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MEASURING THE TECHNOLOGY ACHIEVEMENT INDEX: COMPARISON AND RANKING OF COUNTRIES

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Ahmet Incekara[1], Tugba Guz[3], Gulden Sengun[2]
[1]Istanbul University, Istanbul, Turkey. incekara@istanbul.edu.tr
[2]Istanbul University, Istanbul, Turkey. sengungulden@gmail.com
[3]Istanbul University, Istanbul, Turkey. tugbaguz@gmail.com

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ABSTRACT

Purpose- Countries that can adapt to the pace of technological developments, follow and use this speed have a stronger economy and obtain a significant competitive advantage in the global arena. Therefore, the countries make various regulations to increase the technological achievements, access to the global technologies, adapt to the rapid technological transformation and organize their sub-structures according to these technologies. Technology Achievement Index (TAI), which is one of the studies to evaluate the technological performance of countries, classifies countries according to their technological achievements.

Methodology- In this study, TAI-16 of 105 countries is calculated by using the methodology based on the original study of Desai et al. TAI that originally proposed in 2002 by Desai et al. is a unified index that revealing countries' technological abilities and performance in terms of technology capacity, diffusion of new technologies, diffusion of old innovations and development of human skills. TAI which consists of four main dimensions and eight sub-indicators of the dimensions calculate the average of the dimensions of the index based on the selected indicators. Each of four dimensions includes two sub-indicators.

Findings- In this study, technological capabilities and performances of 105 countries were analyzed and Technology Achievement Index (TAI-16) was calculated using most of the data of 2015. Moreover, TAI-16 values of the 105 countries were classified as Leaders (TAI > 0,5), Potential Leaders (TAI = 0,35-0,49), Dynamic Adopters (TAI = 0,20-0,34), and Marginalized (TAI < 0,20) following the methodology in TAI-02.

Conclusion- According to TAI-16 classification, the countries were identified as follows; 40 countries as Leaders, 38 countries as Potential Leaders, 17 countries as Dynamic Adopters, and 10 countries as Marginalized. Furthermore, TAI ranking of the 105 countries was created. In this classification, while Switzerland had the highest with 0.813 TAI value, Ethiopia had the lowest value with 0,028 TAI value.

Keywords: Human skills, technology achievement ındex, technology creation, technology development, technology diffusion.
JEL Codes: O31, O33, 034

1. INTRODUCTION

The factors such as technology achievement capacity, creativity, diffusion of innovation, and knowledge generation have become fundamental conditions to provide the sustainable competitive advantage, economic growth, and development in the global arena. In this process, countries make various regulations to increase the technological achievements, access to the global technologies, adapt to the rapid technological transformation and organize their sub-structures according to these technologies.

Countries benefit from global technological advantages when they increase their technological capacities and performances. There are many factors that influence the technological achievement and progress in a country, as well as several methods used to measure this success. Human Development Index (HDI), ICT Development Index (IDI) reported by

ITU, Global Competitiveness Report (GCR) reported by World Economic Forum, The Global Information Technology Report, Global Innovation Index (GII), and Technology Achievement Index (TAI) are one of these methods.

Technology Achievement Index (TAI) is a composite index that measures of the countries' skills to participate in the network age. The TAI was included in Human Development Index 2001 and originally developed by Desai et al. It reflects countries' ability to create and diffuse technology as well as building human skills.

The TAI evaluates the technological performance of countries and classifies the countries according to their technological achievements but not measure the overall size of their technological development. (Nasir et al. 2011). It focuses on the countries technological performances based on their capabilities in creating and using technology. The countries in the TAI also divided into four sub-groups called as Leaders (TAI > 0,5), Potential Leaders (TAI = 0,35-0,49), Dynamic Adopters (TAI = 0,20-0,34), and Marginalized (TAI < 0,20) (Desai et al, 2002).

The components of the TAI consist of four main dimensions as total eight indicators. Each dimension has two indicators, and each of four dimensions and eight indicators has equal weight. Four main dimensions are Technology Creation (TC), Diffusion of Recent Innovations (DRI), Diffusion of Old Innovations (DOI), and Human Skills (HS). Two sub-indicators of each dimension in the TAI are summarized below.

- Technology creation represents by the sub-indicators' patents granted per capita and receipts of royalties and license fees from abroad per capita. These sub-indicators reflect respectively the current level of invention activities and the stock of successful past innovations that are still useful and therefore market value (Desai et al, 2002)
- Sub-indicators of diffusion of recent innovations are numbers of Internet hosts per 1000 people and high-and-medium technology exports as a share of all export.
- Diffusion of old innovations measured by telephones mainlines and cellular per 1000 people and electricity consumption per capita (kW per capita) (Desai et al, 2002)
- The two sub-indicators in the human skills are mean years of schooling of the population age 15 and above and gross tertiary science enrolment ratio. These two measures indicate the general level of basic educational skills in the population, in spite of the fact that education quality varies from country to country. (Desai et al, 2002)

In this study, technological capabilities and performances of 105 countries are analyzed and Technology Achievement Index (TAI-16) is calculated using most of the data of 2015. The internet users per 100 people are used instead of the internet hosts per 1000 people which sub-indicator of diffusion of recent innovation as it gives a more certain idea about the diffusion of internet among the population in our study. We also use the high technology exports as a share of all export instead of the high-and-medium technology exports in TAI-02 (Desai et al. 2002). Furthermore, the countries are classified as leaders, potential leaders, dynamic adopters and marginalized countries and created the TAI ranking of the 105 countries.

