Although the basic model has remained consistent, the precise meaning of these values varies from one edition of the *Survey* to the next as understanding of the potential of e-government changes and the underlying technology evolves. This is an important distinction because it also implies that it is a comparative framework that seeks to encompass various approaches that may evolve over time instead of advocating a linear path with an absolute goal.

Mathematically, the EGDI is a weighted average of three normalized scores on three most important dimensions of e-government, namely: scope and quality of online services (Online Service Index, OSI), development status of telecommunication infrastructure (Telecommunication Infrastructure Index, TII) and inherent human capital (Human Capital Index, HCI). Each of these sets of indices is in itself a composite measure that can be extracted and analyzed independently.

$$EGDI = \frac{1}{3}\,(OSI_{normalized} + TII_{normalized} + HCI_{normalized})$$

Prior to the normalization of the three component indicators, the Z-score standardization procedure is implemented for each component indicator to ensure that the overall EGDI is equally decided by the three component indexes, i.e. each component index presents comparable variance subsequent to the Z-score standardization. In the absence of the Z-score standardization treatment, the EGDI would mainly depend on the component index with the greatest dispersion. After the Z-score standardization, the arithmetic average sum becomes a good statistical indicator, where "equal weights" truly means "equal importance."

For standard Z-score calculation of each component indicator:

$$x_{new} = \frac{x - \mu}{\sigma}$$

where:

x is a raw score to be standardized;

μ is the mean of the population;

σ is the standard deviation of the population.

The composite value of each component index is then normalized to fall between the range of 0 to 1 and the overall EGDI is derived by taking the arithmetic average of the three component indexes.

As indicated, the EGDI is used as a benchmark to provide a numerical ranking of e-government development across United Nations Member States, yet this approach has its own weaknesses.

The methodological framework for the United Nations E-Government Development Index has remained consistent across the *Survey* editions. At the same time, the *Survey* has been adjusted to reflect emerging trends of e-government strategies, evolving knowledge of best practices in e-government, changes in technology and other factors, and data collection practices have been periodically refined.

Figure A.1. The three components of the E-Government Development Index (EGDI)

A.2. Telecommunication Infrastructure Index (TII)

Research shows that every 10 point increase in broadband penetration increases economic growth rates, on average, by 1.38 per cent in low- and middle-income countries.[1] Ten years ago, there were only eight cell phones for every 100 people in the developing world while today there are almost 90,[2] opening opportunities for tens of millions of people who previously felt marginalised or isolated and unable to participate fully in society and engage with others. In this context, the influence of mobile broadband in the overall telecommunication infrastructure in any one nation is important.

Given the availability of suitable data,[3] a new wireless broadband subscription indicator was included in the computation of Telecommunication Infrastructure Index (TII) in the 2014 *Survey*. The TII is an arithmetic average composite of five indicators: estimated internet users per 100 inhabitants, number of main fixed telephone lines per 100 inhabitants, number of mobile subscribers per 100 inhabitants, number of wireless broadband subscriptions per 100 inhabitants and number of fixed broadband subscriptions per 100 inhabitants. The International Telecommunication Union is the primary source of data in each case.

The TII has remained largely unchanged since 2002, except for the replacement of online population with fixed-broadband subscription and the removal of number of television sets in 2008; the replacement of personal computer (PC) users with fixed Internet subscriptions in 2012; and the replacement of fixed Internet subscriptions with wireless broadband subscriptions in 2014.

The improvement of data quality and coverage has led to reduction in some data gaps that appeared in prior *Survey*s. However, in the case where gaps still occurred, data was retrieved firstly from the Word Bank data base; and secondly, when all previous measures proved unsuccessful, the most recent ITU data was used.

