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Satya Pratipatti
The University of Scranton, satyanarayana.prattipati@scranton.edu

Ahmed Gomaa
The university of Scranton, ahmed.gomaa@scranton.edu

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Analysis of the Impact of the Indicators in the Networked Readiness Index

Satya Pratipatti
Ahmed Gomaa
(The university of Scranton)

ABSTRACT

World Economic Forum publishes the Networked Readiness Index (NRI) annually, to reflect the Information and Communication Technology (ICT) status of different countries. The NRI is developed by aggregating 53 indicators. The study identifies the most critical indicators to focus on, to improve the NRI status of countries at different stages of economic development. It uses data from 117 countries and analyzes the changes in the indicators along with their impacts between the years 2012 and 2016. The study explores the differences between countries by grouping them into four groups based on their NRI status. The analysis identifies six indicators with a significant impact. Low income (low –NRI) countries achieved a multi-fold increase in the use of the internet and cellular-related applications. However, the NRI for low-income countries increased by less than 5%. Contrary to the popular perception, use of cellular applications and internet use have no significant impact on the NRI. The education-related indicators were abysmally low for the low-NRI countries. In fact, the digital divide between the developed and under-developed countries had widened during the years.

Keywords: Networked Readiness Index (NRI), Information and Communication Technologies (ICT), Internet, Country Ranking, World Economic Forum, Cellular use, Digital Divide

INTRODUCTION

Policymakers in many countries believe that improvements within the Information and Communication Technologies (ICT) domain will result in economic development. Due to the lack of clear-cut evidence, the policymakers struggle to identify the impact of the most critical factors they need to focus on to improve their ICT status. Current ICT related indexes provide an overall position of each country in comparison to others but do not provide clear guidance on the most relevant factors to focus on.

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To address this need, the paper groups the countries for identifying the most important factors affecting the country ICT status. The paper uses empirical data from 117 countries to conduct a longitudinal analysis over a five years period.

Many researchers and policymakers look for a single composite measure to represent multiple phenomena in a given domain. For example, the Dow Jones Industrial Average (DJIA), and the S & P 500 are used as popular indices reflecting the stock prices in the United States. Similarly, there are many other indices reflecting competitiveness, innovation, corruption, transparency, diseases, and several other areas. Economists use measures like Consumer Price Index, GDP, housing index, sentiment index, etc., to analyze the economic trends.

The "Networked Readiness Index" (NRI) is an index developed by the World Economic Forum as a composite measure of Information and Communication Technology (ICT) in a country. The "Global Information Technology Report (GITR)" published annually by the World Economic Forum since 2001, developed an index called a Networked Readiness Index (NRI) for about 140 countries. The index reflects the capacity, adoption, use, and impacts of information and communication technologies of each country included in the GITR report. This report indicates how the countries are using digital technologies and how they are exploiting the opportunities offered by information and communications technologies (ICT). Specifically, NRI is an international assessment of a country's capacity to exploit the opportunities offered by ICTs and the impacts of ICT. It is the first global framework to map out factors that measure the ICT capacity of each country (Kirkman GS, 2002). The NRI rests on six principles: (1) A high quality regulatory and business environment (2) ICT readiness measured by ICT skills, Affordability, and infrastructure (3) Leveraging ICT through government, businesses, and population (4) ICTs impact on the economy and society (5) Drivers – environment, readiness, and usage – coevolve and reinforce each other to form a repetitive cycle and (6) Networked readiness framework should have clear policy guidance (Baller, Dutta, & Lanvin, 2016). Just like any other index, the NRI index is developed using 53 indicators. The 53 indicators are grouped into 10 pillars, they are in turn grouped into four sub-indexes. The four sub-indexes together constitute the final NRI index. Figure 1 shows the structure of the NRI.

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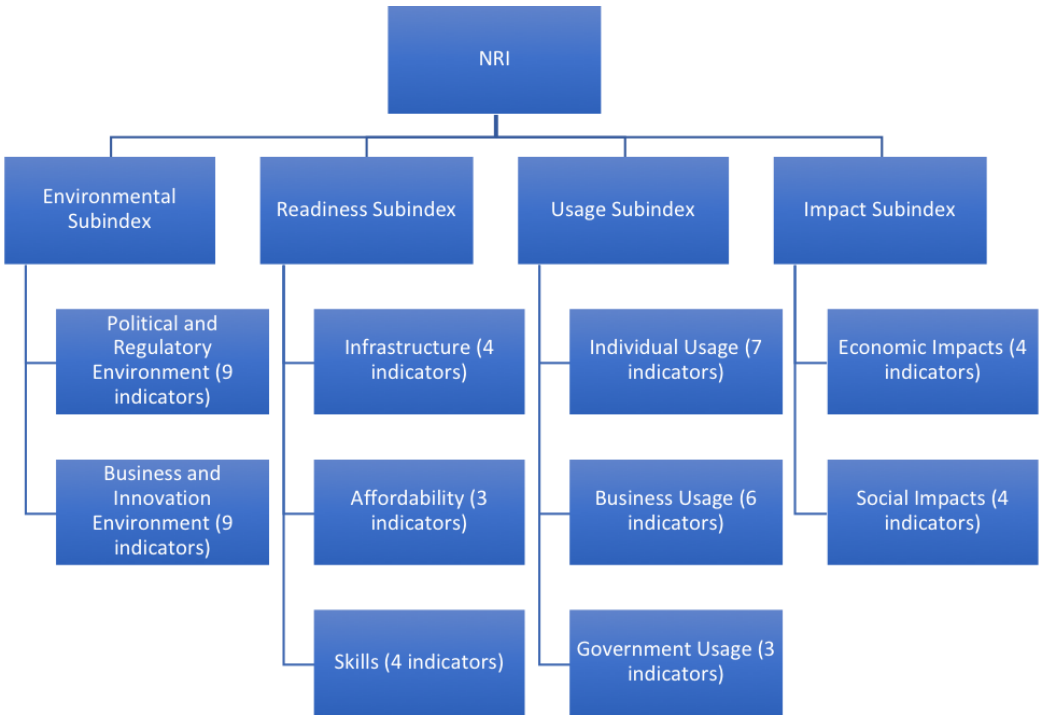
Figure 1. Networked Readiness Index (NRI) components



Whenever any index is released, the decision makers (policymakers, CEOs, etc.) ask three questions:

1) Where do we stand when compared to our peers?
2) What is the trend when compared to previous years?
3) How do we improve our standing (ranking)?