The rest of this study is organized as follows. Section two provides a brief review of the empirical literature. In the third section presents the data set and methodology, and in the fourth section, the findings and discussions are mentioned. These sections are followed by the conclusion part.

2. LITERATURE REVIEW

Technology creation, diffusion, and having human skills have been the key factors for economic growth, development, and global competition. For this reason, there are many studies evaluating the technological performances and progress of the countries using the different methods in the literature. Technology Achievement Index (TAI) developed by Desai et al. (2002) and called TAI-02, is one of these studies.

Desai et al. (2002) calculated the Technology Achievement Index (TAI-02) using data from 72 countries. In their study, they ranked 72 countries according to their TAI values and evaluated the technological performance of the countries based on their capability about creating and using technology but not focus on the overall size of their technological development. Thus, although Finland is a smaller country than USA, UK, and Germany, it has a higher ranking in TAI than those countries (Nasir et al. 2011) As a result, their study shows that there are great differences in technological progress among developing countries (Desai et. al. 2002)

Following TAI-02, TAI-09 was proposed by Nasir et all. (2011). TAI-09 differs from TAI-02 in that it analyzes the technology capacities and capabilities of 91 countries using the data of 2009. Furthermore, the main purpose of TAI-09 indicates the changes take place in the TAI rankings of various countries. Since the data for the two sub-indicators used in 2002 are no longer available, these two sub-indicators revised in TAI-09. The study also compares 56 countries which are included in both TAI-09 and TAI-02 in terms of their technological progress. Later on, The TAI-02 containing 72 countries modified and made compatible with TAI-09. In the result of the study, 20 countries within 56 countries moved up, 23 countries moved

down and 13 countries retained their ranking positions in the index and 4.7% reduction is observed in the TAI values from 2002 to 2009.

Archibugi and Coco (2004) presented a new indicator of technological capabilities (ArCo) for measure the developed and developing countries technological capabilities. Index took into account a number of other variables associated with technological change and it allowed for comparison between countries over time. When they developing the index, they benefited from the methodology including Technology Achievement Index, Human Development Report, and Industrial Performance Scoreboard.

Fan et al. (2008) indicated that technology achievement gap among countries could be affected by such effects as that Matthew effect, convergence effect, and balance effects, according to the time sequence. They calculated TAI of 134 developed and developing (regions) countries bu following the method in Technology Achievement Index and extended the index from single year to 21 years between 1985 and 2005. The result of their study indicated that technological gap among countries was getting shorter and to some extent developing countries' technology surpassing strategy was effective. This means that the overall trend was convergence and individual Matthew effect.

Xu et al. (2013) calculated the TAI of 21 innovative cities in the period of 2001-2008. According to their result of their study, TAI of 21 innovative cities and four sub-indicators showed an increasing trend. Furthermore, in terms of diffusion of recent innovations, diffusion of old innovation, and human skills there were no big differences among these cities, apart from the creation of technology which directly results in the differences of TAI among these innovative cities.

Burinskiene (2013) was investigated the relationship between international trade and technological innovations. Burinskiene examined the concept of innovations and presented the models of innovations linked to international trade by using different types of models in the study. Moreover, TAI was presented for 68 countries and the results of TAI were compared with achievements on e-commerce technology in different countries. In this comparison, TAI and the application of e-commerce technologies were conducted to reveal how TAI represents the application of e-commerce technology in countries. Also, the countries classified into groups representing the difference in technological achievement. The empiric study results showed that some countries are ranked higher according to TAI and lower in the application of e-commerce technology or vice versa.

Ali et al. (2014) proposed the TAI-13 OIC to reveal the technological progress of Muslim nations. They ranked 34 Muslim countries, and each sub-dimension of the index included in the ranking. They also made a comparative analysis of TAI ranking of 22 countries, common to the present and previous studies of 2011 under similar conditions, and presented information about the shift in the technological situation of these countries over a period of 5 years. They used the standard deviation approach to investigate the technological spread. Moreover, made a comparison such different indices as GCI, HDI, and GDP per capita in TAI-13 OIC.