Each of these indicators was standardized via the Z-score procedure to derive the Z-score for each component indicator. The telecommunication infrastructure composite value for country "x" is the simple arithmetic mean of the five standardized indicators derived this way:

Figure A.2. Telecommunication Infrastructure Index (TII) and its components

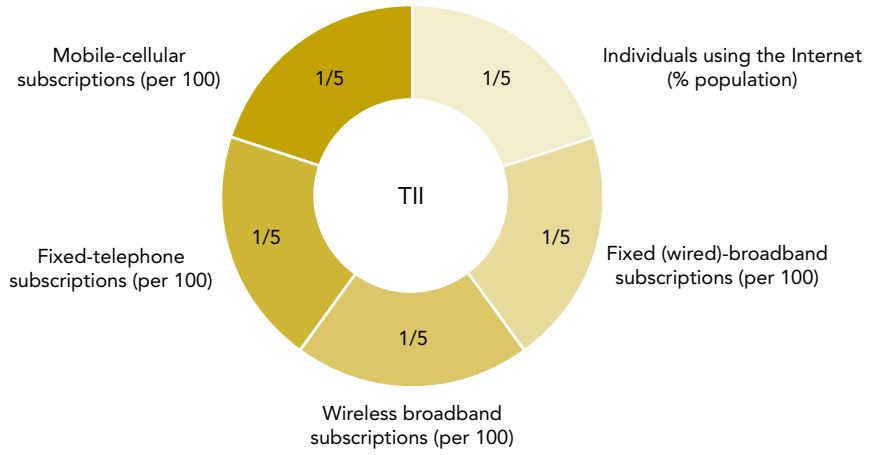


Table A.1. Telecommunication Infrastructure Index and changes of its components (*2003–2014*)

TII (2002)	*TII (2003)*	*TII (2004)*	*TII (2005)*	*TII (2008)*	*TII (2010)*	*TII (2012)*	*TII (2014)*
Internet users	Internet users	Internet users	Internet users	Internet users	Internet users	Internet users	Internet users
Online population	Online population	Online population	Online population	Fixed-broadband subscriptions	Fixed-broadband subscriptions	Fixed-broadband subscriptions	Fixed-broadband subscriptions
Personal computer (PC) users	Personal computer (PC) users	Personal computer (PC) users	Personal computer (PC) users	Personal computer (PC) users	Personal computer (PC) users	Fixed Internet subscriptions	Wireless broadband subscriptions
Fixed-telephone subscriptions	Fixed-telephone subscriptions	Fixed-telephone subscriptions	Fixed-telephone subscriptions	Fixed-telephone subscriptions	Fixed-telephone subscriptions	Fixed-telephone subscriptions	Fixed-telephone subscriptions
Mobile-cellular subscriptions	Mobile-cellular subscriptions	Mobile-cellular subscriptions	Mobile-cellular subscriptions	Mobile-cellular subscriptions	Mobile-cellular subscriptions	Mobile-cellular subscriptions	Mobile-cellular subscriptions
Television sets	Television sets	Television sets	Television sets	-	-	-	-

Telecommunication infrastructure composite value=

Arithmetic Mean (Internet user Z-score
+ Telephone line Z-score
+ Mobile subscription Z-score
+ Wireless broadband subscription Z-score
+ Fixed broadband Z-score)

Finally, the TII composite value is normalized by taking its value for a given country, subtracting the lowest composite value in the *Survey* and dividing by the range of composite values for all countries. For example, if country "x" has the composite value of 1.3813, and the lowest composite value for all countries is -1.1358 and the highest is 2.3640, then the normalized value of TII for country "x" would be:

$$Telecommunication\ Infrastructure\ Index\ (Country\ "x") = \frac{[1.3813-(-1.1358)]}{[2.3640-(-1.1358)]} = 0.7192$$

A.3. Human Capital Index (HCI)

The 2014 Survey introduced two new components to the Human Capital Index (HCI), namely (i) expected years of schooling; and (ii) average years of schooling. A study was conducted to analyze the behaviour of the new HCI. The effects of introducing new components, i.e. the expected years of schooling and the mean years of schooling, were investigated and the impact was evaluated with particular attention on significant changes in the calculation of HCI. The preliminary statistical study commissioned by DPADM validated the use of the new HCI, accentuating that the two new components has strengthened the HCI and it does not introduce any error.

