher education than to economic and other market factors. Another point of discussion concerned whether a variable on the percentage of female higher education graduates in the labour force should be added. However, this variable was ultimately dropped, as the inclusion of adjusted gender parity variables and male-to-female teacher ratio in the learning environment seemed sufficient to indicate equity issues as part of the higher education sub-index. The employment sub-pillar ultimately comprised two variables: the labour force participation rate with advanced education; and unemployment rate with advanced education.

The third sub-pillar in the outputs pillar relates to the impact of universities. Initially, multiple variables were proposed, including soft power impact. However, this was not selected, as data were only available for a limited number of countries. The same conclusion was reached for university sustainability impact and COVID-19 research productivity. Two variables from the World Bank System Approach for Better Education Results (SABER) were also assessed and discarded—again, because data were available only for very few countries. The ranking of universities—represented by an average across the three largest ranking systems—was broadly disqualified by the review team for a number of reasons, including the fact that such rankings do not indicate impact. Ultimately, two variables were selected. The first is university–industry collaboration in R&D, which indicates economic and business impact; the second is citable documents per R&D personnel in higher education, which indicates research and knowledge creation impact.

Introduction

Research and development (R&D) "comprise creative and systematic work undertaken in order to increase the stock of knowledge—including knowledge of humankind, culture and society—and to devise new applications of available knowledge".[24] Innovation, on the other hand, is viewed as creative activity leading to the development of new products or processes that differ significantly from the product previously delivered to consumers, or the process previously used by the company or the industry.[25,26] Based on these definitions and rationale, scientific research, development and innovation (RDI) represent a central aspect of knowledge generation, dissemination and application processes in support of development.

Furthermore, innovation products and processes introduce new or significantly improved goods and services to be used in product markets. They therefore represent an important factor supporting the acceleration of economic growth and the achievement of sustainable development in a country. Given the recent advancements in knowledge markets, and the surge in intelligent digital technologies associated with the Fourth Industrial Revolution, scientific research and innovation have become a cornerstone of the transformation to knowledge societies and economies in 21st century.

Ever since the conception of the GKI in 2017, research, development and innovation (RDI) has been consolidated in one key sub-index. This unanimous choice is justified by the GKI's dual orientation, estimating the transformation of countries towards knowledge societies on one hand—through the role of R&D in creative work undertaken to increase the stock of knowledge, and the use of this stock of knowledge to devise new applications—and considering the growing role of 'innovation' in developing knowledge economies, on the other.

Although innovation is not only produced within the R&D process—and is not merely considered as an output of R&D—merging innovation with R&D in order to form a composite RDI sub-index is justified by four factors. (i) Innovation can be the outcome of the complete cycle of research and experimental development that begins with the exploration of ideas and natural phenomena, and ends with prototyping, production models and commercialization. This choice is also based on the '4Ps' process that begins with publishing a paper, then producing a patent, followed by a prototype model for testing to finally reach a final product that can be commercialized. (ii) Innovation in business enterprises and civil society requires a minimum level of research and development capabilities. (iii) Successful innovation generally requires 'knowledge workers' equipped with R&D and knowledge skills, and to a certain extent advanced cognitive capability. Finally, (iv) innovation generally requires an R&D culture and understanding.

Based on the above rationale, the RDI sub-index was developed with the inception of the GKI in 2017.

The 2017 RDI sub-index

Following the decision to associate innovation with scientific research as one composite sub-index of the GKI, the conceptual model of the 2017 RDI sub-index was developed according to the following considerations.

First, in spite of the common global recognition of inputs and outputs representing the scientific research and development (R&D) production function, methods for measuring innovation vary in their concepts, implementation and types of indicators used based on a multidimensional model of estimation.[27,28]

Second, the production function used for collecting statistics about R&D is composed of: inputs needed to support the R&D process; and outputs contributing to increasing the stock of knowledge and generating the desired socio-economic impact. Inputs are broadly divided into expenditure on R&D, size of the research workforce, and the size of high-technology net imports. Outputs include research publication, citation counts, ranking of scientific journals, quality of research institutions, patent statistics and research cooperation.

Third, given its sizeable impact on markets for goods and services, as well as the performance of the business sector and civil society, innovation is conceptually represented by a multidimensional model. Studies on innovation and approaches for estimating its impact are grouped under three alternate categories or dimensions including: i) sources for producing innovation; ii) innovation domains; and iii) classes of innovation outputs.[29] The first category assumes that innovation is developed (or produced), as part of R&D activities in research institutions.

In principle, the complete research and development cycle ends generally with new commercialized products or new production processes (considered as innovation outputs). This first innovation-producing model is generally associated with advanced or modern R&D infrastructures such as science and research parks, and technology valleys.[30] Another source of producing innovation is the business sector (or commodity producing enterprises). The output of this innovation production category is generally represented by new or significantly improved goods, services, managerial models or marketing methods. The estimation of innovation inputs and outputs, according to this model, is generally carried out using community surveys.[31,32]

Fourth, innovation can also be produced outside research centres and the production sphere of the economy. This is generally associated with societies characterized by creative, high-skilled and educated labour. This innovation model is known as 'societal innovation'.[33] As a source of innovation, this model demands a technologically advanced environment that can cope with the knowledge era and the Fourth Industrial Revolution, a highly skilled population, and a favourable enabling economic and social environment.[34,35]

Based on the above rationale and analytical points, the structural design of the 2017 RDI sub-index was composed of three pillars; 'research and development (R&D)'; 'innovation in production (or business innovation)'; and 'societal innovation'. Each of these pillars is broken down into inputs and outputs sub-pillars.

2021 RDI sub-index review

After four years of applying RDI as a main constituting component of the 2017 GKI, it was deemed necessary and useful to revise its rationale and structure—including selected pillars, sub-pillars and variables. Furthermore, extensive discussion and assessment of its usefulness and weaknesses as an analytical tool have stressed the need to consider its evaluation and revision in order to enhance its capacity as a dynamic comparative policy analysis tool. It was deemed equally important to assess the status of variables used to estimate RDI. As will be shown below, while some variables previously considered in the 2017 structure are no longer produced, others have acquired a new formulation and estimation process. Correlation among variables of the same sub-pillar or across sub-pillars also needed re-estimation. Finally, and most importantly, the RDI multidimensional conceptual model has evolved during this four-year period through sensible changes, new considerations and additional dimensions. All these changes and considerations have affected the structure and variables included in the RDI sub-index.

A major drawback of the 2017 design was that the variables under the pillar 'research and development' did not account for the innovation output generated or produced in research institutions, which generally occurs with the completion of the R&D cycle that ends with prototypes, industrial models and commercialized products. This separation, however, was deemed difficult given the availability and coverage of worldwide RDI statistics. Furthermore, the second pillar on business innovation may include research activities to prepare the ground for innovative outputs, which can either be achieved in a separate R&D department or within a different department. This represented a major factor that affected the authors' choice to deal with RDI as an integrated activity in the modified version.

Selection of weights

Another issue related to the original RDI structure was the allocation of relative weights for pillars and sub-pillars. During the initial phases of index conceptualization, multiple statistical techniques were applied to determine weights associated with pillars and sub-pillars based on empirical considerations. Given the conflicting results, the logic, rationale and relative role of each pillar were used to determine the allocation of weights.

Although general practice suggests the use of equal weights, it was decided to allocate 50 percent to both business enterprises and societal innovation sub-pillars, and 50 percent to the R&D institutions sub-pillar in both the inputs and outputs pillars of the modified structure (Figure 6).

This decision was based on a number of supporting criteria and considerations: i) R&D is considered the main source for generating new theoretical and practical knowledge (through basic research, applied research and experimental development). Despite the considerable impact of innovation on accelerating economic growth,

productivity and the transition to knowledge economies, the main bulk of knowledge creation and application pertains to R&D. ii) R&D is generally needed as an input to business innovation (in business enterprises with or without R&D units). iii) Societal innovation requires knowledge workers with R&D skills and culture. Finally, iv) innovation can be generated in research institutions, as previously explained.

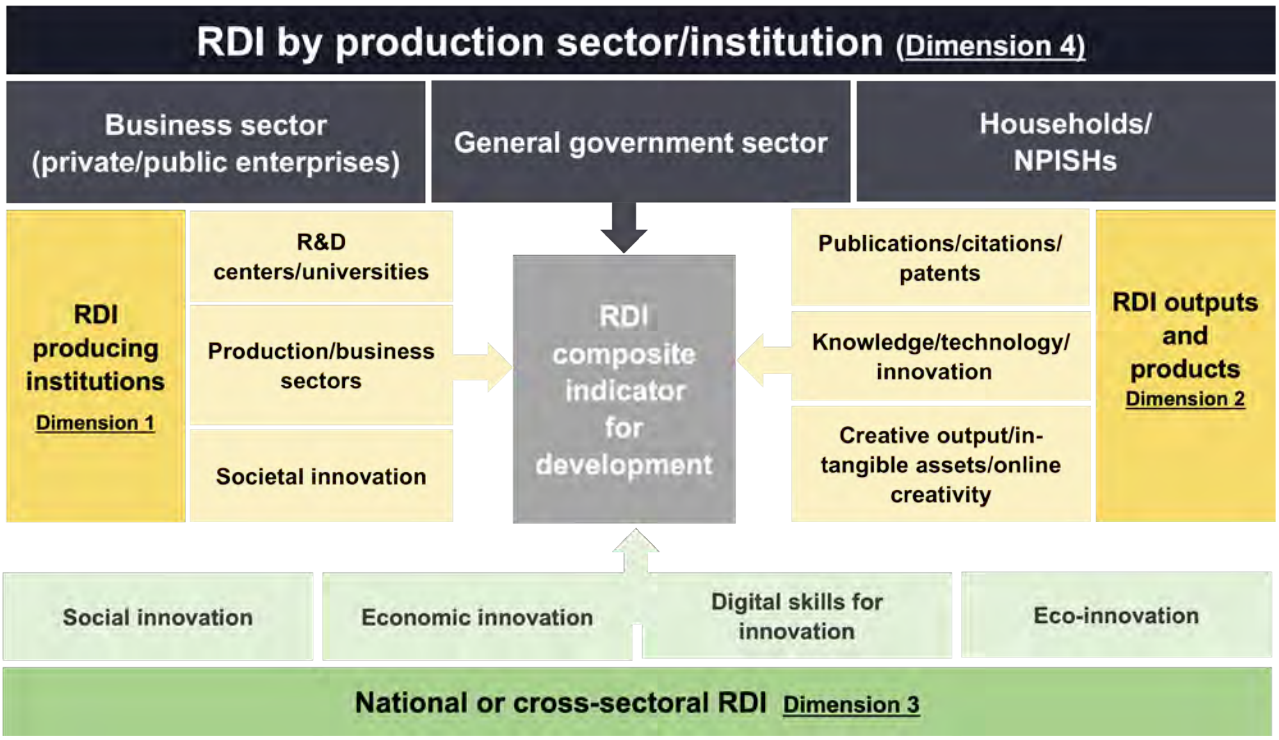
The four-dimensional RDI conceptual model