TAI-15 proposed by Shahab is an another study in the Technology Achievement Index (2015). TAI scores of 167 countries calculated in TAI-15. Cluster analysis was used in the TAI-15 and update and enhance the technology achievement index with classification and grouping of the countries by using latest data. By using the cluster analysis countries are classified 31 countries as Leaders, 34 as Potential Leaders, 44 as Dynamic Adopters and 58 as Marginalized. All the features of Potential Leaders such as high levels of human skills and high diffusion of recent innovations in TAI-15 and TAI-02 are the same.

3. DATA AND METHODOLOGY

The methodology used to calculate the TAI-16 is based on the original study of Desai et al. TAI which consists of four main dimensions and eight sub-indicators of the dimensions calculate the average of the dimensions of the index based on the selected indicators. Each of four dimensions includes two sub-indicators. Equal weight is given of the indicators in each dimension and in the final index, the dimensions are given one-quarter (equal) weight. The observed minimum and maximum values among all countries with data are selected as goalposts for each of the indicators in these dimensions. The performance on each indicator is stated as a value between 0 and 1 applied the following general formula: (Human Development Report, 2001).

$$\text{Indicator Index} = \frac{\text{Actual Value} - \text{Observed Minimum Value}}{\text{Observed Maximum Value} - \text{Observed Minimum Value}}$$

The data sources belong to the sub-indicators are stated below.

The indicators which used to measure technology creation are patents granted per capita and receipts of royalties and license fees from abroad per capita. World Bank World Development Indicators contains the data of receipts of royalties and license fees from abroad per capita. Patents granted per capita data is obtained from the European Patent Office (EPO)

The numbers of Internet hosts per 1000 people and high-and-medium technology exports as a share of all export used to measured the diffusion of recent innovation in the original study of Desai et al. TAI-02. In our study, the internet users per 100 people are used instead of the hosts per 1000 people. We also use the high technology exports as a share of all export instead of the high-and-medium technology exports in TAI-02 (Desai et al. 2002). The data of the internet users per 100 people are acquired from the World Bank World Development Indicators. High technology exports as a share of all exports data are obtained from World Bank World Development Indicators.

For the telephones mainlines and cellular per 1000 people and electricity consumption per capita (kW per capita) sub-indicators logarithm is taken and capped at OECD average levels in our study. Data regarding Electricity consumption per capita (kW per capita) is taken from World Bank Database. The data of the telephones mainlines and cellular per 1000 people derived from International Telecommunication Union (ITU).

To measuring the human skills dimension used mean years of schooling of the population age 15 and above and gross tertiary science enrolment ratio. The data of mean years of schooling of the population age 15 and above is gathered from the United Nation Devolepment Programme (UNDP) data. The data of gross tertiary science enrolment ratio' data is obtained from International Telecommunication Union (ITU).

4. FINDINGS AND DISCUSSIONS

TAI-16 is calculated using Desai's original institutional framework. 105 countries' technological capabilities and performances analyzed using the most of the data of 2015. The internet users per 100 people are used instead of the hosts per 1000 people which sub-indicator of diffusion of recent innovation as it gives a more certain idea about the diffusion of internet among the population in our study. We also use the high technology exports as a share of all export instead of the high-and-medium technology exports in TAI-02 (Desai et al. 2002). Moreover, two sub-indicators in the diffusion of old innovations telephones mainlines and cellular per 1000 people and electricity consumption (kW per capita) logarithm was taken and capped at OECD average levels.

Table 1 in appendix gives the TAI-16 ranking of 105 countries. The values indicate great differences between developed and developing countries within specific categories. While the highest TAI value is 0.813 for Switzerland, the lowest value is 0,028 for Ethiopia. Furthermore, TAI-16 values of the 105 countries are classified as Leaders (TAI > 0,5), Potential Leaders (TAI = 0,35-0,49), Dynamic Adopters (TAI = 0,20-0,34), and Marginalized (TAI < 0,20) following the methodology in TAI-02. According to this classification, 40 countries as Leaders, 38 countries as Potential Leaders, 17 countries as Dynamic Adopters, and 10 countries as Marginalized identified.

- Leader (TAI > 0,5): Technology creation and innovation capacity are important for all the countries and provide highest technological progress. Leaders as owners of the technological innovation get a big advantage in the global economy. This group is at the top of the technological innovation and mostly consist of the developed countries. They also have a high achievement in technology creation, diffusion, and skills. Such developed countries as Switzerland, Luxembourg, Netherlands, Sweden, Korea Rep., and the United States are including in the top ten among Leaders.
- Potential Leaders (TAI = 0,35-0,49): Most of the countries in Potential Leaders are developing countries. Potential Leaders comprise 38 countries include the countries as Turkey, Brazil, Chile, Chine, Colombia, Portugal, Thailand. Most of the countries in this group have used old technologies extensively and invested in high-level human skills. However, innovation level of these countries is low.
- Dynamic Adopters (TAI = 0,20-0,34): Seventeen countries such as Indonesia, Egypt, Cuba, Sri Lanka come under the Dynamic Adapters category. Some countries in this group have human skills levels and diffusion recent and old technologies comparable with Potential Leaders.
- Marginalized (TAI < 0,20): Marginalized countries consist of eleven countries include Pakistan, Senegal, Sudan, Ethiopia. These countries are lagging behind in almost every aspect of technological success. The countries in this group have low levels of technological advance and need to have a long way to go technology diffusion and human skill building. In large parts of these countries, people still do not have access to "old" technologies.