These were added to two existing components of adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio which had been used for the past Surveys since 2002. This addition also echoed the call of the United Nations Secretary-General's Report[4] "A life of dignity for all: accelerating progress towards the Millennium Development Goals and advancing the United Nations development agenda beyond 2015, transformative and mutually reinforcing actions to provide quality education and lifelong learning were highlighted, amongst others, as essential for development. It was stressed that young people should be able to receive high-quality education and learning, from early childhood development to post-primary schooling, including not only formal schooling but also life skills and vocational education and training.

The definitions of the four indicators of HCI are:

1. **Adult literacy** is measured as the percentage of people aged 15 years and above who can, with understanding, both read and write a short simple statement on their everyday life.

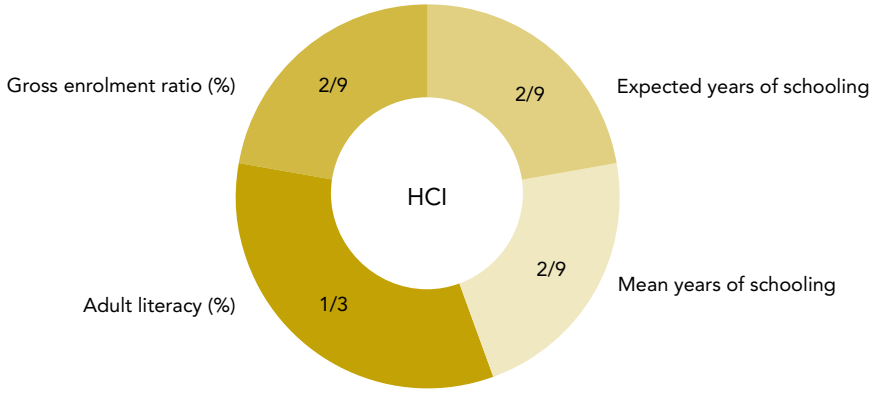
2. **Gross enrolment ratio** is measured as the combined primary, secondary and tertiary gross enrolment ratio, of the total number of students enrolled at the primary, secondary and tertiary level, regardless of age, as a percentage of the population of school age for that level.

3. **Expected years of schooling** is the total number of years of schooling which a child of a certain age can expect to receive in the future, assuming that the probability of his or her being in school at any particular age is equal to the current enrolment ratio age.[5]

4. **Mean years of schooling (MYS)** provides the average number of years of education completed by a a country's adult population (25 years and older), excluding the years spent repeating grades.[6]

The HCI is a weighted average composite of the four indicators. Similar to calculating the TII, each of the four component indicators is first standardized via the Z-score procedure to derive the Z-score value for each component indicator. The human capital composite value for country "x" is the weighted arithmetic mean with one-third weight assigned to adult literacy rate and two-ninth weight assigned to the gross enrolment ratio, estimate years of schooling and mean years of schooling derived this way:

Figure A.3. Human Capital Index (HCI) and its components



Human capital composite value =
1/3 x Adult literacy rate Z-score +
2/9 x Gross enrolment ratio Z-score +
2/9 x Expected years of schooling Z-score +
2/9 x Mean years of schooling Z-score

Then, the human capital composite value is normalized by taking its composite value for a given country, subtracting the lowest composite value in the *Survey* and dividing by the range of composite values for all countries. For example, if country "x" has the composite value at 0.8438, and the lowest composite value for all countries is –3.2354 and the highest equal to 1.2752, then the normalized value of the Human Capital Index for country "x" would be:

$$\textit{Human Capital Index (Country "x")} = \frac{[0.8438–(–3.2354)]}{[1.2752–(–3.2354)]} = 0.9044$$

Table A.2. Human Capital Index and changes of its components (2003–2014)

Components of HCI in past Surveys (2002, 2003, 2004, 2005, 2008, 2010, 2012)	*Components of HCI in 2014 Survey*
Adult literacy	Adult literacy
Gross enrolment ratio	Gross enrolment ratio
-	Expected years of schooling
-	Mean years of schooling

Missing data for mean years of schooling

For countries with missing data on the mean years of schooling (MYS) component the MYS is calculated by UNDP using UNESCO as a source and the 2010 Barro and Lee methodology.[7] This methodology makes at least five assumptions in determining the MYS estimate and it is based on the following steps:

- The other three components of the HCI, for all the nations, have been used as an input of a linkage cluster algorithm. The components of the HCI are all connected because they all refer to education and culture.