Given its observed impact on the transition of countries to knowledge societies and economies, and its increasing role in keeping pace with the Fourth Industrial Revolution and digital transformation, the conceptual model of the RDI sub-index has witnessed sensible changes and acquired new features. RDI has become an integral part of most national sustainable development strategies. These recent developments have required changes in the original design and structure of RDI sub-index developed in 2017. As shown in Figure 5, approaches to estimate different RDI variables and evaluate their impact on knowledge transformation in a country are represented by four dimensions. These dimensions are: i) sources of producing RDI; ii) alternative RDI output categories; iii) cross-sectoral or national specific RDI; and iv) RDI pertaining to a specific sector in the production sphere of the national economy (based on the International Standard Industrial Classification [ISIC] scheme).[36]

With respect to the first dimension of the model in Figure 5, RDI can be generated (or produced), as part of the activities of R&D institutions. These institutions include universities, research centres and other knowledge-producing units. RDI can also be produced in private and public industrial business sectors, and in society as a whole.[37]

Innovation in production activities or the business sector (as part of RDI) is analysed in detail in the *Oslo Manual*.[38] Experience has shown that innovation generated by R&D institutions and business enterprises represents the largest proportion of RDI outputs. RDI in general, and innovation in particular, are also produced outside R&D centres and the production sphere of the economy. This generally happens in societies characterized by a high percentage of creative, highly skilled and educated labour.

Figure 5: The four-dimensional conceptual model of RDI



The second dimension of the RDI conceptual framework shown in Figure 5 relates to the nature and diversified features of its expected outputs and impacts. Here, we can identify three categories of outputs. The first is concerned with publication counts, citation statistics and patent records; the second category is related to knowledge and technology outputs as an outcome of RDI activities; the third includes creative and cultural outputs, investment in intangible assets, and online creativity. It is worth noting here that the second dimension reflects, to a great extent, the modern vision and output components of RDI.[39,40,41]

As shown in Figure 5, RDI is classified similarly according to its domain of application, special purpose or technical orientation. This third dimension is defined as 'national or cross-sectoral RDI'.[42] It groups specific types of innovation, such as social and economic innovation, eco-innovation and innovative digital skills. Social innovation is defined by the OECD as a creative activity directed to address social challenges that cannot be handled by market economies.[43] Given this rationale, social innovation seeks to improve the living standards of citizens, as well as their welfare measures. It is worth noting that 'social innovation' differs from 'societal innovation' associated with the sources of producing RDI addressed previously. On the other hand, innovation in the 'economic domain' aims at creating "new or significantly improved marketed goods and services"[44] to enhance the productivity and economic growth prospects of a country. As such, it is considered the corner stone for accelerating the economic development process.

The last category of this dimension (eco-innovation) addresses innovation in support of sustainable development. It offers promising prospects for the emergence of innovation-friendly green markets. Its main purpose is to reduce the cost of environmental protection, increase energy efficiency and facilitate the necessary shift to a green economy.

Finally, the last RDI dimension addresses development and innovation in selected economic sector or production activity based on the ISIC classification scheme.[45] Despite the variety of breakdowns of economic activity, the most used sectoral division in RDI-based research identifies private and public industrial activities, general government sectors, the households' sector and non-profit institutions serving households (NPISHs).

Revisions to the 2017 RDI sub-index

The revision procedure that has led to the modified RDI sub-index was guided by an RDI advisory board members. It was carried out in four phases:

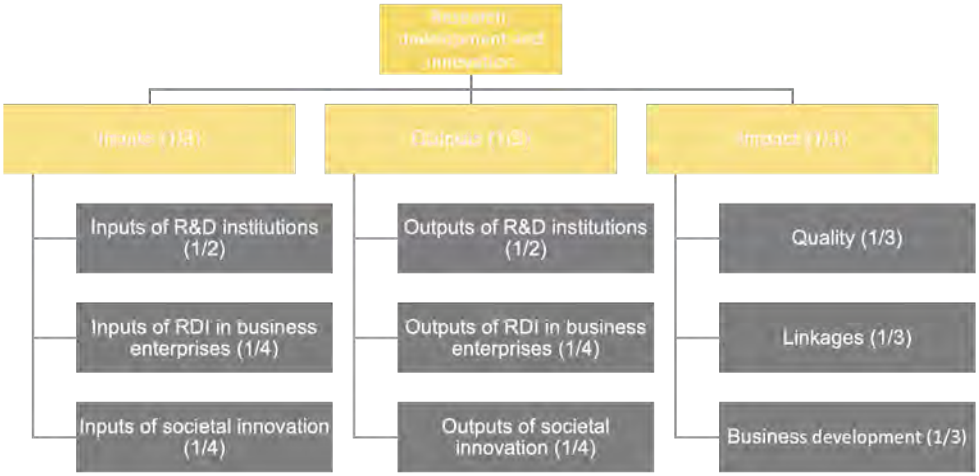
1. Discussion, evaluation and critical review of concepts, general orientation, development approach, structural features and possible modifications of the 2017 RDI sub-index by the advisory board members, based on a detailed conceptual review paper.
2. Based on the outcome of phase 1, and given the statistical constraints on the number of pillars, sub-pillars and variables, the discussion led to the final structure presented in the next section.
3. Based on the approved structure, a comprehensive set of variables was introduced and evaluated based on their relevance, reliability and impact on the objective and orientation of the RDI sub-index, as well as their contribution to the GKI. The outcome of this phase was a reduced set of variables to be included in the RDI structure.
4. The reduced number of variables pertaining to the sub-pillars of RDI were determined after excluding irrelevant, less important variables and those having limited country coverage or that were no longer produced. Other variables are not considered because of their selection in other sectors of the GKI, or given their high correlation with other variables.

The revised structure of the RDI sub-index and its justification

The pillars and sub-pillars of the modified RDI sub-index are shown in Figure 6. The sub-index is broken down into three pillars, two for estimating inputs and outputs of RDI, and a third for determining the impact of RDI. Based on this rationale, the design treats RDI as a unified or integrated sub-sector, with a production function (composed of inputs and outputs) and a separate pillar for its impact. Compared with the previous RDI sub-index, this new structural division of pillars enhances the analytical capacity. In addition to computing inputs supporting the production of RDI and outputs, it provides analytical information about its quality, linkages with other sectors, and contribution to business development. These two vital changes—treating RDI as an integrated function and adding a separate pillar for the evaluation of its impact—contribute to making the revised RDI sub-index a better comparative policy analysis tool for countries. It is worth noting that the breakdown of RDI sub-pillars aligns with

the first dimension of the new RDI conceptual model of Figure 5 (including R&D research institutions, RDI in business enterprises, and societal innovation) as shown in Figure 6), whereas the variables under each of them follows a combination of dimensions one, two and three of the RDI conceptual model (as will be discussed in the following section).

Figure 6: Modified RDI structure: pillars, sub-pillars and weights



Although the revised 2021 RDI sub-index, pillars and sub-pillars reflected, to a great extent, the RDI four-dimensional conceptual model previously described—as well as its desired features, orientation and purposes as defined by the members of the advisory board—the process of variable selection witnessed four major difficulties. The first difficulty concerned the conflicting views about the significance, relevance and analytical scope of some of the selected variables, taking into consideration the broad definitions of innovation types, different approaches to their estimation, and their interaction with R&D activities. The second difficulty resulted from the duplication of part of the selected variables in other sectors of the GKI—in particular the economy and higher education sub-indices. However, theoretical and statistical analyses solved these two difficulties. The third difficulty concerned the reliability, country coverage and statistical problems associated with an increasing percentage of RDI variables, and several variables were omitted from the structure for these reasons. Finally, the last problem concerned the preference to rely on hard data or survey results in developing the set of variables associated with the sub-pillars where several variables were excluded because they were integrated into other sub-indices of the GKI, are no longer produced, or have high correlation with other variables. The general structural constraints defined by the statistical methodology have also contributed to reducing the degree of freedom for an extensive and exhaustive selection of variables. Figure 7 summarizes the final structure of the modified RDI sub-index along with its associated variables.

The RDI inputs pillar

The 'inputs' pillar includes three sub-pillars: 'inputs of R&D institutions'; 'inputs of RDI in business enterprises'; and 'inputs of societal innovation'. The constituent variables of the 'inputs of R&D institutions' sub-pillar are similar to the 2017 'R&D inputs' sub-pillar that concentrates on 'gross expenditure on R&D (% GDP)' and 'gross expenditure on R&D per researcher (computed as full time equivalent [FTE])'; and the 'share of researchers per thousand labour force'. Furthermore, the 'percentage of tertiary graduates from science, technology, engineering and mathematics (STEM) programmes' is included here, given its relevance to R&D processes.

In the 'inputs of RDI in business enterprises' sub-pillar, two types of gross expenditure are considered. The first estimates the total amount of spending allocated to RDI in business enterprises (GERD performed by business enterprises [%]), whereas the second type of spending concentrates on business sector own financing (GERD financed by business enterprises [%]). Based on this definition, the first spending variable reflects the interest of

a country in enhancing R&D in the business sector. The second variable estimates the internal policy of enterprises to finance R&D needs. The 'percentage of researchers in business enterprises' represents RDI inputs that determine research capacity and resources in an enterprise. Finally, the 'percentage of firms that spend on R&D' in a given country is added here to show the dissemination of a research culture in business sector.

'Inputs of societal innovation', as a third sub-pillar, is composed of three variables. The first variable reflects the importance of having knowledgeable and skilled labour to achieve societal innovation. High-skilled labour is generally required in the knowledge-intensive industries that characterize developed economies. In order to produce innovative or creative goods and services, civil societies need to acquire intellectual property rights. This represents the second input of societal innovation. Finally, the 'state of cluster development' is another measure that reflects the capacity of a country to have well established cluster industrial and services units that are geographically distributed in support of innovation.

The RDI outputs pillar

The sub-pillar 'outputs of R&D institutions' is similar to the R&D outputs sub-pillar of the 2017 RDI sub-index. It concentrates mainly on publications, citations and resident patent applications.