5. CONCLUSION

In this study, technological capabilities and performances of 105 countries were analyzed and Technology Achievement Index (TAI-16) was calculated using most of the data of 2015. TAI-16 was calculated based on Desai's original study. Moreover, TAI-16 values of the 105 countries were classified as Leaders (TAI > 0,5), Potential Leaders (TAI = 0,35-0,49), Dynamic Adopters (TAI = 0,20-0,34), and Marginalized (TAI < 0,20) following the methodology in TAI-02. According to TAI-16 classification, the countries were identified as follows; 40 countries as Leaders, 38 countries as Potential Leaders, 17

countries as Dynamic Adopters, and 10 countries as Marginalized. Furthermore, TAI ranking of the 105 countries was created. In this classification, while Switzerland had the highest with 0.813 TAI value, Ethiopia had the lowest value with 0,028 TAI value.

Following the TAI-02, TAI-09 and TAI-15 were proposed. All these studies investigated the countries technological performance. While TAI-02 analyzed 72 countries, TAI-09 investigated 91 countries and the TAI-15 analyzed 167 countries. The changes and developments in the technological performances of the countries within the years can be seen and compared in these studies. Looking at the rankings of Turkey in these indices, it has been observed that ranked 79th among Dynamic Leaders in 167 countries in TAI-15.

In our study, Turkey with 0,412 TAI value was included in Potential Leaders category and ranked in 66 among 105 countries. In this frame, when the countries are ranked according to four main dimensions of the index, Turkey was in the 38th place in Technology Creation index; 73rd place in Diffusion of Recent Innovation Index, 70th place in Diffusion of Old Innovation index and 21st place in the Human Skills index. The fact that the diffusion of recent innovation and diffusion of old innovation index values were low was one of the factors pushing down the ranking of technology achievement index of Turkey. Because the calculation of the diffusion of old innovations index by the logarithm function and the second derivative of the logarithm function is negative, the increasing in this sub-indicator that contributes to the TAI has a decreasingly growing course. Therefore, if Turkey attaches more importance to other sub-indices in order to increase TAI values, it is expected that TAI value will be reflected positively.