- It has been verified that these clusters are composed by countries with similar MYS values.
- The aim is to assign to nations with missing MYS value the average of the cluster they belong to.
- Tests have been applied to the results in order to verify the consistency of the results.

A.4. Online Service Index (OSI)

Taking into account the new and emerging trends since 2012 the 2014 *Survey* questionnaire was improved to encompass the new developments with a focus on:

- the rising importance of a whole-of government approach and integrated online service delivery;
- the use of e-government to provide information and services to citizens on environment related issues;
- e-infrastructure and its increasing role in bridging the digital divide, with a particular emphasis on the provision of effective online services for the inclusion of disadvantaged and vulnerable groups, such as the poor, the disabled, women, children and youth, the elderly, minorities, etc;
- the increasing emphasis on service usage, multichannel service delivery, 'open government data', e-procurement;
- the expansion of e-participation and mobile government.

The outcome was an enhanced Survey instrument with a wider range of point distributions reflecting differences in levels of e-government development among countries.

To arrive at a set of Online Service Index values, more than 90 researchers -qualified graduate students and volunteers from universities in the field of public administration—assessed each country's national website in the native language, including the national portal, e-services portal and e-participation portal, as well as the websites of the related ministries of education, labour, social services, health, finance and environment as applicable.

To ensure consistency of assessments, all the researchers were provided with a rigorous training by e-government and online service delivery experts, with years of experience in conducting the assessments. All the researchers were guided by a Data Team Coordinator who provided support and guidance throughout the assessment period. Researchers were instructed and trained to assume the mind-set of an average citizen user in assessing sites. Thus, responses were generally based on whether the relevant features could be found and accessed easily, not whether they in fact exist although hidden somewhere on the sites. While it is possible, although implausible, to search the sites meticulously for all content and features, this approach misses the key point that the average user needs to find information and features quickly and intuitively for a site to be "usable" with content readily discoverable by the intended beneficiaries.

The data collection and *Survey* research ran from May 2013 until the end of June 2013. Each country was assessed by at least two researchers who conducted the *Survey* in the country's national language in May-June. After the initial assessment, the evaluations by the two researchers on each country were compared and questions with discrepancies were reviewed again by the researchers. The third phase, from July to August, was the final review by the Data Team Coordinators who analyzed all the answers and, where needed, carried out further review and verification processes using multiple methods and sources before the scores were sent for approval by a senior researcher. Through this multilevel approach, all surveyed sites were thoroughly assessed by at least three people, one of whom has years of experience in assessing public sector online services and reviewed by one of the Data Team Coordinators.

Once the evaluation phase was completed, the statistics team produced the first draft of the OSI ranking. The data was extracted from the platform and the raw OSI scores were created. Rankings were compared with previous OSI scores, and any discrepancies were reviewed thoroughly.

The Survey questionnaire is organized in specific thematic sets of questions (subthemes) structured in four patterns corresponding to the four stages of e-government development (see Figure A.4). The patterns have been designed to provide a qualitative assessment within a rigorous quantitative methodology. Each question calls for a binary response. Every positive answer generates a new "more in depth question" inside and across the patterns. For the 2014 Survey questionnaire, the thematic subthemes identified are:

- Whole-of-government;
- Multichannel service delivery;
- Bridging the digital divide;
- Increasing usage;
- Open Government;
- E-participation.

The outcome is an enhanced quantitative *Survey* with a wider range of point distributions reflecting differences in levels of e-government development among countries.

The total number of points scored by each country is normalized to the range of 0 to 1. The online index value for a given country is equal to the actual total score less the lowest total score divided by the range of total score values for all countries. For example, if country "x" has a score of 114, and the lowest score of any country is 0 and the highest equal to 153, then the online services value for country "x" would be:

$$\textit{Online Service Index (Country "x")} = \frac{(114-0)}{(153-0)} = 0.7451$$