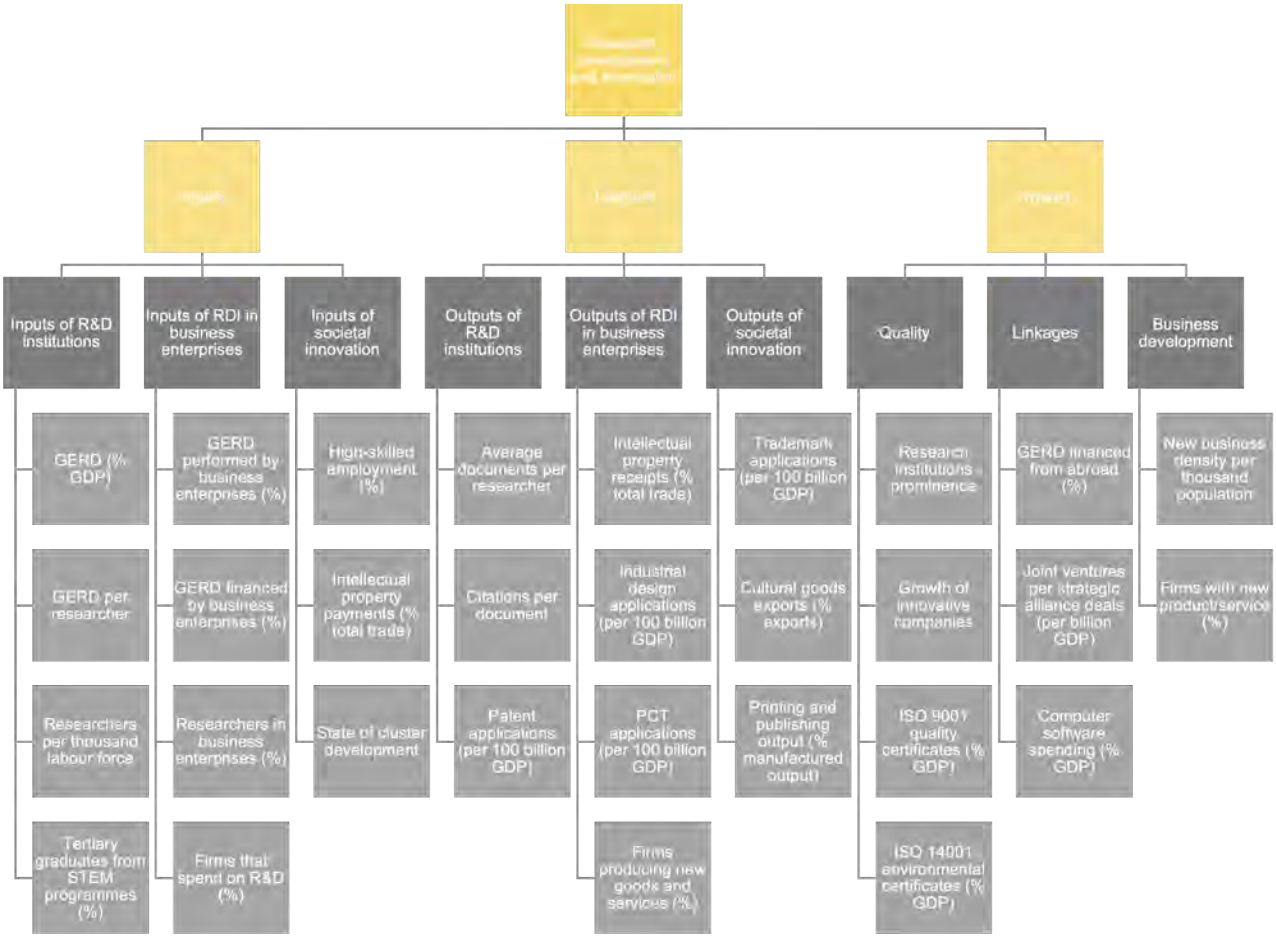
The 'outputs of RDI in business enterprises' sub-pillar is based on four variables. Two relate to the number of receipts the business sector collects against the utilization by other national institutions of their intellectual property rights and industrial design applications. The increase in this type of income means that the business enterprises of a country are more productive and innovative. A third variable measures the number of patents under the Patent Cooperation Treaty (PCT)—administrated by the World International Property Organization (WIPO) to provide patent protection in a number of countries simultaneously—which reflects the level of advanced innovation products. Finally, the 'percentage of firms producing new goods and services' is a direct measure of the innovative capacity of a business sector in a country.

Based on the conceptual four-dimensional model of RDI, the third sub-pillar is concerned with 'outputs of societal innovation'. This latter is generally broken down into the acquisition of intangible assets, outputs of creative and culture products, and online creativity. Investment in intangible assets is represented in the output of societal innovation sub-pillar by 'trademark applications per GDP'. Creative and cultural products are measured within the structure of the sub-index by two variables: 'cultural goods exports (% exports)' and 'printing and publishing output (% of manufactured output)'.

The RDI impact pillar

This third pillar is a new addition that goes beyond the previous RDI sub-index applied from 2017 to 2020. In addition to the variables explaining inputs and outputs of RDI, this pillar captures some elements of RDI impact—as far as the international scientific and socio-economic database permits. This pillar comprises three sub-pillars with variables pertaining to the quality of RDI, RDI linkages and how RDI affects the business sector development process—business development. The 'quality' of RDI is measured using both survey questions and hard data. Two survey questions determine the 'prominence of research institutions' and 'growth of innovative companies' of a country. A third variable estimates the management quality of institutions (ISO 9001) (% GDP), and a fourth variable determines eco-innovation performance measured by 'ISO 14001 environmental certificates (% GDP)'. Gross expenditure on R&D (GERD) financed by the outside world is allocated to the 'linkages' sub-pillar in order to measure the cooperation between domestic and foreign RDI institutions. Furthermore, 'joint ventures per strategic alliance deals (% GDP)' is another measure of linkages. Finally, the increase in 'computer software spending (% GDP)' is interpreted as a way of ensuring linkages between RDI and information technology (IT). A third sub-pillar included under the impact pillar is 'business development'. Since the development ideas of new business enterprises are considered as innovation outcomes, a measure of 'new business density per thousand population' can be viewed as part of the innovation impact on business development. Finally, the variable 'percent of firms with new products or services' that are considered new or significant improvements to the main economic market is viewed as a measure leading to the development of business enterprises.

Figure 7: Structure of the RDI sub-index



INFORMATION & COMMUNICATIONS TECHNOLOGY

Introduction

As the digital economy grows to constitute an increasingly significant portion of the broader global economy, industries in all sectors are striving to meet the requirements of the Fourth Industrial Revolution,[46] and its demands on information and communications technology (ICT) and other knowledge sectors. For ICT to reach its full potential, knowledge creation should not be restricted to a cluster of countries or regions; rather, it should be localized and shared for the well-being of all societies. Therefore, to gain an insight into how the future will unfold, we must acknowledge the interactions embedded within a number of mutually reinforcing trends in ICT.

ICT has fundamentally changed the way people live, affecting both our daily activities and the way we do business, necessitating a paradigm shift in how ICT infrastructure and policies are shaped. The adoption of such new technologies is dependent on the willingness of governments, businesses and citizens to drive technology/digital-led transformations in their countries, both in terms of investing in a robust, reliable and sustainable ICT infrastructure—represented by networks, software, hardware and platforms—or in terms of its usage by individuals, governments and businesses, and its impact on development. Furthermore, regional and international regulatory frameworks play a key role in enabling cross-border data flows and trade digitalization, as countries revisit the scope of their existing frameworks to ensure equitable distribution of economic development gains.[47]

The use of digital technologies has led to the development of new products and services, and the re-engineering of production systems in order to improve quality and reduce costs.

> *ICTs are specifically mentioned as a means of implementation under SDG 17, highlighting the cross-cutting transformative potential of ICTs. Indeed, ICTs are crucial in achieving all of the SDGs, since ICTs are catalysts that accelerate all three pillars of sustainable development – economic growth, social inclusion and environmental sustainability – as well as providing an innovative and effective means of implementation in today's interconnected world. Paragraph 15 of the 2030 Agenda for Sustainable Development highlights that the spread of information and communication technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies…*
>
> *Source: ITU, n.d.*

This has brought about a fundamental change in traditional business models, which now seek to leverage big data and global communication networks to increase market share. However, the impact of technology extends beyond expanding profits and cutting costs to realizing inclusive growth by enhancing access to services and creating employment opportunities. Thus, for governments and businesses to remain relevant and competitive, and to maximize the benefits from deploying new technologies, they must align the development of both their human resources and infrastructure with the demands of the digital transformation.

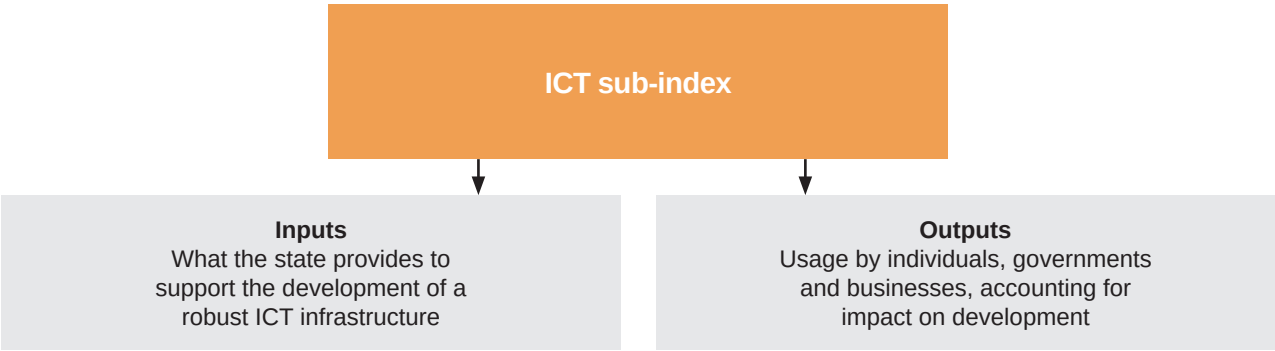
In this context, the need for relevant and timely indicators that measure the state of ICT in a given country is all-important. Hence, the ICT sub-index serves as a benchmarking tool, adding value to existing indices by examining ICT through the prism of sustainable development.

The 2017 ICT sub-index

Technological revolutions have provided unprecedented opportunities for knowledge ecosystems and accelerated the creation, accumulation and dissemination of knowledge both within and across countries. The progress of knowledge-intensive production has therefore become linked to the provision of advanced technologies.