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Appendix

Table 1: Technology Achievement Index 2016

TAI Rank	Country	Category	TAI 2016	Technology Creation (TC)			Diffusion of Recent Innovations(DRI)		
				Patents granted to resident (per million people)[a]	Receipts of royalty and license fees(US$ per1000 people)[b]	TC Index	Internet User (per 100 people)[c]	High-technology exports (%of manufactured exports)[d]	DRI Index
1	Switzerland	Leaders	0,813	366,48	1.952.204,76	0,842	87,97	26,84	0,6978081
2	Luxembourg	Leaders	0,766	368,63	2.827.320,93	1	97,33	6,82	0,5596317
3	Netherlands	Leaders	0,745	117,97	2.307.474,64	0,568	93,10	19,90[e]	0,6600475
4	Sweden	Leaders	0,685	197,88	900.901,56	0,427	90,61	14,26	0,5934678
5	Ireland	Leaders	0,682	58,18	1.606.854,93	0,363	80,12	26,76	0,6548525
6	Singapore	Leaders	0,673	22,58	596.570,74	0,136128	82,10	49,28	0,8776447
7	Denmark	Leaders	0,666	122,97	364.518,69	0,231	96,33	15,96	0,6403547
8	Korea, Rep.	Leaders	0,661	39,26	122.460,72	0,074908	89,90	26,84	0,7081995
9	Germany	Leaders	0,658	173,46	179.149,12	0,266958	87,59	16,66	0,5998605
10	United States	Leaders	0,635	46,51	387.858,43	0,131676	74,55	19,01	0,5517483
11	Finland	Leaders	0,633	135,72	437.736,90	0,261499	92,65	8,73	0,5523547
12	Norway	Leaders	0,626	49,85	98.177,09	0,084977	96,81	20,52	0,6858808
13	France	Leaders	0,622	81,32	224.128,77	0,149937	84,69	26,85	0,6802542
14	Japan	Leaders	0,619	83,37	288.528,58	0,164106	93,33	16,78	0,6319112
15	Austria	Leaders	0,617	120,89	102.533,20	0,182105	83,93	13,35	0,5489564
16	Australia	Leaders	0,616	13,88	32.929,44	0,02465	84,56	13,51	0,5538807
17	Belgium	Leaders	0,604	76,73	282.996,32	0,154121	85,05	13,02	0,5519132
18	Israel	Leaders	0,597	47,37	130.793,28	0,087382	78,89	19,66	0,58127
19	New Zealand	Leaders	0,596	11,1	66.271,05	0,026776	88,22	9,62	0,5368918
20	Malta	Leaders	0,589	44,05	652.647,01	0,175166	76,18	31,90	0,6820629
21	Iceland	Leaders	0,582	84,64	694.103,78	0,237553	98,20	19,90	0,6875388
22	Estonia	Leaders	0,576	7,62	8.521,55	0,011843	88,41	11,40	0,5546536
23	Kazakhstan	Leaders	0,575	0,23	50,48	0,000321	72,87	41,19	0,7517113
24	Russian Federation	Leaders	0,563	0,53	5.039,46	0,00161	73,41	13,76	0,4961583
25	Greece	Leaders	0,562	2,03	4.997,40	0,003637	66,84	10,99	0,4346122
26	Czech Republic	Leaders	0,557	7,01	44.159,03	0,017318	81,30	14,90	0,5494236
27	Slovenia	Leaders	0,556	31,5	28.196,99	0,047712	73,10	6,42	0,4253179
28	Hong Kong SAR, China	Leaders	0,549	3,7	0,00	0,005019	84,95	10,71	0,5295148
29	United Kingdom	Leaders	0,546	32,19	269.296,40	0,091286	92,00	20,81	0,6627299
30	Malaysia	Leaders	0,536	0,73	3.038,81	0,001528	71,06	42,80	0,7571824
31	Lithuania	Leaders	0,535	3,78	7.853,54	0,006516	71,38	11,85	0,4672394
32	Spain	Leaders	0,534	11,25	34.750,27	0,021405	78,69	7,15	0,4622644
33	Latvia	Leaders	0,531	4,04	3.364,92	0,006075	79,20	15,05	0,5394998
34	Slovak Republic	Leaders	0,526	2,03	4.837,48	0,003609	85,02	10,29	0,5259626
35	Poland	Leaders	0,522	3,95	10.921,20	0,007289	68,00	8,78	0,4200476
36	Belarus	Leaders	0,521	0	2.407,23	0,000426	62,23	4,31	0,3469423
37	Hungary	Leaders	0,516	3,86	152.723,72	0,032244	72,83	13,74	0,4928515
38	Italy	Leaders	0,507	40,72	50.134,09	0,064098	65,57	7,34	0,3934654
39	Argentina	Leaders	0,506	0,3	3.941,89	0,001104	69,40	9,01	0,4297863
40	Canada	Leaders	0,506	21,09	115.097,04	0,04896	88,47	13,83	0,57794

41	Croatia	Potential leaders	0,499	1,42	10.805,47	0,003837	69,80	8,98	0,4316911
42	Chile	Potential leaders	0,499	0,89	4.879,51	0,00207	64,29	5,90	0,3729536
43	Ukraine	Potential leaders	0,496	0,04	1.880,61	0,000387	49,26	7,27	0,3049207
44	Bulgaria	Potential leaders	0,492	0,98	6.950,41	0,002558	56,66	7,65	0,348336
45	Bahrain	Potential leaders	0,491	0	0	0	93,48	0,96	0,4836099
46	Cyprus	Potential leaders	0,482	12,01	0	0,01629	71,72	6,15	0,4153491
47	Saudi Arabia	Potential leaders	0,478	1,55	0	0,002102	69,62	0,77	0,3533541
48	Qatar	Potential leaders	0,47	0,89	0	0,001207	92,88	3,41	0,5034845
49	Serbia	Potential leaders	0,468	0	0	0,001128	65,32	0	0,3229051
50	Portugal	Potential leaders	0,467	4,45	8.573,89	0,007552	68,63	4,59	0,3839719
51	Brunei Darussalam	Potential leaders	0,458	0	0	0	71,20	17,93	0,5235925
52	Costa Rica	Potential leaders	0,451	0	0	0	59,76	16,83	0,4515897
53	Philippines	Potential leaders	0,443	0,04	111,14	0	40,70	53,06	0,6903662
54	Kuwait	Potential leaders	0,442	0,77	0	0,001044	82,08	2,72	0,4387832
55	Oman	Potential leaders	0,439	0	0,00	0	74,17	4,13	0,4094845
56	Georgia	Potential leaders	0,437	0	154,06	0	45,16	5,57	0,2667987
57	Romania	Potential leaders	0,436	0,45	4.494,71	0,001405	55,76	7,50	0,3421426
58	Brazil	Potential leaders	0,426	0,35	2.795,71	0,000969	59,08	12,31	0,4052662
59	Azerbaijan	Potential leaders	0,424	0	0	0	77,00	2,53	0,4097025
60	Armenia	Potential leaders	0,423	0	0	0	58,25	5,27	0,3345424
61	Thailand	Potential leaders	0,422	0,07	1.245,89	0,000315	39,32	21,44	0,3849261
62	China	Potential leaders	0,419	1,03	790,97	0,001537	50,30	25,75	0,4847135
63	Jordan	Potential leaders	0,416	0	1.680,23	0,000297	53,40	1,82	0,2758538
64	Macedonia, FYR	Potential leaders	0,414	0	4.449,03	0,000787	70,38	2,99	0,3783237
65	South Africa	Potential leaders	0,413	1,07	1.876,35	0,001783	51,92	5,88	0,3061673
66	Turkey	Potential leaders	0,412	2,77	0	0,003757	53,74	2,16	0,2809341
67	Albania	Potential leaders	0,41	0	662,81	0,000117	63,25	1,49	0,3258044
68	Moldova	Potential leaders	0,407	0	1.260,50	0,000223	49,84	3,99	0,2771243
69	Kyrgyz Republic	Potential leaders	0,404	0	234,02	0	30,25	11,86	0,2458114
70	Vietnam	Potential leaders	0,402	0,04	0	0	52,72	26,93e	0,5088412
71	Uruguay	Potential leaders	0,401	0,58	47,79	0,000795	64,60	13,85	0,4495217
72	Panama	Potential leaders	0,394	0,51	1.494,98	0,000956	51,21	0	0,24691
73	Lebanon	Potential leaders	0,392	0	4.083,90	0,000722	74,00	2,07e	0,389165
74	Colombia	Potential leaders	0,386	0,08	1.086,29	0,000301	55,90	9,49	0,3616408
75	Mauritius	Potential leaders	0,385	6,34	1.043,55	0,008784	50,14	0,06	0,2417258
76	Mexico	Potential leaders	0,377	0,33	2.423,07	0,000876	57,43	14,69	0,4188336
77	Mongolia	Potential leaders	0,365	0	806,67	0,000143	21,44	4,03	0,1245657
78	Tunisia	Potential leaders	0,35	0,27	1.959,67	0,000713	48,52	6,33	0,2920672
79	Bosnia and Herzegovina	Dynamic Adopters	0,342	0,26	3.383,61	0,000951	65,07	2,82	0,3481141
80	Botswana	Dynamic Adopters	0,34	0	53,90	0	27,50	0,63	0,1251941