The last question "How do we improve our standing" is the most important question. In general, it is the main purpose of developing an index to know where we stand and how to improve our "standing". It is widely believed that Information and Communication Technologies (ICT) is one of the multiple contributing factors of economic growth. Thus, an improvement in the NRI status of a country is likely to have a positive impact on the economic growth of the country. In fact, the study finds a strong correlation between the NRI scores and the Gross Domestic Product (GDP) of a country. In addition to other factors, countries should take measures to improve their NRI scores to improve their economies. Then, the question is: How to improve the NRI scores (status) of a country?

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LITERATURE REVIEW

Many research studies have used data sets used in the annual Global Information Technology Reports (GITR). The research based on the GITR data can be broadly classified into four categories: 1) analysis and adjustment of the weighting framework used to compute the Networked Readiness Index (NRI), 2) relationship between NRI and other broad measures of economic activities like innovation, IT-outsourcing in selected countries, 3) regional comparisons of NRI / ICT development between specific countries and geographic blocks like European Union, and 4) mutual impacts of government policies and NRI on networked readiness in specific countries.

An alternative weighting framework based on I-distance methodology to compute the NRI score is developed by (Milenkovic, Brajovic, Milenkovic, Vukmirovic, & Jeremic, 2015), instead of the equal weighting scheme used in the GITR. "Adjusted Weighting Function (AWF) is designed by (Oriogun, 2017) to overcome the perceived inadequacies of the NRI framework, in addressing the issues of the digital divide between the developed and developing economies. The AWF model was tested in 18 countries in three regional blocks. The NRI scores computed with the new model reduced the apparent digital divide between the developed and the developing countries to a realistic level.

The relationship between the ICT reflected through NRI scores and the Summary Innovation Index developed by the European Commission is analyzed by (Ana-Maria Preda, 2014). The study was confined to the EU region and Romania. The same author published the results of a similar study in 2016 (Crisan D. A.-M., 2018) analyzing the relationship between NRI scores and the Global Innovation Index (GII) developed by INSEAD. These studies found a strong link between ICT (as measured by the NRI) and innovation. The degree of the development of the digital economy in Poland in comparison to chosen European countries, using the NRI and the Digital Economy and the Society Index (DESI) is assessed by (Miroslaw, 2017). The impact of IT Characteristics, laws, and secure communications on the Networked Readiness of different countries is evaluated by (Yunis, Ngafeeson, & Koong, 2014). The application of Roger's Diffusion Theory of Innovation developed in 1962, to the GITR data between the years 2012 to 2015 is tested by (Değerli, 2015). The authors validated several generalizations from the diffusion theory of innovation. For example, they tested the generalization: "*The consequences of the adoption of innovations usually tend to widen the socioeconomic gap between the earlier and later adopting categories in a system."* Through the analysis of GITR data, the authors found that the gap in NRI scores between high-income and low-income countries widened between the years 2012

and 2016. The authors used the NRI score as a proxy for innovation. They grouped the countries into four income levels (high, upper middle, lower middle, and low) based on the World Bank classification.

A comparative analysis of Serbia and EU countries in the context of NRI and its components is performed in (Soldić-Aleksić & Stankić, 2015). They identified the areas in which policy intervention can boost the impact of ICT on Serbian economic development. Thailand's NRI status with other countries in the ASEAN group is evaluated in (Malisuwan, Kaewphanuekrungsi, Tiamnara, & Suriyakrai, 2016). Some studies have used NRI to study e-commerce in specific countries or globally. For example, a study titled, "A Composite-Model for E-Commerce Diffusion: Integrating Cultural and Socio-Economic Dimensions to the Dynamics of Diffusion," The impact of technology, culture, and socio-economic factors on the global diffusion of e-commerce is studied by (Yap, Das, Burbridge, & Cort, 2016). This study takes other studies one step further by analyzing the impact of culture and socio-economic factors.

Other studies used NRI to evaluate the steps the government of a country has taken to improve the country's NRI standing. A study titled, "Playing the games: explaining how Luxembourg has responded to the Networked Readiness Index," observed how the NRI of the country changed as the government took steps to improve the country's ICT sector (Binsfeld, Whalley, & Pugalis, 2017). Another study titled, "A comparative analysis of IT outsourcing readiness in the East African community," evaluates the current status of IT in East African community countries by establishing a relationship between the countries' NRI and its readiness for IT outsourcing (Nduwimfura & Zheng, 2016). Some studies have used the NRI to develop new classification to show the relationship between ITC and economic development in a country or on a continent. One such study titled, "Classification Tree for Modelling the Relationship between IT&C and the Economic Development for the EU-28 Member States," introduces a new solution to show the relationship between ITC and the economic development of EU-28 members by using the NRI reports ten pillars (Crisan, Crisan, Grigore, & Baluta, 2015). The research titled, "A Cross-Cultural Study on e-Government Services Delivery," uses NRI as a secondary data to validate the hypothesis that there are social and organizational factors that play a role in how well a country adopts e-government initiatives (Nguyen, 2016). Further, this study offers recommendations that a government can use to help improve e-government development. There are other e-government studies that do not use NRI but use the components of NRI that impact the ICT usage of government.

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None of the existing studies used longitudinal analysis to identify the most relevant indicators to improve the NRI status of the countries. Such information will help the governments to focus on the most relevant indicators. More importantly, they need to know which policies have previously shown success in countries with similar stages of development. This study analyzes the changes in the indicators and their impacts on the NRI status between the years 2012 and 2016. Therefore, this research is new and expected to be helpful to governments and policymakers.

PROBLEM STATEMENT

The main problem addressed in this paper is: How to improve the NRI status of a country?

As stated before, the Networked Readiness Index (NRI) is based on 53 indicators. If a country wants to improve its NRI score should it improve scores on all the 53 indicators? Instead, should it concentrate on few high impact indicators? How to identify the relative importance of each indicator in terms of its impact on the NRI status? While the Global Information Technology Report (GITR) provides a comprehensive picture of the status of ICT, it doesn't include any detailed analysis or recommendations on individual indicators used in the report. The indicators are the basic bricks on which NRI is built and any country which wants to improve their NRI status needs to focus on these indicators. This study analyzes the indicators used in the NRI reports, in terms of their relative impact on changing the NRI status of the countries.