Consequently, as technology constantly evolves and the ICT sector witnesses significant advancements, it is paramount to have indicators and tools to measure the progress of countries against the development of this sector underlines the importance of developing an ICT measure; hence, this sub-index aims to exploring the capacities of countries to leverage the possibilities presented by technological advancements to drive their economic growth and prosperity.

The previous structure comprised two pillars—ICT inputs and ICT outputs—and six sub-pillars covering 20 variables from international sources such as the International Telecommunication Union (ITU), the World Bank, the World Economic Forum and the United Nations Department of Economic and Social Affairs (UN DESA), among others.



The input pillar encompassed two sub-pillars: infrastructure and sector competitiveness. The infrastructure sub-pillar measured the degree to which a country supplies citizens with the compulsory resources to access basic services; while the sector competitiveness sub-pillar reflected the affordability of fast, reliable and secure ICT services, in addition to laws relating to ICTs.

The output pillar was designed to measure the availability of technologies and the role of the government and organizations in committing to the integration and adoption of ICT for social and economic welfare and development. The output pillar was divided into four sub-pillars: subscriptions; usage by individuals; usage by government and institutions; and impact on development. The subscriptions sub-pillar measured the penetration of ICT services, whereas the two usage sub-pillars reflected how connected a society is, and the efficiency and quality of public services. The impact on development sub-pillar measured the effect of ICT on society in terms of innovation, doing business and participation.

2021 ICT sub-index review

The methodology of the ICT sub-index was refined through a rigorous revision of the existing literature related to the measurement and evaluation of the performance of the ICT sector, complemented by a series of consultations with distinguished subject-matter experts. As such, in the framework of the Global Knowledge Index (GKI), the ICT sub-index takes into account variables relating to ICT infrastructure, and access to, and usage of, technologies to: (i) create knowledge; (ii) localize knowledge; and (iii) disseminate knowledge for sustainable development. There is therefore a strong correlation between the ICT sub-index and the other sub-indices constituting the GKI because ICT has become the *de facto* underlying sector of a knowledge society. Examining ICT from this perspective helped in developing the pillars, sub-pillars and variables of the index.

Revisions to the 2017 ICT sub-index

The revised edition of the index accounted for several key alterations:

- Replacing subjective variables by quantitative and objective variables where available. For instance, opinion surveys that are driven by personal beliefs and experiences have been replaced by scalable and robust variables.

- Omitting variables that are not regularly updated. For example, the ICT Price Basket variable, which was discontinued by the ITU, has been replaced by two variables reflecting the price of fixed- and mobile-broadband baskets relative to GNI per capita.
- Considering new variables that were not collected and reported when the first edition of the index was produced, such as Internet activities by individuals and trade in digitally deliverable services.
- Introducing emerging trends in the ICT field. The revised version comprises a new sub-pillar, 'skills and employment', reflecting the importance of digital skills and ICT employment in the new digital era.

The revised structure of the 2021 ICT sub-Index

The ICT sub-index was revised to capture wider notions; as such, the pillars have been revisited in line with progress in ICT measurement.[48] The ICT sub-index now comprises three pillars: infrastructure, access and usage; the three of them being mutually reinforcing.

The infrastructure pillar

The infrastructure pillar reflects the importance of infrastructure as a prerequisite for the realization of the gains of technologies, and as an enabler for digital transformation. The deployment of mobile network coverage, and investments in telecommunication networks, tangible and intangible assets, are critical for the development of the sector in any country. Not only should governments invest in their fixed assets, they should also guarantee that quality services are provided at affordable prices, whereby these services are accessible by anyone anywhere. The latter requires efforts by the government to design inclusive and modern regulatory frameworks that ensure the growth and competitiveness of the Internet and telephony sector. Consequently, the competitiveness of the sector, along with a robust ICT infrastructure, supports the country in realizing the potentials offered by innovations and advancements in the Internet of Things (IoT).

Accordingly, the infrastructure pillar is divided into three sub-pillars, coverage, quality and affordability. The coverage sub-pillar includes three variables: 3G/4G mobile network coverage (% population); secure Internet services per 1 million population; and investment in telecommunication services (% GDP).

In their broad definition, the variables under the coverage sub-pillar, directly or with the use of proxies, measure the fixed assets investments in the telecommunication sector necessary to ensure that the whole population is covered by the equipment and the secure networks required to connect to the Internet. Subsequently, a secure and strong ICT infrastructure will allow countries to strengthen the means for individuals, businesses and governments to benefit from basic services, and to enhance knowledge exchange between them; notwithstanding the challenges to e-government and the realization of the digital transformation posed by the deployment of frontier technologies—such as artificial intelligence, machine learning, blockchain and biotechnology—within an inadequate ICT infrastructure.[49]

The quality sub-pillar measures the quality of fixed- and mobile-broadband subscriptions provided in terms of speed using three variables: mobile upload and download speeds; fixed-broadband upload and download speeds; and fixed-broadband subscriptions by speed per hundred people.

It is worth noting that while mobile-broadband technology is advancing at a fast pace, it is not yet an alternative for fixed-broadband, given that businesses to date are highly dependent on fibre-optic communication to conduct business. As such, equal importance is allocated to both fixed- and mobile-broadband in measuring the penetration and quality of telecommunication services in a country.

As the pandemic has changed both the work and educational environments, they are now characterized by remote working and distance learning, the majority of Internet activities could be classified as data-hungry and would entail high-speed Internet services. Thus, this sub-pillar serves as a good measure for the quality of the services provided and the ability of the ICT sector to support the development of sturdy business and learning environments.

While the availability of quality services is essential, ensuring that the services are provided at affordable prices is also indispensable. Hence, a third sub-pillar, affordability, was introduced to measure the relative prices of ICT services; it encompasses three variables: fixed-broadband basket (% GNI per capita); mobile-broadband basket (% GNI per capita); and Internet and telephony competition.

These variables reflect the maturity of the regulatory environment of a country and its capacity to introduce competition to the sector, thereby lowering prices to affordable levels and consequently achieving universal connectivity. Further, affordable access to broadband and ICT infrastructure and services is crucial to the growth and innovation of the ICT sector as it permits business continuity and improves the welfare of society by enhancing the flow of knowledge and strengthening social cohesion.[50]

> *In general there is a negative correlation between price levels and penetration rates, for the ICT services monitored. Yet the relationship is not always a straightforward one. Thus, even as prices in LDCs [least developed countries] declined for the mobile and fixed broadband baskets, subscription numbers remained low, a possible indication that penetration will only increase once prices drop to a level where they are affordable for the average earner.*
>
> *Source: ITU, 2021.*

The access pillar

The development of an advanced and integrated ICT infrastructure alone is not sufficient for the development of a dynamic and inclusive ICT sector. Access and usage of ICTs by citizens, businesses and governments to drive innovation, maximize the growth potential of technologies and realize development goals, remains at the core of the digital agenda. While businesses are striving to have an online presence in an attempt to reduce their costs and increase their market share, it is imperative for individuals and consumers, on the other side of the spectrum, to have access to these services, which is only possible by enhancing Internet accessibility. This, in turn, reduces social disparities and inequalities. Accordingly, the access pillar was introduced to measure the penetration of ICT in the country and human capacities in the ICT field. It is divided into two sub-pillars: subscriptions; and skills and employment.

The sub-pillar 'subscriptions', measuring the penetration of ICT services among citizens, includes three variables: active-mobile broadband subscriptions per 100 inhabitants; international Internet bandwidth per user; and households with Internet access at home (%).

The variables included in the subscriptions sub-pillar reflect the level of penetration, which plays a key role in determining the volume and scope of knowledge creation, localization and diffusion. As more people are connected to the Internet, knowledge creation increases exponentially and people, regardless of where they are located, are connected to the ideas and knowledge generated online.

A new sub-pillar 'skills and employment' was developed to reflect the digital skills of citizens and employment in ICT. It comprises three variables: individuals with standard ICT skills (%); tertiary graduates from ICT programmes (%); and ICT employment (%).

This 'skills and employment' sub-pillar assesses the capacity of human capital to integrate the new technologies and to contribute to the growth of the ICT sector. As the demand for digital skills is increasing with the rise in digital-oriented jobs, and the adoption of technologies in the workplace and by governments, citizens should acquire a set of digital skills to harness these technologies for economic and social development. Furthermore, as global competition is now concentrated over ICT-enabled goods and services, creating a massive number of jobs in the field, the need for self-motivated and talented ICT specialists that possess programming and analytical skills is paramount.

Innovating skills for a digital economy

To realize opportunities presented by digitalization, governments need to understand how jobs—and the skill sets demanded by these jobs—are changing. Digital skills have moved from 'optional' to 'critical' and need to be complemented with transversal 'soft skills' such as the ability to communicate effectively in both online and offline mediums. In developing countries, digital skills are also in high demand and greatly improve prospects for decent employment. They are linked to higher earning potential, and experts have predicted a growing number of jobs for people with advanced digital skills. Not only are there new jobs available, some of them are actually going unfilled, making the provision of advanced digital skills part of a solution to unemployment.

Source: UNESCO, 2018.

The usage pillar

The technological, societal and scientific impacts of ICT remain the utmost factors in determining the contribution of this sector to the development of a country. While the infrastructure and access pillars set the digital foundations for a strong ICT sector, the usage of technological services to promote development and create new opportunities is fundamental in measuring the advancement of this sector in an economy. An increase in the use of ICT services promotes the rapid exchange of knowledge—as more people are connected through social networks—and enables the effective development of solutions to pressing challenges via Internet-enabled innovation, creativity and entrepreneurship.[51] Additionally, the availability of online government services and the transition towards digital government is imperative in promoting transparency, accountability and governance in public administrations.

To illustrate the exchange of knowledge and the impact driven by ICT, the usage pillar was developed, including two sub-pillars: services and outcomes.

The 'services' pillar measures the provision of adequate ICT services, and includes four variables: government online services; fixed-broadband Internet traffic per subscription; mobile-broadband Internet traffic per subscription; and Internet users (%).

These variables reflect the intensity of Internet use through the Internet traffic variables, mobile- and fixed-broadband, and the development and availability of online government services in the country. "Commercial traffic through large data centres for business applications represents a significant portion of the data generated in digital form."[52] The proportion of individuals using the Internet remains a relevant and realistic measure to assess the usage of ICT services, as it provides insights on the portion of individuals interacting among each other, with businesses and governments.