81	Dominican Republic	Dynamic Adopters	0,339	0	0	0	51,93	3,83	0,286907
82	Jamaica	Dynamic Adopters	0,334	0	2.025,55	0,000358	43,18	0,09	0,2044683
83	Indonesia	Dynamic Adopters	0,308	0	211,46	0	21,98	6,97[e]	0,155168
84	Egypt, Arab Rep.	Dynamic Adopters	0,308	0,02	0	0	35,90	0,78	0,1718573
85	Sri Lanka	Dynamic Adopters	0,308	0	0	0	29,99	0,84	0,1405213
86	El Salvador	Dynamic Adopters	0,307	0	4.756,89	0,000841	26,92	4,39	0,1574091
87	Peru	Dynamic Adopters	0,306	0,06	694,97	0,000204	40,90	4,74	0,2360495
88	Morocco	Dynamic Adopters	0,304	0	96,21	0	57,08	3,54	0,3118722
89	Bolivia	Dynamic Adopters	0,275	0	2.091,54	0,00037	45,10	6,46	0,2748943
90	Cuba	Dynamic Adopters	0,256	0,7	0	0,000949	31,11	0	0,1386685
91	Guatemala	Dynamic Adopters	0,25	0	1.008,23	0,000178	27,10	5,02	0,1643815
92	Nepal	Dynamic Adopters	0,248	0	0	0	17,58	0,62	0,0716875
93	India	Dynamic Adopters	0,229	0,14	355,86	0,000253	26,00	7,52	0,182001
94	Honduras	Dynamic Adopters	0,226	0	107,75	0	20,36	2,42[e]	0,1035528
95	Zimbabwe	Dynamic Adopters	0,207	0	145,35	0	16,36	2,89	0,0865094
96	Cote d'Ivoire	Marginalized Countries	0,195	0	0	0	21,00	4,79	0,1293436
97	Cameroon	Marginalized Countries	0,181	0	0	0	20,68	3,71	0,1174618
98	Bangladesh	Marginalized Countries	0,157	0	7,42	0	14,40	0	0,0486859
99	Senegal	Marginalized Countries	0,154	0	0,00	0	21,69	3,62	0,1220409
100	Pakistan	Marginalized Countries	0,151	0	79,40	0	18,00	1,56	0,0827494
101	Mozambique	Marginalized Countries	0,147	0	0	0	9,00	11,61	0,1290274
102	Sudan	Marginalized Countries	0,124	0	0,01	0	26,61	0	0,1144707
103	Togo	Marginalized Countries	0,104	0	0	0	7,12	0,41	0,0133526
104	Tanzania	Marginalized Countries	0,098	0	3,70	0	5,36	0,76	0,0071346
105	Ethiopia	Marginalized Countries	0,028	0	0	0	11,60	4,00	0,0713306