The Global Information Technology Report (GITR) provides information on the status of ICT in a specific year in each country. The reports do not include a detailed analysis of the changes in indicators between the years. Some studies estimated, that it would take anywhere from 3 to 7 years to achieve positive results, from the IT investments (Brynjolfsson & Hitt, 2003). For example, if a country invested in IT infrastructure in 2012, it may take several years for the impacts of improved infrastructure to show up in increased usage among individuals, businesses, and governments. The NRI score for the year 2012 will not reflect the impacts of the incremental investments in the IT infrastructure in that year (2012). Those impacts are likely to be captured in the NRI scores of subsequent years. The GITR studies, do not capture the lag effects of investments in IT infrastructure, training, government policies, and other related factors. These lag effects can be identified through longitudinal analysis. Since its inception in 2002, the methodology to compute NRI changed frequently to accommodate changing trends in the ICT domain. However, from 2012 onwards, the NRI methodology remained stable. It

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appears that the World Economic Forum stopped publishing GITR and NRI after 2016. Because of these constraints, the longitudinal analysis can only be performed between the years 2012 and 2016. The goal of the longitudinal analysis is to identify the IT indicators with high impact on the NRI status of a country and recommend appropriate policies to improve the NRI status.

The study attempts to develop specific recommendations to the policymakers on how to improve the NRI status of their countries, which will have an indirect impact on economic growth. The GITR study provides data for nearly 140 countries, ranging from developed countries to poor countries. It is assumed that different countries need different policies to improve their NRI status. Each country has a different economic status and different needs. A nation, with the highest NRI score, is likely to be more technologically advanced than the countries in the lower quartile of NRI scores. For example, the more advanced countries with highly developed IT infrastructure may focus on cutting edge applications like machine learning, whereas the poor countries may be struggling to provide basic infrastructures like cell phone spectrum and internet access. Because of different stages of development, the relative impact of the IT indicators is likely to be different for different countries. This study divides the countries into four groups based on the NRI scores and develops policies to improve the NRI status in each group of countries.

In summary, to answer the main issue, i.e. to improve the NRI status of a country, the study attempts to address the following:

1. What are the most important indicators in terms of their relative impact on the NRI status of a country?
2. To develop policy recommendations to improve the NRI status of the countries, in different stages of economic development.

The methods used to address these issues are explained in the next section.

METHODOLOGY

Data

The study uses the data from the annual Global Information Technology Reports (GITR) published by the World Economic Forum, for the years 2012 and 2016. The main purpose of GITR is to compute the Networked Readiness Index (NRI) for each country from the data collected from 53 indicators. As conceptualized by

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the World Economic Forum the Networked Readiness Index reflects the "set of factors that determine a country's capacity to use information and communication technologies for increased competitiveness and well-being". The structure and the components of the NRI are shown in Figure 1(Page No: 2). The GITR collected the data on the 53 indicators and aggregated the data into the Networked Readiness Index (NRI), through "pillars" and "sub-indexes" as shown in Figure 1.

In the year 2016, the GITR covered 139 countries accounting for 98.1% of world GDP. Of the 53 indicators, the data on 27 indicators were sourced from various international organizations like the International Telecommunication Union (ITU), UNESCO, the World Bank, etc. The data on the remaining 26 indicators were derived from the World Economic Forum's Executive Opinion Survey.

Data Analysis

The analysis is done in three steps:

1. Computation of the changes in indicator values and the NRI scores between
   the years 2012 and 2016 (Longitudinal analysis)
2. Grouping the countries based on their NRI status. Because of the strong correlation between the NRI scores and the Gross Domestic Product (GDP) of a country, the groups based on NRI status are similar to the groups based on economic status.
3. Evaluate the relative impact of the indicators on the Networked Readiness Index (NRI), using statistical techniques.

1. Longitudinal analysis (2012 – 2016):

Since its inception in 2002, the NRI report frequently changed its methodology to accommodate changing trends in the ICT domain. However, from 2012 onwards, the NRI methodology remained stable.

The study compares the Networked Readiness Index (NRI) and the indicators for the years 2012 and 2016. It first removed all anomalies, by removing the null values from the 2016 index to match the list of countries in 2012. Data normalization took place in the report, to account for extreme values and missing data. After cleaning the data, the analysis is done using the data for 117 countries and 43 of the 53 indicators. The list of the countries with NRI scores for the year 2016 are provided in Appendix A. The list of the 43 indicators used in this study is given in Appendix B. This paper uses the raw scores for all the indicators, provided by the World Economic Forum, the main sponsor of the Global Information Technology Reports

(GITR). However, it should be noted, the GITR study converted the raw scores of some of the indicators, into scaled scores (1 to 7), for computing the Networked Readiness Index (NRI). The GITR study used the same methodologies to convert the raw scores into scaled scores in both the years 2012 and 2016.

The rate of changes in the indicator scores and the NRI scores are computed using standard methods as shown in equations 1, 2 and 3.

(1)

$$\% \Delta NRI = \left[\frac{NRI_{2016} - NRI_{2012}}{NRI_{2012}}\right] x\ 100$$

(2)

$$Average\ (\% \Delta Indicator_{i,all\ countries}) = Average\left[\frac{Indicator_{i,all\ countries\_2016} - Indicator_{i,all\ countries\_2012}}{Indicator_{i,all\ countries\_2012}}\right] x\ 100$$

(3)

Where, for each indicator i, in country c:

$$(\% \Delta Indicator_i) = \left[\frac{Indicator_{i,c-2016} - Indicator_{i,c-2012}}{Indicator_{i,c-2012}}\right] x\ 100$$

The list of countries, with NRI scores, changes for the years 2012 and 2016, are given in Appendix A, with other details for each country.

2. Country grouping methodology:

The paper groups the countries into four different quartiles based on the NRI score for the year 2016. This methodology is similar to the methodology used in the summary innovation index for the European Union SII (Enterprise, 2001) where the countries are grouped based on the level of innovation.

This paper uses NRI ranking as a proxy for the level of innovation. For example, the indicators that may influence the NRI of Cambodia may be different from the indicators that affect the NRI of France. Therefore, grouping the data set into quartiles and analyzing the data within each group helps to identify the most important indicators in each group in terms of impact. The groups are labeled A, B, C, and D, from the most advanced tier as tier A to the least advanced tier as tier D.

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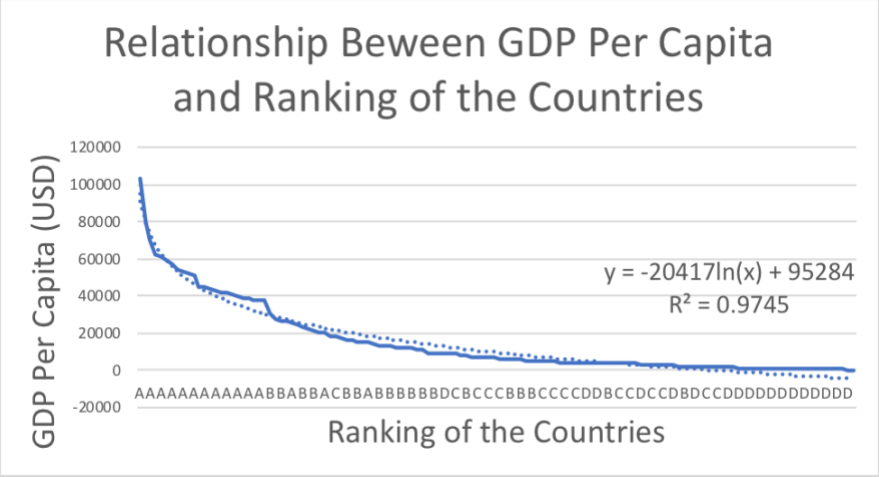
The list of countries in each group are given in Appendix A. The list also provides the NRI score of each country for the years 2016, the percentage change in NRI scores, the per capita GDP for each country and the GDP growth rate between 2012 and 2016. Appendix B provides group averages for each indicator in terms of the change in indicator scores between the years 2012 and 2016.