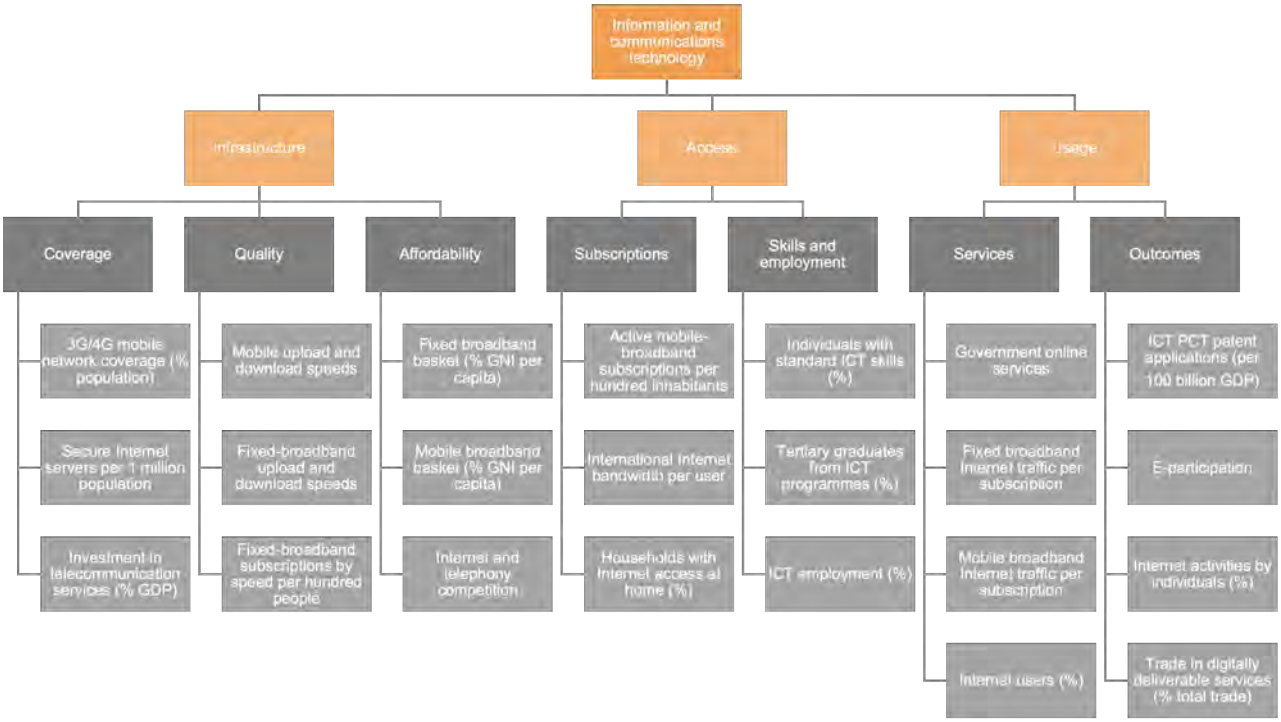
The second sub-pillar, outcomes, witnessed considerable changes to reflect the efficacy of the sector and its dynamic effects on other aspects of the economy such as trade, innovation, governance and doing business. It covers four variables: ICT PCT patent applications (per 100 billion GDP); e-participation; Internet activities by individuals (%); and trade in digitally deliverable services (% total trade).

These variables capture the outcomes of ICT as seen in innovation through ICT inventions registered through the international patent system, 'Patent Cooperation Treaty' (PCT), and in trade, whereby ICT-enabled digitally deliverable services, financial services, use of intellectual property, telecoms and computer and information services, among others, are traded across countries. They also show how governments are using online tools to promote citizen engagement and facilitate provision of knowledge by public administrations to citizens. The Internet activities by individuals (%) variable presents perceptions and behaviours on the usage of the Internet for private purposes, Internet banking, purchasing goods and services, and online courses, among others. Hence, this sub-pillar is a good measure of the absorption of modern technologies and their usage for business-to-consumer (B2C), business-to-business (B2B) and government-to-citizen (G2C) transactions.

Finally, the gender digital divide is reflected in the seventh GKI sub-index 'enabling environment', as it impacts all sectors presented in the Global Knowledge Index and is considered an important variable in measuring gender equity. The variable, female-to-male Internet users' ratio, measures the usage of Internet and knowledge-enhancing

applications and services by females relative to that of males, which is in turn a good measure of female empowerment, as the use of ICTs enables women greater independence and autonomy, providing them with economic and social opportunities.[53] Furthermore, it is worth noting that due to data unavailability and insufficient data coverage, the digital divide variable was extended to cover the gender aspect only, as disaggregated data related to infrastructure, access and usage by location, wealth or other socio-economic factors are limited.

Figure 8: Structure of the information and communications technology sub-index



ECONOMY

Introduction

The establishment of knowledge economies—characterized by their diversity of production, productivity, labour and human capital—has become the main determinant of the ability of countries to adapt to global transformations and developments. Within the Global Knowledge Index (GKI), the components of the knowledge economy related to economic competitiveness, economic openness, and financing and domestic value added, represent important indicators of the ability and resilience of economies to face global transformations and developments. This has been illustrated by the COVID-19 pandemic, which has shown that countries with competitive knowledge-based economies are best able to adapt to, and recover from, such crises.

The knowledge economy is linked to all productive sectors. For example, the ICT sector and related digital activities within the commodity and service sectors, including logistical communication chains, are all direct indicators of the role of the knowledge economy in achieving sustainable development and balanced economic growth. It has also been suggested that knowledge economies require that the numbers of workers in sectors related to knowledge, technologies and digitization must exceed those working in traditional sectors.[54]

> *The World Bank considers education, training, information infrastructure, economic incentives, institutional systems and innovation to be the main pillars for achieving a knowledge economy. These pillars ensure the free transfer of knowledge and stimulate investment, creativity and innovation within the economy.*
>
> *Source: World Bank, 2013.*

Since the launch of the GKI in 2017, the economy sub-index has been shown to be one of the most interactive of the six indices. This is reflected in the interdependence between the components of the economy sub-index and the variables employed for other sectors that feed into the economy. The structure of the economy sub-index reflects the specificity of the sector and the balance between its three pillars: knowledge competitiveness; economic openness; and financing and value added.

The 2017 economy sub-index

A dedicated structure for the economy sub-index was created within the 2017 GKI to ensure sufficient connection and alignment with the components of the other sectors—including pre-university education, TVET, higher education, RDI, ICT and enabling environment; the latter of which constitutes an organic link between the six sectors that make up the Index.

The structure also considered the need for variables that reflect the role, components and status of the global economy in determining the progress of nations in their acquisition, production, transfer and localization of knowledge. Within this general framework, it was agreed that the economy sub-index would consist of three pillars that link the economy with other sectors, and with the broader concept of the knowledge economy in the Index. Each of the three pillars comprised two sub-pillars with individual variables that reflected their potential and role in the economy. The six sub-pillars of the 2017 economy sub-index were: economic infrastructure and competition; competitiveness drivers; creative economy; trade; financing and taxes; and domestic value added. These six sub-pillars comprised 22 variables indicating the role of the economy in knowledge, on the one hand, and its role in other sectors, on the other.

2021 economy sub-index review

Through an objective, scientific and practical review of the components of the economy sub-index, it was determined that its sub-pillars and variables required further development. Global changes and developments in the economic landscape necessitated the qualitative development of the components of the sub-index. This was achieved based on desk studies, including a review of the economic literature and its applications worldwide.

Thereafter, international experts in economics were consulted, resulting in a thorough, qualitative review of the sub-index and its components, including its main pillars, sub-pillars and variables.

Revisions to the 2017 economy sub-index

Discussions with the team of international consultants and experts focused on the following:

- How the economy sub-index can reflect the real role of the pillars in enriching knowledge.
- Using objective numerical indicators while reducing the number of variables based on samples and opinion polls to the greatest extent possible.
- Reconsidering the names of some of the pillars and sub-pillars to better reflect their true meaning.
- Introducing variables that directly relate to the knowledge of human resources and their role in transferring, localizing and building knowledge in countries.
- Ensuring variables cover as many countries as possible, allowing for more objective measurements, comparisons and rankings of countries.
- The exclusion of variables owing to the lack or unavailability of sufficient data. For example, some of the data employed in the 2017 GKI is no longer produced, or does not cover enough countries to meet the requirements of the Index.

The revised structure of the 2021 economy sub-index

Based on the above, and in light of various contemporary global developments and crises, the revised structure of the economy sub-index sought to reflect the intertwined organic nature of the knowledge economy, taking into consideration two key aspects. First, the overlap between the economy and other knowledge sectors included in the GKI that represent essential components of a knowledge economy. Second, the concept of the knowledge economy in the contemporary world required clarification, as it complements other sectors; for example, the infrastructure needed to attract investment—which requires knowledge, funding, production and access to markets. In addition, economic openness, financing and value added play important roles in the localization, adoption and transfer of knowledge both locally and globally. Indeed, the definition of knowledge economy has been much debated among researchers since the 1960s.[55]

> *Although there is no agreed definition of the concept of the knowledge economy, [...] it is useful to say that human cultures throughout history have relied heavily on knowledge to survive and improve their standards of living.*
>
> *Source: Piotrowski, 2015.*

The global experts who reviewed the GKI in general, and the economy sub-index in particular, also concluded that there was a need to limit, where possible, variables that did not depend purely on quantitative data, in order to reduce potential bias—for example, variables that rely on opinion polls and may be affected by the personal judgment of respondents and the surrounding circumstances. However, some limitations, such as the availability of data at the country level or lack of a suitable objective alternative, meant that it was impossible to completely replace all non-quantitative variables.

Accordingly, the main pillars and sub-pillars of the economy sub-index were reorganized as follows. The main pillars of the economy sub-index remained the same; however, the knowledge competitiveness pillar was renamed to economic competitiveness, in line with global designations. The economic openness, and financing and value added pillars remained the same. This was confirmed through all stages of the review, including research, literature review and direct communication with a core group of international experts working in the fields of knowledge economy and human capital at international institutions, universities, and international research and development centres.

It was agreed that the sub-pillars should also be developed in accordance with the reviews and consultations. Equal relative weights were used for the main pillars and sub-pillars in order to avoid bias and ensure relative balance in the distribution of variables among the former. The conviction that variables within each pillar were of equal importance was another reason for the equal relative weights. At the level of the sub-pillars, it was agreed that each main pillar should contain two sub-pillars—similar to the format in the 2017 version—but also that those sub-pillars should be developed and updated in accordance with the abovementioned reviews and available data.