Table 1: Technology Achievement Index 2016

				Diffusion of Old İnnovations(DOI)			Development of Human Skills		
				Telephone (mainlines + cellular per 1000 people)[f]	Electricity consumption (kwh per capita)[g]	DOI Index	Mean years of schooling[h]	Gross enrolment ratio, tertiary (%of tertiary school-age population)[k]	DHS Index
TAI Rank	Country	Category	TAI 2016						
1	Switzerland	Leaders	0,813	1867,2	7.807,31	0,983406	12,8	57.229[j]	0,73
2	Luxembourg	Leaders	0,766	1994,8	14.193,17	1	11,7	19.407[l]	0,51
3	Netherlands	Leaders	0,745	1648,1	6.821,06	0,969789	11,9	78.501[l]	0,78
4	Sweden	Leaders	0,685	1670,5	13.870,39	1	12,1	62.353[j]	0,72
5	Ireland	Leaders	0,682	1445,8	5.701,90	0,918054	12,2	77.626[j]	0,79
6	Singapore	Leaders	0,673	1824,1	8.839,71	0,995928	10,6	69,811[l]	0,68
7	Denmark	Leaders	0,666	1582,6	6.039,61	0,957419	12,7	81.516[j]	0,83
8	Korea, Rep.	Leaders	0,661	1765,2	10.427,89	1	11,9	95.345	0,86
9	Germany	Leaders	0,658	1716,4	7.019,01	0,972674	13,1	68.265	0,79
10	United States	Leaders	0,635	1559,9	12.988,26	0,994535	12,9	85.796	0,86
11	Finland	Leaders	0,633	1452,9	15.509,73	0,968154	10,3	87.289	0,75
12	Norway	Leaders	0,626	1294,9	23.325,75	0,925412	12,6	76.696	0,81
13	France	Leaders	0,622	1625,2	7.373,98	0,977648	11,1	64.390[j]	0,68
14	Japan	Leaders	0,619	1767,7	7.835,60	0,983771	11,5	63.362[j]	0,7
15	Austria	Leaders	0,617	1995,9	8.513,01	0,992131	10,8	81.540	0,75
16	Australia	Leaders	0,616	1707,5	10.133,86	1	13	90.306	0,89
17	Belgium	Leaders	0,604	1558,3	7.966,69	0,979597	11,3	73.318[j]	0,73
18	Israel	Leaders	0,597	1765,5	6.558,72	0,965835	12,5	66.181[j]	0,76
19	New Zealand	Leaders	0,596	1620,8	9.084,22	0,998679	12,5	80.882[j]	0,82
20	Malta	Leaders	0,589	1826,9	4.735,77	0,932999	10,3	46.973	0,57
21	Iceland	Leaders	0,582	1639,5	54.799,17	1	10,6	81,26[l]	0,4
22	Estonia	Leaders	0,576	1789,7	6.664,66	0,96745	12,5	69.550	0,77
23	Kazakhstan	Leaders	0,575	1816,1	4.892,50	0,936282	11,4	46.039	0,61
24	Russian Federation	Leaders	0,563	1849,7	6.539,21	0,965534	12	78.653j	0,79
25	Greece	Leaders	0,562	1602,3	5.029,00	0,939057	10,3	113.871j	0,87
26	Czech Republic	Leaders	0,557	1407,2	6.284,79	0,917822	12,3	66.017j	0,75
27	Slovenia	Leaders	0,556	1494,4	6.833,17	0,948577	11,9	82.926j	0,8
28	Hong Kong SAR, China	Leaders	0,549	2879,1	5.933,63	0,955736	11,2	68.475	0,71
29	United Kingdom	Leaders	0,546	1761,5	5.407,29	0,94637	13,1	61n	0,48
30	Malaysia	Leaders	0,536	1585,4	4.511,97	0,928118	10	26.074	0,46
31	Lithuania	Leaders	0,535	1582,6	3.663,67	0,907017	12,4	68.531j	0,76
32	Spain	Leaders	0,534	1497,2	5.401,05	0,925557	9,6	89.670	0,73
33	Latvia	Leaders	0,531	1450,3	3.472,54	0,869205	11,5	67.039j	0,71
34	Slovak Republic	Leaders	0,526	1381,9	5.202,47	0,89203	12,2	52.923j	0,68
35	Poland	Leaders	0,522	1663,8	3.937,65	0,91439	11,8	71.158l	0,75