(Sabbagh & Katz, 2012) Found a strong correlation between digitization and economic growth. The chart in Figure 2 shows high NRI Countries (Group A) have higher GDP per capita and the low NRI countries (Group D) have lower GDP, validating the group methodology used. For example, Qatar, which is in group A has the highest GDP per capita ($127,480) compared to Malawi, which is in category D, has the lowest GDP per capita of $1,169. However, countries in groups B and C do not show a clear linear relationship between GDP per capita and our ranking. For instance, Brazil, which is in category C, has a GDP per capita, $8555, which is higher than China, which is in category B and has a GDP per capita of $8113. Thus, there exists a logarithmic relationship between GDP per and NRI score, as shown in Figure 2. Further, the paper ranking system explains that 97% of the countries that have high GDP per capita have high NRI scores and low GDP per capita countries have low NRI scores.

Figure 2. The relationship between the GDP per capita of countries and ranking of the countries based on NRI scores



Differences between the groups

To identify the indicators with significant differences between the groups, t-tests were used. The study tested whether there is any statistically significant difference between the "High NRI (Group A)" and "Low NRI (Group D)" groups, using the criterion variable "change in indicator scores between 2012 and 2016". The t-tests were run for each of the 43 variables (Indicators). The results discussed in the next section, show that the changes in nearly one-half of the indicators used are significantly different between the groups.

3. The relative importance of "indicators" on the changes in the Networked Readiness Index (NRI)

While the GITR study used all the indicators to compute the Networked Readiness Index (NRI), it is assumed that some of the indicators will be more influential than others, in changing the NRI between the years 2012 and 2016. One of the main goals of this study is to identify the indicators that have a significant impact on the changes in the Networked Readiness Index (NRI). For this purpose, the study used the multiple regression analysis using "change in NRI" as the dependent variable and the "change in indicators" as the independent variables. The results discussed in the next section, indicate that six indicators have a statistically significant impact on the "change in NRI". The study used stepwise multiple regression analysis to identify the significant indicators.

RESULTS

Appendix A gives the overall profile of the countries included in this study. After removing inconsistent and missing data, the study analyzed data from 117 countries and 43 of the 53 indicators used in the Global Information Technology Reports (GITR) of the years 2012 and 2016. The list of the countries and other statistics for each country are also provided. The list of the 43 indicators used are given in Appendix B

Analysis of Groups

Appendix A gives the group-wise data for countries and Appendix B provides data for changes in the 43 indicators used in the study. The countries are grouped based on the NRI scores for the year 2016. The summary stats for the groups are as follows:

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Table 1. Overall stats for the countries' groups

	All Countries	Group A	Group B	Group C	Group D
NRI 2016 (1-7)	4.26	5.4	4.38	3.83	3.12
NRI 2012	3.96	5.22	4.05	3.65	3.09
NRI Change %	5	4.6	7.3	5.3	1.8
GDP Per Capita $	23,847	51,922	24,528	10,931	4,199

Groups A to D has progressively lower NRI scores and GDP levels. The NRI growth rates are higher for the middle groups and lowest for Group D. In 2012 Group D NRI was 59.2% of Group A NRI, in 2016 the Group D NRI was 57.8% of Group A NRI. The digital divide between the high NRI group and the low NRI group increased marginally, between the years 2012 and 2016. The low NRI groups are falling further behind when compared to other groups.

Appendix B gives the details of average changes between the years 2012 and 2016 for each of the 43 indicators. The top ten indicators (in terms of changes) are listed in table 2 below.

Table 2. Top ten indicators in terms indicator changes in each country group.

Indicator	All Countries	Group A	Group B	Group C	Group D	D-A
	% Change 2012-16	% Change 2012-16	% Change 2012-16	% Change 2012-16	% Change 2012-16	Diff.
Int'l Internet bandwidth	476	442	475	435.6	578.2	136
E-Participation Index	301	122	254	343	541	419
Households w/ Internet access	273	13.8	100	489	549.6	536

Fixed broadband Internet subs	199	35.8	73	261.6	498.7	463
Internet servers	127	52.7	114.6	149.6	210	157
Households w/ personal computer	63.6	10.5	50.6	110.4	85.5	75
Individuals using Internet	58.4	13.1	41.4	60.3	138	125
Government Online Service Index	55.5	48.4	52	57	67	19
Capacity for Innovation	29.4	15.9	25	37.8	41	25
Fixed broadband Internet tariffs	27.2	28.2	10	18.6	61.75	33.6

It may be observed from Table 2 that all the top ten indicators are related to the internet and its use by individuals and government. The indicator growth rates for Group A, are lower than the growth rates in the other groups, especially when compared with the growth rates in Group D. More likely the countries in group A were at a very high level in 2012 with a limited room to grow more. The countries in group D are likely to be at a lower base, with much more room to grow. For example, the growth rate for the indicator "individuals using internet" is 13% for Group A compared to 138% for group D. In 2012, nearly 90% of the individuals in Group A must be using internet, as compared to a very small percentage in group D. The patterns are similar for other internet related indicators. The averages of the rates of growth for indicators for each group are: Group A: 20.1%, Group B: 30.4% Group C: 46.7, Group D: 70% and for all countries: 40.23%. The growth rate for the individual indicators will be much less for Group A countries, as those countries have already achieved a higher level of NRI status compared to other groups. The indicators also include a few indicators in non-internet related areas like education, training, etc. Table 3 below gives the rate of growth for the education-related indicators in each group.