The economic competitiveness pillar

The economic competitiveness pillar consists of two sub-pillars: infrastructure investment and business agility.

- The infrastructure investment sub-pillar represents one of the most important factors for the competitiveness of economies and their ability to attract investments, which together form the backbone of the economy. Investment in infrastructure facilitates access to resources, which in turn accelerates the pace of innovation and knowledge production. According to the Organisation for Economic Co-operation and Development (OECD), infrastructure investment includes all variables and indicators relating to the infrastructure of the economy, including roads, buildings, transportation and even financial legislation and the availability of capital.[56] This sub-pillar comprises four variables that represent the concept of investment infrastructure in its broad sense, as follows: gross fixed capital formation (% GDP); Logistics Performance Index; transport productive capacities index; and building quality control index.

  Gross fixed capital formation as a percentage of GDP is generally used to express the flow of investments into infrastructure. Such investments are essential for accelerating economic growth and enhancing future production capacities. The sub-pillar also contains the logistics performance index, transport productive capacities index and building quality control index variables. These variables directly reflect the ability of infrastructure to meet the requirements of, and strengthen, foreign and domestic investment. This is an important determinant for activating and advancing the economy in terms of the production, localization and transfer of knowledge.

- Economics literature today clearly indicates the importance of agility in economic decision-making at the micro and macro levels, among individuals and institutions.[57] Therefore, as part of the development and modernization of the economy sub-index, business agility was introduced as a sub-pillar within the economic competitiveness pillar to reflect data that measures the economy's agility in relation to complex and unprecedented changes and transformations—whether global, regional or local. This data is based on: (1) the ability to dynamically respond to developments, changes and shocks; (2) the strength and flexibility of the integrative links between actors in the economy, especially horizontally between the public and private sectors, and vertically between institutions and units within one sector, whether government or private; and (3) the availability of digital infrastructure that facilitates projections and monitors the impact of external transformations on various sectors of the economy and on economic actors—be they government, private sector or individuals—and their ability to transform quickly and flexibly in order to adapt to or mitigate adverse effects. Therefore, the business agility sub-pillar includes four variables as follows: ease of starting a business; insolvency recovery rate (cents per dollar); entrepreneurial employee activity rate; and extent of corporate transparency index.

> *In today's world, agile organizations combine efficiency of scale, speed, flexibility, and resilience to compete and win.*
>
> *Source: McKinsey, 2021.*

These variables constitute the basic measures for calculating the economy's agility, its ability to renew itself, engage with positive global transformations, and work with sufficient flexibility to interact in the global economy, not only in terms of local expansion and serving local sectors, but also in attracting, maintaining and sustaining foreign investments in a safe, effective and rapid manner. It is noted here that all the variables reflected the main determinants of agility, especially with regard to: speed and flexibility in the execution of

work; response to shocks and crises; labour; productivity; institutional transparency; the ability to highlight the agility of institutions in all circumstances; and in effective cooperation and transparent communication with stakeholders.[58]

The economic openness pillar

Two sub-pillars were employed within this pillar: trade and diversification, and financial openness

- While developing the structure of the economy sub-index, the components of the trade and diversification sub-pillar were reconsidered to reflect the level of knowledge associated with trade exchange between countries on the one hand, and because diverse markets offer an opportunity to increase knowledge at the level of micro- and macro- economics. This sub-pillar contains the following variables: trade (% GDP); high-technology trade (% total trade); product concentration index; and market concentration index.

  The technology-related variables are perhaps the most expressive of the reality of knowledge exchange through trade between countries. Global intra-state trade increases the level of productive knowledge exchange between countries, and even between consumers and institutions. The same applies for trade in advanced technology. However, concentration of markets and products results in limited knowledge exchange and constitutes a lost knowledge opportunity for consumers, institutions and countries in general. Hence, the trade and diversification sub-pillar reflects the role of international trade and the openness of countries in enhancing the level of knowledge shared among them, depending on the level of trade exchange and the diversity of production and markets.[59]

> *Both geographical location and international trade […] affect the flow of knowledge between countries.*
>
> *Source: Sjöholm, 1996.*

  However, some changes were applied to the variables of the trade and diversification sub-pillar owing to data availability and updates, or their association with quantitative or non-quantitative methodologies. The variable trade (% GDP) has been retained. The variable for the prevalence of non-tariff barriers has been removed because it is based on opinion surveys.

  Some appropriate quantitative variables have been introduced, as indicated above, in order to give greater momentum to the role of trade exchange, and the diversity of markets and products.

  All of these variables are significant for transferring productive knowledge between countries, and even transferring and adopting modern technology between different countries of the world. This reinforces the argument presented that economic openness is the gateway to knowledge exchange between countries, and that foreign trade, freedom of trade and diversity in markets and products constitute the best means to produce, transfer and localize knowledge among countries.

- Within the concept of economic openness, financial openness is an essential component that determines the ability of countries to obtain and circulate knowledge. The sub-index was updated to include a sub-pillar related to financial enablement titled 'financial openness'. This sub-pillar replaces the creative economy sub-pillar; the variables of which were redistributed among other pillars and sub-pillars of the economy sub-index. In this context, the sub-pillar on financial openness contains the following variables: Chinn-Ito Financial Openness Index; foreign direct investment, net inflows (% GDP); and debt dynamics.

  The Chinn-Ito Financial Openness Index measures the level of openness of countries' markets to capital flows. It captures the level of international exchange in financing investments and financial operations, both of which are necessary for stimulating, encouraging and supporting the launch of businesses, and facilitating investments in the service and commodity sectors. Facilitating the transfer of capital, in accordance with controls on transparency and financial commitment, necessarily means supporting the transfer of knowledge between countries. The more open a country is in these respects, the higher its ability to generate, localize and transfer knowledge.

On the other hand, net foreign direct investment flows, which are mainly related to investments in real productive sectors, themselves imply the transfer and localization of knowledge. The debt dynamics variable measures the extent of change in public indebtedness, after weighting it by the credit rating of countries. Credit ratings affect the ability of countries to borrow for the purposes of capital spending, which is one of the indicators of the development capabilities of the state, i.e. its ability to manage public budgets, as well as directing debt towards development and capital projects, thereby contributing to increasing knowledge, borrowing can be used to support current spending, which may affect the ability of countries to pay and fulfil their obligations to the international community, i.e. creditors. Hence, credit rating has become one of the most important determinants of the ability of countries to obtain financing. This ability to secure financing is a result of the desire to obtain knowledge; without adequate funding, access to knowledge—through international exchange, or even domestic spending—becomes unrealizable.

The financing and domestic value added pillar

Based on the agreement of the experts involved in the review, the sub-pillars on financing and taxes, and domestic value added, were retained from the 2017 edition.

- The financing and taxes sub-pillar has been redeveloped to better reflect the positive impact of financing on the dissemination and localization of knowledge in countries, as well as to clarify the effects of tax on the generation and dissemination of knowledge. Legalizing the easy transfer of goods and services between countries is considered one of the most important factors in knowledge exchange and transfer. This sub-pillar includes four variables: domestic credit to private sector (% GDP); MSME financing gap (% GDP); total tax and contribution rate (% profit); and bank non-performing loans (%).

  The variables of domestic credit to private sector, and total tax and contribution rate, were maintained. Two new variables were introduced: bank non-performing loans to total gross loans, and MSMEs financing gap (% GDP). This gap is negative; the wider the gap, the more restricted access to knowledge becomes. The importance of this lies in the fact that MSMEs dominate today's global economy and represent more than 40 percent of GDP in emerging economies.[60] The financing gap for these companies and institutions is a major disincentive to the localization, transfer and even adoption of knowledge in the economy.

> *Small and medium-sized companies play an important role in most economies […] They are important contributors to job creation […] They represents about 90 percent of the volume of business and 50 percent of employment globally […] The World Bank estimates that about 600 million new jobs will be needed in the year 2030. Therefore, small and medium-sized companies will be of high importance for world governments.*
>
> *Source: World Bank, 2021.*

  Hence, it is important to determine the role of the banking system in supporting MSMEs and the financing capabilities of these institutions in various countries of the world. This is a major determinant of the level of knowledge in many countries.

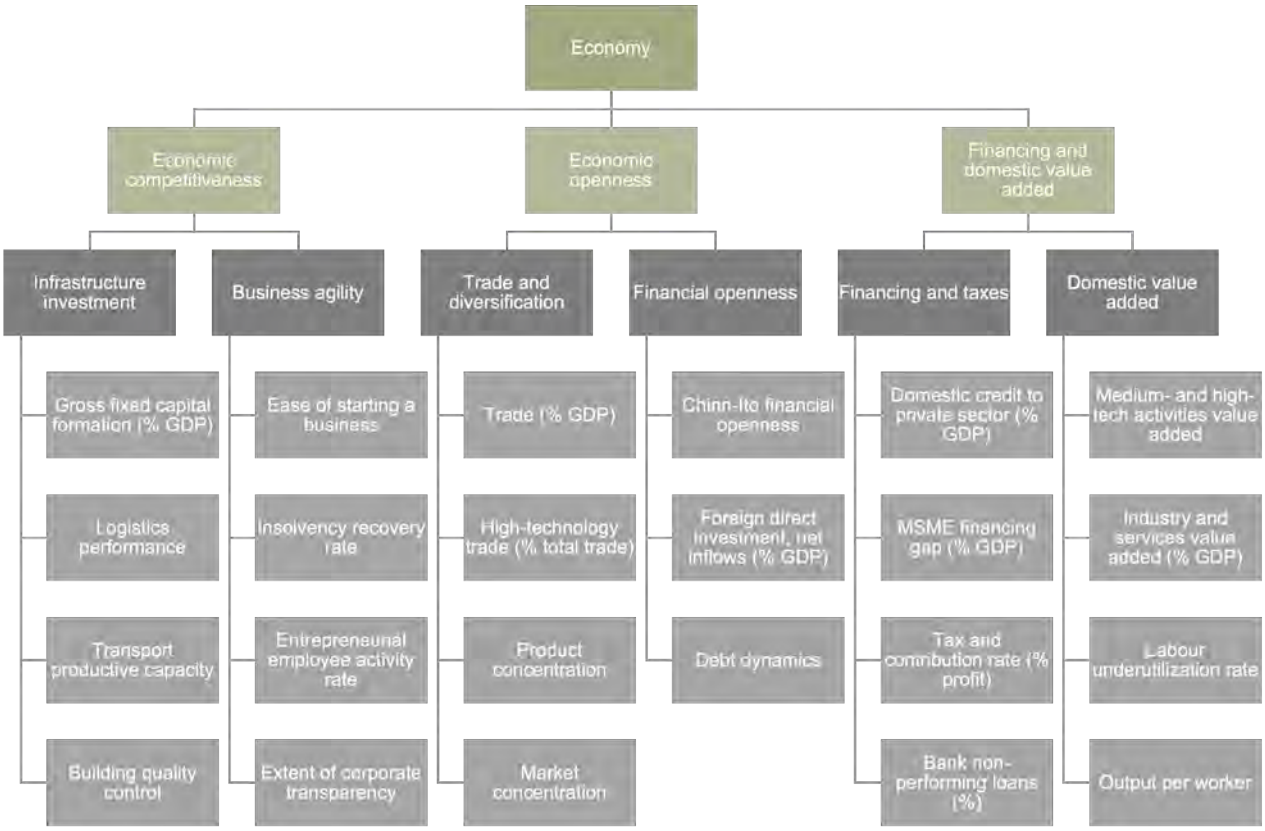
  The variable for bank non-performing loans to total gross loans has been introduced, because default rates identify the extent to which companies are able to work and expand in the future, which ultimately affects levels of knowledge. Such knowledge could be lost due to defaulting institutions, or slowed down by the failure of some businesses in certain periods. This means that the banking system has an important role to play in the continuation of knowledge exchange. Hence, a sound banking system is required for financing expansion, new projects, new innovations and large, medium, small and even micro enterprises.