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Table 3. Education related indicators growth rates

Indicator	All Countries	Group A	Group B	Group C	Group D
	% Change 2012-16	% Change 2012-16	% Change 2012-16	% Change 2012-16	% Change 2012-16
Secondary Education: Gross Enrollment	9.3	8.2	8.2	6.5	16.4
Internet access in schools	5	0	2.5	4.5	15.5
Quality of math & science education	2.4	3.3	2.8	3.6	-4.4
Extent of staff training	1.67	1.7	1.4	1.7	0.3
Quality of management schools	1.4	2.5	2.8	0.23	-0.4
Quality Educational Sys.	0/45	1.2	1.8	-0.8	-2

The growth rates for the education-related indicators are very low, especially when compared to the growth rates for internet related indicators. The countries in higher NRI and economic groups (Groups A, and B) may already be at higher levels, in the case of secondary education and quality of educational systems, with very little room for further improvement. However, the countries in low NRI groups (Groups C and D), need to do much more in relation to educating their citizens, to be able to effectively use the information technologies. Without educational skills, and computer literacy, the countries in the low NRI groups, cannot improve their NRI status, no matter how much they spend on internet related indicators. It is pointed out by (Dutta & Bilbao-Osorio, 2012) that unfortunately, the countries in Group D, have negative to no growth in education-related indicators between 2012 and 2016.

As mentioned in the previous section, t-tests were conducted to identify the indicators with a significant difference between the groups. The study tested whether there is any statistically significant difference between the "High NRI

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(Group A)" and "Low NRI (Group D)" groups, using the criterion variable "change in indicator scores between 2012 and 2016". The t-tests were conducted for each of the 43 indicators. The results are shown in Appendix C. Only those indicators with a significance level of .05 or less are shown in Appendix C. There are 20 indicators whose change scores are significantly different between Groups A and D. Appendix C also shows the average scores of the indicator for each group, the growth rate, and the t-statistic. The takeaways from the t-test results are as follows:

1. In general, for the countries in the "low NRI Group (D)" the percentage of growth in the "indicators" is significantly higher than for the countries in the "high NRI Group (A)". The indicator scores for the countries in Group A are much higher than the scores for the Group D countries. With a "low base scores", the countries in Group D, have much more room to grow than the countries in Group A with a higher base.

2. The highest rate of growth in group D: 191% - Households with Internet Access. Despite such a high growth rate, only 9.9 percent households in group D countries have Internet Access in 2016, as compared to 85 percent of households with internet access in Group A countries with a growth rate of 12.5%. The patterns are similar to other indicators like Fixed Broadband subscriptions, individuals using the internet, households with personal computers, etc.

3. With 90% coverage of mobile phone subscriptions, and individuals using the internet, the group D countries have nearly caught up with Group A countries, who have more subscriptions than the number of people.

4. Except for mobile phone coverage and subscriptions, for all other indicators the Group D countries, have a long way to catch up with group A countries. For example, the electricity production for group A countries is 11,349 kWh per capita as compared to 749 kWh per capita for group D countries. Same is the case with "internet servers", "secondary education", and others. The Secondary Education Enrollment rate is around 50% for Group D, as compared to over 100% enrollment for Group A countries. Secondary education is one of the most important requirements to effectively harness the benefits of information technologies.

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Relationship between the Indicators and the Networked Readiness Index (NRI)

While the GITR study used all the indicators to compute the Networked Readiness Index (NRI), it is assumed that some indicators will be more influential than others in impacting the NRI. One of the main goals of this study is to identify the indicators that have a significant impact on the changes in the Networked Readiness Index (NRI). For this purpose, the study used the multiple regression analysis using "change in NRI" as the dependent variable and the "change in indicators" as the independent variables. The study used stepwise multiple regression analysis to identify the significant indicators. The analysis was done using SPSS software. The criteria to include the variables was set at a p-value of 0.10 or less. Only the variables with significance level of 0.05 or less were retained for the final analysis. The results of the final multiple regression analysis are shown below.

Dependent Variable: Percent Change in NRI between 2012 and 2016

R Square Adjusted:0.611 F-Value:31.3 Significance level:.00, Degrees of freedom: 6

Independent Variables (Indicators) Percent Change between 2012 -2016	Co-efficient	Significance
Constant	4.437	
Laws relating to ICTs	0.190	0.00
Intellectual property protection	0.073	0.004
Impact of ICTs on access to basic services	0.208	0.000
Fixed broadband Internet tariffs	-0.004	0.005
Intensity of local competition	0.134	0.001
Internet access in schools	-0.67	0.04

The changes in these six indicators between the years 2012 and 2016, explain 61% Change in the NRI Index between the years 2012 and 2016. Each significant independent variable (indicators) is discussed below.

Laws related to ICTs: Average scores (2016): Group A: 5.15 and Group D: 3.1 on 1 to 7 scale. Growth Rates (2012-2016): Group A: - 1.9%, Group D: - 1.5 %. No significant difference between groups A and D in growth rates. With very little change in growth between 2012 and 2016, for both the groups, the laws related to ICTs appear to remain stable. Regulations/laws relating to ICT have a positive impact on the NRI. The governments in Group D countries should try to enact effective laws using the experience of the countries in Group A.

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Intellectual Property protection: Average scores (2016): Group A: 5.54 Group D: 3.30 on 1 to 7 scale. Growth Rates: Group A: 5.4%, Group D: 15.7%. With 16% growth, the Group D countries appear to have tried to improve, the IP protection between 2012 and 2016. Still, they are far behind Group A countries who are at the top of the scale.

Access to basic services – impact on IT: Average scores (2016): Group A: 5.7, Group D: 3.4 on 1 to 7 scale. Growth Rates: Group A: 1.9% Group D: - 8.8%. Growth rates significantly different between groups A and D. Group D countries appear to have reduced the access to basic services through IT by 9%, between 2012 and 2016. Better access to basic services will improve the NRI score. The group D countries need to increase access to basic service, through information technologies (IT).

Fixed Broadband Internet Tariffs: Average tariffs (2016): Group A: $36.51 per month, Group D: $96.71 per month Group A countries increased the tariff from $30 to $36.51 per month between 2012 and 2016. The Group D countries reduced the tariff from $179 to $97 per month between 2012 and 2016. Still, the broadband tariffs in Group D are three times higher than the Group A countries. Fixed broadband internet services are needed for online education and other applications where mobile broadband is not suitable. The fixed broadband tariff in Group D countries is too high, and only rich people can afford it. The higher tariffs on fixed broadband appear to impact the NRI negatively. The governments in Group D countries should take steps to reduce the tariffs for the fixed broadband so that broad segments of the population can take advantage of the broadband internet applications.

The intensity of local competition: Average scores (2016): Group A: 5.53, Group D: 4.7 (on 1 to 7scale). Growth Rates: Group A: 1%, Group D: 7.7%. Growth rates significantly different between groups A and D. The local competition increased by 8% in Group D countries compared to about 1% in Group A countries between 2012 and 2016. However, Group A countries have more competition in ICT industries than the Group D countries. Higher competition is expected to result in higher NRI score.

Internet access in schools: Average scores (2016): Group A: 5.7, Group D: 3.3 (1 to 7 school). Growth Rates: Group A: - 0.4%, Group D: 12.8%. Growth rates significantly different between groups A and D. The internet access in schools for group A countries remained at a high level with little room for further growth. For group D the internet access in schools increased by nearly 13% from a low level.

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Even after this modest growth, internet access in schools remained much lower than group A countries. Internet access in schools is positively correlated to the NRI change. However, the regression coefficient is negative. Intuitively, internet access in schools is expected to have a positive impact on the NRI scores. Group D countries should try to provide more internet access in the schools.

DISCUSSION AND CONCLUSION

As stated earlier, the study focused on two main goals: 1) to identify the most important indicators in terms of their relative impact on the NRI status of a country, and 2) to analyze the differences between the developed and low-income countries, from the perspective of Networked Readiness. The study identified six indicators, having a significant impact on the NRI. These six indicators explain 61% of the changes in NRI between the years 2012 and 2016. The study also analyzed the differences between "High NRI (Group A)" and "Low NRI (Group D)" groups, extensively. Because of the strong correlation between the GDP and the NRI, the high NRI and low NRI groups are considered as proxies for "developed" and "low-income" countries. The takeaways from the study are as follows:

1. The digital divide between the advanced countries and the low-income countries has increased slightly between the years 2012 and 2016. The growth rate in NRI was 1.8% over a five-year period for low-income countries as compared to 8% for advanced countries. With a low starting base (60% of the advanced group), the low-income countries should be growing in double-digit rates.

2. Low-income countries achieved large growth in the areas related to the internet and mobile use but not in the areas that matter in terms of Networked Readiness.

3. Low-income countries had small to negative growth in the areas related to the six indicators shown to have a significant impact on the NRI. In fact, in two out of the six areas they had negative growth.

4. Over the five-year period, the quality of the educational systems has declined slightly for the low-income countries. As the quality of education is "poor" to start with, the quality should be increasing rather than going backward.

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THE SOLUTIONS

1. Focus on the significant areas that matter. Governments in low-income countries can act on all the areas related to the significant indicators. Regarding the "*Laws relating to the ICTs*", and the "*Intellectual Property Protection*", the governments can take direct action. These two steps will encourage more IT companies to enter the low-income countries and increase the competition to provide digital services. The governments can provide more and more basic services online, increasing the quality of the service, increasing transparency, and the potential to decrease corruption. The governments can also take steps to provide more access to the internet in the schools. The governments should study the benefits of online education at primary and secondary levels, especially in those countries which lack basic infrastructure for education (school buildings, books, and competent teachers). The governments should also take steps to reduce the fixed broadband tariffs, through increased competition and subsidies to low-income communities.

2. Redirect the focus from internet and mobile related areas to the improvement of educational systems. The mobile and internet will grow on their own without much government action. But education is necessary to harness the benefits of information technologies. Without education, a large segment of the population in poor countries, will not be able to harness the benefits of the digital economy.

FUTURE WORK

Measuring "Information and Communication Technologies (ICT)" and its impacts is a complex undertaking. The NRI is a comprehensive index, incorporating many areas like infrastructure, use, impacts, etc. As discussed, the NRI uses over 50 indicators to compute the index. Some of the indicators are not independent, some of them depend on each other. For example, the usage indicators depend on the affordability of services (tariffs), educational levels, and other infrastructure factors like electricity. To identify the pure impacts of each indicator, more advanced statistical analysis techniques, like path analysis, and simultaneous equations need to be used.

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The impacts of NRI on other macro factors like competitiveness, governance, corruption, and other areas can be examined. Countries can be grouped into different categories based on population sizes, type of governance (democracy, autocracy, monarchy, communist, etc.). It may be easier to improve NRI in smaller countries, than in larger countries. Similarly, it may be much easier to implement policies in non-democratic countries than others. There is a vast potential for research in these areas.
One future area of research is to develop a Function Index Readiness Matrix (FIRM). The FIRM can be used as an assessment tool for policymakers, organizers, developers, and the public to view the country and its top categories that make most of the impact on the country NRI.

Another area of future research is the validation of the model by using one country to check whether the investment by the government in one of the top five categories actually impacted the NRI positively. In addition, why are the top 5 categories mentioned in each group are important? The paper provided "the what" but did not provide the empirical aspect of why they are important. Furthermore, additional research may follow our methodology to check for different usage of publicly available indexes to find the most important factors that will make an impact on a specific index.

In addition, the NRI data is just one data source. This data should be overlaid with other data sources to gain more actionable insights, for instance, the absolute value of the GDP needs to be looked at, as a country with a high GDP will have different objectives, especially if it increased in the NRI rank or the ICT Usage sub-index. Same goes for the type of Government (Democratic, Dictatorship or Kingdom), as the influence of the government authority will be different in terms of ICT investment. This can be viewed on a proxy level by comparing the adoption of new technologies where progressive governments exist in more centralized governments when compared to less centralized governments. In addition, the population level has an impact, as 100,000 individuals in a 1 billion populous country will not be the same as 100,000 individuals in a 10 million populous country. Finally, the number of educated people in a country, from an absolute perspective as well as from a relative perspective to the total population will have an impact on the changes in the investment on ICT and the presentence of ICT infrastructure usage. Those interrelationships and their impact on which variables make more sense to work on from a government perspective need to be looked at with a more cautious eye.

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APPENDIX A

Countries used in the Study (117)
(NRI Data from GITR and GDP Data from World Bank)

Country Names	NRI (2016)	NRI Change % 2012 to 2016	GDP Per Capita PPP$ 2016	GDP Growth Per Capita % 2012 to 20	Group-Basedsed on NRI 2016
Albania	3.87954981	-0.39%	11540	9.6	C
Algeria	3.2057467	6.35%	15013	12	D
Armenia	4.27440728	22.40%	8833	15.5	B
Australia	5.49225596	3.84%	46012	8	A
Austria	5.44747481	3.68%	50552	8.8	A
Azerbaijan	4.30905009	9.10%	17257	6.6	B
Bahrain	5.06955505	3.49%	50000	19.9	A
Bangladesh	3.33277449	4.14%	3580	29.9	D
Belgium	5.37473768	4.73%	46429	9.6	A
Benin	2.88634706	-5.32%	2168	14.7	D
Bolivia	3.33767097	14.23%	7234	22.6	D
Bosnia and Herz.	3.63757773	-0.40%	12172	19.5	C
Botswana	3.53227897	-1.42%	16957	16.9	C
Brazil	4.01498595	2.52%	15124	-1.8	C
Bulgaria	4.11177136	5.66%	19243	18.7	C
Cambodia	3.35207677	1.08%	3737	30.7	D
Cameroon	2.98217529	1.61%	3609	17.3	D
Canada	5.56378108	1.06%	44644	5.9	A
Cape Verde	3.82630028	3.09%	6564	7.7	C
Chile	4.6151928	3.96%	23194	7.3	B
China	4.24229808	3.17%	15529	36.8	B
Colombia	4.13309294	6.83%	14154	17.4	C
Costa Rica	4.47844302	11.85%	16610	17.5	B
Côte d'Ivoire	3.38570905	13.68%	3693	33.7	D