  Finally, the variable expressing the tax burden was maintained. This shows the extent to which large companies and institutions are able to use their surplus profits, after taxes, to spend on various fields of knowledge, including through horizontal and vertical expansion. A high tax burden will discourage companies from spending more on different fields of knowledge, and from expanding horizontally or vertically, both domestically and abroad.

- The term, domestic value added, within the concept of economy, refers to the potential resources of countries in producing knowledge. It necessarily implies the extent to which local human and material resources are used in the production processes of both goods and services. This sub-pillar has been maintained in the new version of the sub-index, with the following variables: share of medium and high-tech activities in total manufacturing value added; industry and services value added (% GDP); composite rate of labour underutilization; and output per worker.

  The concept and role of domestic value added explicitly indicate the need to examine technology and the role of human resources. This is achieved through the four variables mentioned above. In an age of increasing technological advancement and digitization, the transfer, localization and production of knowledge becomes dependent on the level of involvement of technology sectors in various manufacturing processes. This determinant is not limited to manufacturing, but is also of great importance to service sectors. The COVID-19 pandemic has shown the importance of these sectors, and especially logistics and supply chains, in combating the virus on the one hand, and in supporting the continued functioning of economies on the other. Furthermore, labour is the basis for generating domestic value added in countries. Human capital is essential for the production, transfer and localization of knowledge. Hence, the last two variables in this pillar cover both the extent of utilization of human capital and worker productivity. Failure to utilize human capital has a negative impact on the production, transfer and localization of knowledge. A positive change in the rate of worker productivity means a positive and significant change in the progress of knowledge economies.

Figure 9: Structure of the economy sub-index



ENABLING ENVIRONMENT

Introduction

The enabling environment represents the necessary conditions for the incubation and support of the production, development and utilization of knowledge to achieve sustainable development. It is a key determinant for the development of knowledge indicators as it is related to all sectors—institutional, social, economic and political enabling factors are considered as the main pillars for knowledge empowerment. This environment comprises many elements, such as development, education and qualification policies and plans; economic and political reform projects; and legislative frameworks that help support the processes of nurturing new generations, establishing the rule of law and strengthening human rights systems to ensure human safety, welfare and equality. Health services, quality of life and the environment are also general elements that play a key role in achieving and sustaining human development.

Therefore, the six sectoral sub-indices that make up the GKI are open and dynamic systems that constantly interact with each other on the one hand, and with their surroundings within the general context on the other. They were linked to a number of contextual variables that have been proven to influence the functioning of sectors and their outputs, based on a holistic view of development and its components, placing them in the context of an integrated synthetic system that is dynamically active and interactive, without being closed or confined to one factor or component.

Enhancing the performance of the education system and improving the quality of its ouputs require a supportive environment; a health care system that ensures the physical and mental well-being through basic health services; and the preservation and protection of the environment from all forms of pollution and degradation. It also requires an enlightened culture in which broad segments of society are highly educated and social justice prevails; and a stable political climate, in which rights and duties are respected, the rule of law is established, and freedoms are exercised responsibly. Perhaps the most telling evidence of the importance of these factors is the deterioration of education in all its stages in countries that suffer instability due to conflict.

The enabling environment also plays a pivotal role in supporting the higher education sector. Establishing an effective higher education system requires a number of supportive contextual factors, including—most notably—political stability, the absence of violence/terrorism, quality legislations and government effectiveness, in addition to prominent socio-economic variables such as social inclusion and income level. All of these variables determine the general educational context, which inevitably affects the fortunes of individuals enrolling in higher education.

The RDI sector requires an appropriate political and legal environment, including political stability, rule of law, suitable legislation for the knowledge age, and the government's efficiency and effectiveness in making investment and organizational decisions that support scientific research and innovation for development. The success of countries in RDI is linked to economic performance, the achievement of the sustainable development goals, and the preservation of the natural environment. Public health variables also support a suitable environment for RDI.

The same applies for the ICT sector, which is also affected by the enabling environment—especially the legislative and political environment, as political stability provides an encouraging environment for investment and attracts international companies to participate in the provision of communications services, and both Internet and mobile applications. Having clear laws and regulations for investment helps companies grow and expand. Prompt justice, rule of law and litigation processes also help attract capital to this central sector. The level of education and, literacy, and the availability of trained manpower are essential factors for the growth of this sector and its active contribution to the knowledge system.

The socio-economic aspects of the enabling environment, especially in terms of gender equity, represent an essential determinant that supports economic indicators, particularly in relation to the local

added value and the knowledge competitiveness of countries. The institutional and political environments constitute the main pillars for knowledge formation in the economy; added value, internal and external competitiveness, and economic openness are all closely linked to the institutional framework of the country—especially in relation to the type and quality of procedures, effectiveness of the litigation system, efficiency of the government, and political stability. In addition, socio-economic enablement is important, especially with regard to women's contribution to local added value. On the other hand, public health, the level of health services, and the quality of life and the natural environment are among the general enablers upon which the economy depends to establish a competitive environment and attract sustainable investments.

The 2017 enabling environment sub-index

The enabling factors across sectors were aggregated into an independent sub-index called 'enabling environment'. Despite awareness of the many contextual factors within the various sectors, special focus has been placed on three main pillars, namely: political and institutional; socio-economic; and health and environment.

- The political and institutional pillar is divided into two sub-pillars: political and institutional. The political sub-pillar comprises two variables: political stability and the absence of violence and terrorism; and government effectiveness. The institutional sub-pillar comprises three variables: judicial independence; regulatory quality; and World Press Freedom Index.
- The socio-economic pillar is divided into two sub-pillars: gender parity and empowerment. The gender parity sub-pillar is measured through three variables: women-to-men ratio in parliament; labour force participation rate; and educational attainment (at least completed upper secondary). school). The empowerment sub-pillar is measured using five variables: adult literacy rate; mean years of schooling; GDP per capita; unemployment rate; and share of youth not in employment, education or training.
- The health and environment pillar is divided into two sub-pillars: health and environment. The health sub-pillar comprises two variables: life expectancy at birth; and under-five mortality rate. The environment sub-pillar consists of three variables: total CO2 emissions (CO2 per capita); energy intensity of the residential sector; and renewable energy consumption.

2021 enabling environment sub-index review

The enabling environment sub-index did not undergo drastic changes, and reflected dimensions which cut across and influence all six sectoral sub-indices. The three-pillar structure was maintained, with some modifications to names and variables to reflect current realities.

The revised structure of the 2021 enabling environment sub-index

The governance pillar

Governance is an issue that transcends all sectors and determines their performance. It is an essential requirement for establishing an incubating environment for development, especially in terms of participation, accountability, political stability, absence of violence, government effectiveness, quality of legislation and regulations, rule of law and control of corruption.

The effectiveness of the political environment is an important indicator due to its role in unlocking potentials, setting priorities, working to promote justice and equal opportunities, and controlling corruption. These are the dimensions emphasized by the World Bank in its efforts to monitor and measure governance at the global level by collecting and documenting data on aggregate and individual governance indicators. These indicators are categorized into six areas: control of corruption; political stability and absence of violence/terrorism; rule of law; voice and accountability; government effectiveness; and regulatory quality.[61]

Based on the above, the governance pillar was divided into two sub-pillars:

- Political environment, which is measured through two variables: peace and political stability; and voice and accountability.
- Quality of institutions, which is measured through three variables: rule of law; control of corruption; and government effectiveness.

These variables interact within the governance system, with voice and accountability serving as one of the pillars of wise leadership. Greater freedom of expression, enhanced accountability mechanisms, and follow-up, monitoring and evaluation, support peace and stability in society. All of this is only possible through radical reforms of institutional structures, improved performance of state institutions and agencies, and increased government effectiveness. These factors also contribute to strengthening the rule of law, and ensuring transparency and control of corruption of all kinds (financial, administrative, political, moral, etc.). Corruption hinders the achievement of the SDGs, as "the SDGs are comprehensive and their susceptibility to be undermined by corruption is unsurprising: it is entirely conceivable that 'a better and more sustainable future for all' often runs counter to the interests of a few and can be derailed through many forms of corruption".[62]

The socio-economic environment pillar

As explained above, the concept of enablement is today seen as a continuous societal process that complements and supports modernization and development. Through its tools and mechanisms, it enables sectors and empowers entire societies to integrate and participate in development processes, thus contributing to achieving sustainable development. Therefore, empowerment is one of the strategies adopted by international organizations to overcome the problems of poverty, exclusion, marginalization and injustice.

In this sense, the socio-economic environment falls within the context of concepts adopted by the United Nations, such as human development and sustainable development, or those related to equity, inclusion, integration, etc. The agreed definition focuses on enabling individuals and groups to acquire increased control over their lives, and the variables and factors affecting them, as well as raising their income and standard of living. It also helps individuals to build their capabilities and skills, become full partners in society, and access mechanisms that regulate their influence in society.[63]

Since social, economic and knowledge dimensions necessitate the ability to influence and participate in change, this pillar comprises three sub-pillars:

- Gender equity, which comprises three variables: female-to-male ratio in parliament; female-to-male labour force participation; female-to-male ratio in Internet usage.
- Social inclusion, which also includes three variables: social protection coverage (% of population); adult literacy rate; and share of youth not in employment, education or training.
- The standard of living sub-pillar is measured using two variables: poverty headcount ratio at national poverty lines (% of population); and GDP per capita.