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Country Names	NRI (2016)	NRI Change % 2012 to 2016	GDP Per Capita PPP$ 2016	GDP Growth Per Capita % 2012 to 20	Group-Basedsed on NRI 2016
Croatia	4.28649362	1.62%	23422	10.8	B
Cyprus	4.57466059	-1.83%	32708	2.5	B
Czech Republic	4.7388113	9.39%	34749	19.6	B
Dominican Republic	3.63698316	0.90%	15205	29.9	C
Ecuador	3.91525723	13.28%	11242	6.9	C
Egypt	3.66133686	-2.78%	11129	11.3	C
El Salvador	3.71453045	9.91%	8617	12.3	C
Estonia	5.40583592	6.15%	29743	14.3	A
Finland	5.95628282	2.57%	43346	6.7	A
France	5.34206083	4.39%	41343	9.8	A
Gambia, The	3.30807129	-2.95%	1677	5.5	D
Georgia	4.25381925	18.28%	10005	24.6	B
Germany	5.55449235	4.32%	48861	12.2	A
Ghana	3.5070749	1.87%	4292	16	C
Greece	4.06584028	1.83%	26779	5.9	C
Guatemala	3.4534365	0.64%	7945	13.1	D
Guyana	3.59618707	0.42%	7836	19.9	C
Honduras	3.70914129	8.23%	4737	12.4	C
Hungary	4.35868225	1.36%	26701	15.6	B
Iceland	5.54869232	4.15%	50104	23.8	A
India	3.75158305	-3.65%	6571	33.6	C
Indonesia	4.00890323	7.05%	11609	23.2	C
Iran, Islamic Rep.	3.740683	11.29%	19949	17.8	C
Ireland	5.33859738	6.44%	71472	53.7	A
Israel	5.43830831	3.86%	37258	17.5	A
Italy	4.42525202	6.15%	38370	5.9	B
Jamaica	3.88159532	0.59%	8821	8.1	C
Japan	5.6488188	7.50%	42203	13.5	A

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Country Names	NRI (2016)	NRI Change % 2012 to 2016	GDP Per Capita PPP$ 2016	GDP Growth Per Capita % 2012 to 20	Group-Basedsed on NRI 2016
Jordan	4.22410619	1.19%	9048	-0.9	B
Kazakhstan	4.58955649	14.02%	25286	12.9	B
Kenya	3.82595378	8.86%	3155	19	C
Korea, Rep.	5.56646569	1.78%	36532	13.8	A
Kuwait	4.20585606	6.49%	74264	-6.1	B
Kyrgyz Republic	3.68523716	17.83%	3552	21.5	C
Latvia	4.83021289	11.12%	25587	20.4	A
Lebanon	3.80208232	8.97%	14309	-6.7	C
Lesotho	3.2761689	18.06%	2951	10.7	D
Lithuania	4.91741135	5.45%	29838	21	A
Luxembourg	5.6664481	8.51%	102389	11.8	A
Macedonia, FYR	4.40991568	12.82%	14942	26.2	B
Madagascar	2.63574337	-3.28%	1506	7.9	D
Malawi	2.72869684	-10.67%	1169	10.4	D
Malaysia	4.91129007	2.34%	27683	20.3	A
Mali	2.90295315	-0.91%	2126	15.6	D
Mauritania	2.50121711	-1.78%	3853	9.2	D
Mauritius	4.37917533	7.86%	21103	21.2	B
Mexico	3.99384293	4.45%	17275	5	C
Moldova	4.02675864	6.59%	5332	26.1	C
Montenegro	4.32195153	2.50%	17633	27.2	B
Morocco	3.94604914	10.99%	7857	13.6	C
Mozambique	2.99660769	0.33%	1217	20.2	D
Namibia	3.59676524	7.37%	10625	16.3	C
Nepal	3.18141839	8.92%	2478	15.7	D
Netherlands	5.81058254	3.71%	50539	8.2	A
New Zealand	5.50404066	2.61%	38565	16.9	A
Nicaragua	2.80787354	-1.18%	5540	22.1	D

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Country Names	NRI (2016)	NRI Change % 2012 to 2016	GDP Per Capita PPP$ 2016	GDP Growth Per Capita % 2012 to 20	Group-Basedsed on NRI 2016
Nigeria	3.15120258	-2.24%	5861	7.8	D
Norway	5.82517601	4.16%	58790	-10.2	A
Oman	4.30987525	-0.98%	46900	7	B
Pakistan	3.35008908	-1.25%	5235	17.7	D
Panama	4.28273846	6.89%	23009	24.2	B
Paraguay	3.40086644	4.63%	9567	28.5	D
Peru	3.76272486	12.72%	13019	16.8	C
Philippines	3.97346449	9.18%	7804	28	C
Poland	4.49944848	8.17%	27383	14.9	B
Portugal	4.91623079	6.20%	30607	15.7	A
Qatar	5.18461243	7.72%	127480	-0.1	A
Romania	4.1473384	6.33%	23027	21.3	B
Russian Federation	4.53896547	12.98%	24789	-3.9	B
Rwanda	3.92170507	5.99%	1913	24.6	C
Saudi Arabia	4.81317316	4.25%	54417	7.6	A
Senegal	3.37972609	-1.05%	2566	15.2	D
Serbia	3.99673271	9.70%	14515	10.7	C
Singapore	6.03625639	3.08%	87833	13.4	A
Slovak Republic	4.38838811	11.52%	30460	14.3	B
Slovenia	4.73298618	3.25%	32723	13.2	B
South Africa	4.15929394	7.48%	13197	6.1	B
Spain	4.77047663	5.07%	36305	13.5	B
Sri Lanka	4.1777931	7.57%	12552	23.5	B

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APPENDIX B

Percentage Change in each Indicator between 2012 and 2016 (Group Average)

Indicators (43)	All Countries (Ave.%)	Group A (Ave %)	Group B (Ave%)	Group C (Ave %)	Group D (Ave %)	Difference: D to A (D-A)
Effectiveness of law-making bodies *	7.71	8.79	5.68	6.9	10.24	1.45
Laws relating to ICTs *	-0.76	-1.71	0.67	-1.98	0.16	1.87
Judicial independence *	3.76	1.3	2.91	2.32	10.14	8.84
Efficiency of legal system in settling disputes *	0.89	2.67	0.68	-0.8	1.23	-1.44
Efficiency of legal system in challenging regs. *	-0.07	4.29	-1.58	-1.46	-1.72	-6.01
Intellectual property protection *	13.18	5.97	10.47	18.82	18.49	12.52
No. procedures to enforce a contract	0.21	0.83	-0.31	0.44	-0.21	-1.04
No. days to enforce a contract	5.86	2.31	5.85	11.71	2.39	0.08

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Impact of ICTs on access to basic services *	-2.73	2.15	-0.93	-5.48	-7.76	-9.91
Internet access in schools *	4.95	-0.02	2.48	4.52	15.46	15.48
ICT use & gov't efficiency *	-3.27	-0.88	-2.47	-4.67	-5.56	-4.68
E-Participation Index ++	300.9	122.19	254.02	342.75	541.04	418.85
Availability of latest technologies *	-3.71	-1.46	-2.66	-5.81	-5.16	-3.7
Venture capital availability *	7.15	7.17	4.88	7.78	9.4	2.23
Total tax rate, % profits	-2.63	-3.37	-4.52	0.85	-3.88	-0.51
No. days to start a business	-14.66	-25.87	-18.83	-0.85	-13.47	12.4
No. procedures to start a business	0	-0.42	-6.56	9.25	3.09	3.51
Intensity of local competition *	5.56	1.22	7.68	5.79	7.96	6.74
Quality of management schools *	1.39	2.55	2.76	0.23	-0.42	-2.97

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Gov't procurement of advanced tech *	-6.32	-6.95	-7.69	-5.29	-5.01	1.94
Electricity production, kWh/capita	13.95	1.5	10.29	20.79	25.76	24.26
Mobile network coverage, % pop.	10.25	0.21	6.09	4.25	37.48	37.27
Int'l Internet bandwidth, kb/s per user	476.03	442.13	474.78	435.58	578.25	136.12
Secure Internet servers/million pop.	127.05	52.66	114.59	149.56	210.1	157.44
Prepaid mobile cellular tariffs, PPP $/min.	-4.01	-8.73	-10.11	-16.14	27.48	36.21
Fixed broadband Internet tariffs, PPP $/month	27.24	28.18	10.23	18.59	61.75	33.57
Internet & telephony competition +	6.26	4.68	14.79	1.21	3.45	-1.23
Quality of educational system *	0.45	1.2	1.79	-0.66	-0.85	-2.05

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Quality of math & science education *	2.36	3.26	2.8	3.63	-1.19	-4.45
Secondary education gross enrollment rate, %	9.33	8.19	8.18	6.46	16.42	8.23
Mobile phone subscriptions/100 pop.	22.97	7.41	15.99	18.65	58.95	51.54
Individuals using Internet, %	58.43	13.08	41.43	60.27	138.08	125
Households w/ personal computer, %	63.56	10.54	50.62	110.43	85.53	74.99
Households w/ Internet access, %	272.85	13.81	100.12	489.5	549.64	535.83
Fixed broadband Internet subs/100 pop.	198.78	35.8	73.18	261.59	498.73	462.93
Use of virtual social networks *	7.02	4.12	8.9	7.02	8.18	4.06
Firm-level technology absorption *	-2.21	-1.37	-1.55	-3.19	-2.88	-1.51

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Capacity for innovation *	29.38	15.9	25.24	37.81	41	25.1
Extent of staff training *	1.67	1.66	1.37	1.74	2	0.34
Importance of ICTs to gov't vision *	2.42	3.64	2.03	1.48	2.69	-0.95
Government Online Service Index ++	55.52	48.44	52.14	57.14	67.2	18.76
Impact of ICTs on business models *	1.28	1.17	2.02	0.36	1.67	0.5
Impact of ICTs on new organizational models *	1.5	3.06	3.41	-1.51	0.98	-2.08

(*) Indicator Scale 1 to 7 (best); (+) Indicator Scale: 0-2 (best) (++) Indicator Scale: 0 to 1 (best);
Source: Computed from the indicator scores for the years 2012 and 2016 provided by the World Economic Forum

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APPENDIX C

Significant Indicators (t-value significant at .05 or less)
Differences in "Indicator Changes (%)" Between Groups A and D

Indicator	Group A	Group A2	Group D	Group D3	t-value
	NRI HIGH	**NRI HIGH**	**NRI LOW**	**NRI LOW**	
	Average Score 2016	**% Change 2012-16 (A)**	Average Score 2016	**% Change 2012-16 (D)**	**Based on Diff. in (A) &(D)**
Intellectual property protection *	5.26	5.40%	3.3	15.70%	-2.37
No. procedures to enforce a contract	31.8	0.70%	39.2	-0.20%	1.86
Impact of ICTs on access to basic services *	5.7	1.90%	3.4	-8.80%	3.26
Internet access in schools *	5.7	-0.40%	3.3	12.86%	-2.97
E-Participation Index, 0–1	0.74	44.60%	0.24	137.40%	-2.6
Availability of latest technologies *	6.1	-1.6	4.1	-5.4	2.04

No. days to start a business	7.2	-36.9	26.4	-17.1	-2.09
Intensity of local competition *	5.53	1.10%	4.7	7.70%	-3.74
Electricity production, kWh/capita	11,349	2.30%	759	9.80%	-2.47
Mobile network coverage, % pop.	99.4	0.20%	88	20.80%	-2.51
Secure Internet servers/million pop	1167	28.90%	4.8	113.60%	-2.1
Prepaid mobile cellular tariffs, PPP $/min.	0.24	-19.80%	0.4	14.60%	-3.03
Secondary education gross enrollment rate, %	111.5	8.20%	52.4	14.60%	-1.96
Mobile phone subscriptions/100 pop.	130.5	6.40%	89.9	46.90%	-4.64
Individuals using Internet, %	84.5	11.20%	16.4	81.90%	-4.16

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Households w/ personal computer, %	85.4	9%	11.7	55.40%	-4.33
Households w/ Internet access, %	85.4	12.50%	9.9	190.70%	-3.32
Fixed broadband Internet subs/100 pop	29.7	18.50%	0.93	139.70%	-2.2
Use of Virtual Social Networks	6.2	3.90%	4.8	7.30%	-1.8
Firm Level Technology Absorption*	5.7	-1.60%	4.2	-3.20%	-4.3

(*) Scale: 1-7 (best), from surveys organized by the World Economic Forum.

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