Using these sub-pillars to monitor the social and economic environment reinforces the principle of full citizenship, and links knowledge and development with the adoption of the principles of equality and parity, and countering marginalization, exclusion and discrimination—especially among the most vulnerable groups in the society, such as women, the poor, and youth without education or employment. Therefore, it is generally noted that countries with high levels of human development are those that seek to enable all segments of the population to acquire the skills that allow them to realize their potential and increase their opportunities for work and political participation by promoting smart programmes and strategies. These must provide integrated and comprehensive social services guaranteeing equal opportunities, and participation in society and the economy. They must also meet the needs of the poor and vulnerable, and remove barriers to achieving inclusion and participation.[64] Without these enabling measures, no country will be able to improve living conditions and levels of social welfare.

The health and environment pillar

The environment and health are among the most prominent current issues in the global agenda that require swift, appropriate solutions that protect the safety of humans and all living creatures, and their right to enjoy a normal life in a healthy environment. This requires the adoption of integrated policies that adhere to fair and equitable standards and are capable of achieving development by combining scientific and technological development with the preservation of physical and mental health, and protection of the natural environment.

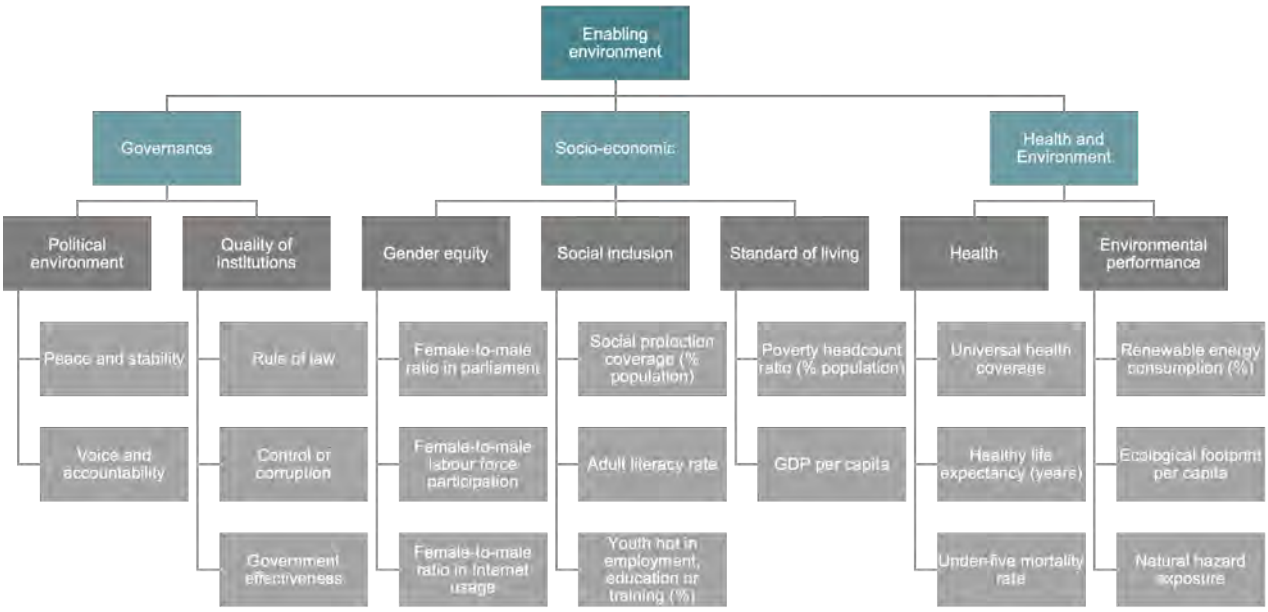
Given the significant inherent challenges in achieving these goals, it is clear that responsibility for their realization does not lie solely with professionals and specialists in these fields; rather, it is a shared, collective responsibility. Dealing with health issues is not the responsibility of medical professionals alone, just as dealing with environmental challenges is not the task of environmentalists alone. Hence, any policy that is good for the environment is also good for health. The WHO Committee on Health and Environment has stated that human health depends primarily on the ability of society to manage the interaction between human activities and its biological environment in a manner that protects and promotes health without compromising the integrity of the ecosystems that form the basis for the physical and biological environment. This requires the provision of a stable climate and the availability of environmental resources (soil, drinking water and clean air) in a sustainable manner, as well as the proper functioning of the natural systems that receive the waste produced by human societies.[65]

Hence, health and the environment were combined in a third independent pillar. This choice was necessitated by the correlative relationship between them, which has been underlined by global health studies,[66] as well as human development reports that link environmental degradation with the resultant change in living conditions. Therefore, greater attention was paid to the expected effects on, and threats to, human health, security and life.[67] This pillar is divided into two sub-pillars:

- The health sub-pillar comprises three variables: universal health coverage; healthy life expectancy; and under-five mortality rate.
- The environmental performance sub-pillar comprises three variables: renewable energy consumption (%); ecological footprint per capita; and natural hazards exposure.

These sub-pillars and their variables are characterized by the interactive relations between them and can be included within a broader concept of human well-being, which is a basic goal of sustainable development. Human well-being can only be achieved through comprehensive healthcare for all biological, mental, psychological and social aspects of life; and effective policies to eradicate poverty, and reduce the frequency of environmental threats and others related to life and society. Perhaps the greatest evidence of the importance of this interactive relationship and its direct impact on economic growth and human development is the paralysis of vital sectors throughout the COVID-19 pandemic, which led to the most severe recession the world has witnessed since World War II. The severity of the effects of these factors varied from country to country, depending on their health, economic and social infrastructure, and the resilience of existing health systems and their ability to respond to the requirements of the crisis. It was not possible to contain the crisis and its repercussions on various aspects of economic, social, health and environmental life without adopting coordinated and comprehensive measures targeting collective health. These required global financial and technical solidarity to help the poorest and most affected countries, providing the basis for the resumption of efforts to achieve safe and equitable development and prosperity for all.

Figure 10: Structure of the enabling environment sub-index



ENDNOTES

1 Organisation for Economic Co-operation and Development (OECD), 2008.

2 For more information about Principal Component Analysis, see Hair et al., 2015.

3 Only very few exceptions were made.

4 The condition was relatively relaxed because the qualifying sample size is 123 countries (conditioned by data availability from credible international sources).

5 For more information about the Budget Allocation Process method, see OECD, 2008.

6 United Nations, 2015.

7 United Nations Educational, Scientific and Cultural Organization Institute for Statistics (UNESCO UIS), 2009.

8 World Bank, 2011.

9 UNESCO IIEP, 2015.

10 World Bank, 2014.

11 UNESCO, 2005.

12 Sadik and Koleva, 2021 [in French].

13 Sadik, 2018 [in French].

14 European Training Foundation, 2015.

15 Ibid.

16 See Biavaschi et al., 2012.

17 UNESCO UIS, 2011.

18 See United Nations Department of Economic and Social Affairs, 2015.

19 World Bank, 2021a.

20 See OECD, 2014.

21 UNESCO, 2013.

22 University of Melbourne, 2018.

23 Al-Samarrai et al., 2021.

24 OECD, 2015.

25 Ibid.

26 OECD and Eurostat, 2018.

27 OECD, 2015.

28 UNESCO UIS, 2017.

29 Khorshid and Ismail, 2019.

30 Khorshid, 2015.

31 Hollanders and Es-Sadki, 2014.

32 Rezk et al., 2015.

33 See Cornell University, INSEAD and World Intellectual Property Organization, 2021.

34 United Nations Development Programme (UNDP) and Mohammed bin Rashid Al Maktoum Foundation (MBRF), 2016.

35 UNDP and MBRF, 2017.

36 United Nations Department of Economic and Social Affairs, 2008.

37 Khorshid, 2015.

38 OECD and Eurostat, 2018.

39 Ibid.

40 Khorshid, 2015.

41 Arab Thought Foundation, 2018 [in Arabic].

42 See Hollanders and Janz, 2013.

43 OECD, 2011.

44 Khorshid et al., 2020.

45 United Nations Department of Economic and Social Affairs, 2008.

46 See Schwab, 2015.

47 United Nations Conference on Trade and Development, 2021.

48 See United Nations Economic and Social Council, 2015.

49 United Nations Department of Economic and Social Affairs, 2020.

50 International Telecommunication Union (ITU), 2021.

51 OECD, 2016.

52 Benson et al., 2010.

53 ITU, 2015.

54 Abdel Moneim and Gaaloul, 2019.

55 Piotrowski, 2015.

56 OECD, 2021.

57 See Su, 2011.

58 McKinsey, 2021.

59 Gould, 2018.

60 World Bank, 2021b.

61 See World Bank, 2021c.

62 United Nations Office on Drugs and Crime (UNODC), 2021.

63 Desmons, 2018 [in French].

64 UNODC, 2021.

65 World Health Organization (WHO), 1994.

66 See WHO, 2008.

67 See European Environment Agency, 2020.

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A clear vision and strategy for knowledge development is essential to achieving the universal goal of sustainable human development. This necessarily requires the availability of tools with which to measure, evaluate and respond to key indicators reflecting global progress in the realm of knowledge development, with a view to supporting relevant and effective policymaking.

To this end, the Global Knowledge Index (GKI) represents an important addition to the global repository of knowledge on development, providing diverse and reliable data that can help countries and decision makers to understand and respond to related transformations and challenges more clearly.

It assesses seven sub-indices, chosen both for their correlative interactive relationships and their centrality to the process of cognitive and developmental progress.

The strong link between the quality of knowledge capital, on the one hand, and the ability to build effective knowledge economies that deliver equitable and sustainable development, on the other, necessitates the assessment of human resource qualification systems and their outputs, which are captured in pre-university education, technical and vocational education and training (TVET), and higher education.

The investments in, and the outputs of, scientific research, development and innovation are also central to sustainable development, and are assessed within research, development and innovation (RDI).

The progress achieved in developing technological infrastructure and applying its outputs is reflected in information and communications technology (ICT), while the economy provides an assessment of economic openness and competitiveness.

Finally, improvements in all these aspects of knowledge-based development require a suitable and supportive environment based on social and political freedoms, as well as sound environmental and health conditions, progress towards which is reflected in the enabling environment.