36	Belarus	Leaders	0,521	1726,8	3.648,32	0,906695	12	87.940	0,83
37	Hungary	Leaders	0,516	1501,3	3.890,29	0,89349	11,6	50.862	0,64
38	Italy	Leaders	0,507	1751,7	5.159,18	0,941634	10,1	63.095[j]	0,63
39	Argentina	Leaders	0,506	1706	3.093,35	0,890057	9,8	82.917[j]	0,71
40	Canada	Leaders	0,506	1265	15.519,34	0,91674	13	60[m]	0,48
41	Croatia	Potential leaders	0,499	1384,7	3.754,27	0,859886	11	69.544[j]	0,7
42	Chile	Potential leaders	0,499	1486,9	3.878,91	0,889616	9,8	88.577	0,73
43	Ukraine	Potential leaders	0,496	1656,4	3.600,23	0,905357	11,3	82.305[j]	0,77
44	Bulgaria	Potential leaders	0,492	1525,4	4.639,71	0,917165	10,6	73.934	0,7
45	Bahrain	Potential leaders	0,491	2058,6	18.216,62	1	9,4	37.375	0,48
46	Cyprus	Potential leaders	0,482	1231,9	3.594,79	0,812101	11,6	60.101	0,69
47	Saudi Arabia	Potential leaders	0,478	1891,2	8.741,42	0,994801	8,7	63.066	0,56
48	Qatar	Potential leaders	0,47	1767,2	15.470,99	1	9,1	17.219	0,37
49	Serbia	Potential leaders	0,468	1569,9	4.444,22	0,9235	10,5	58.287	0,63
50	Portugal	Potential leaders	0,467	1545,5	4.685,05	0,923005	8,2	65.607[j]	0,55
51	Brunei Darussalam	Potential leaders	0,458	1170,9	9.703,55	0,888042	8,8	30.844	0,42
52	Costa Rica	Potential leaders	0,451	1678,4	1.954,56	0,843767	8,4	53.629	0,51
53	Philippines	Potential leaders	0,443	1189,2	692,06	0,63288	8,9	35.753j	0,45
54	Kuwait	Potential leaders	0,442	2451,6	14.910,58	1	7,2	27.027l	0,33
55	Oman	Potential leaders	0,439	1703,2	5.981,45	0,956545	8	31.922	0,39
56	Georgia	Potential leaders	0,437	1510,2	2.459,75	0,849461	12,1	43.419	0,63
57	Romania	Potential leaders	0,436	1269,3	2.494,53	0,786363	10,8	53.220	0,62
58	Brazil	Potential leaders	0,426	1480,4	2.529,30	0,844874	7,7	49.279j	0,45
59	Azerbaijan	Potential leaders	0,424	1299,6	2.092,54	0,777403	11,2	25.483	0,51
60	Armenia	Potential leaders	0,423	1343,3	1.870,20	0,778355	10,9	44.309	0,58
61	Thailand	Potential leaders	0,422	1606,1	2.470,77	0,867398	7,3	48.857	0,43
62	China	Potential leaders	0,419	1086,6	3.762,08	0,770094	7,5	43.392	0,42
63	Jordan	Potential leaders	0,416	1842,3	2.103,86	0,85119	9,9	44.869	0,54
64	Macedonia, FYR	Potential leaders	0,414	1163,7	3.556,50	0,789877	9,3	39.594j	0,49
65	South Africa	Potential leaders	0,413	1722,3	4.325,52	0,923863	9,9	19.375j	0,42
66	Turkey	Potential leaders	0,412	1110,1	2.744,84	0,746251	7,6	86.309j	0,62
67	Albania	Potential leaders	0,41	1134,7	2.531,89	0,746246	9,3	58.109	0,57
68	Moldova	Potential leaders	0,407	1430,3	1.352,79	0,768996	11,2	41.213	0,58
69	Kyrgyz Republic	Potential leaders	0,404	1399,5	1.887,02	0,794473	10,6	45.917j	0,57
70	Vietnam	Potential leaders	0,402	1369,6	1.305,58	0,749315	7,5	28.835	0,35
71	Uruguay	Potential leaders	0,401	1924,7	2.985,06	0,886464	8,5	0	0,27
72	Panama	Potential leaders	0,394	1897,5	2.038,00	0,847983	9,3	38.739	0,48
73	Lebanon	Potential leaders	0,392	1122	3.194,07	0,765493	7,9	38.484	0,42
74	Colombia	Potential leaders	0,386	1300,9	1.177,11	0,719765	7,3	55.589	0,46
75	Mauritius	Potential leaders	0,385	1708,9	2.148,33	0,853298	8,5	36.667	0,43
76	Mexico	Potential leaders	0,377	1018,7	2.056,96	0,685264	8,5	29.940j	0,4
77	Mongolia	Potential leaders	0,365	1137,1	1.908,94	0,718554	9,3	68.567	0,62
78	Tunisia	Potential leaders	0,35	1383,1	1.434,62	0,76246	6,8	34.606	0,35

79	Bosnia and Herzegovina	Dynamic Adopters	0,342	1103,8	3.219,01	0,760206	8,3	38[n]	0,26
80	Botswana	Dynamic Adopters	0,34	1768	1.563,51	0,821259	8,9	27.513[j]	0,41
81	Dominican Republic	Dynamic Adopters	0,339	948,4	1.516,52	0,627983	7,6	47.515j	0,44
82	Jamaica	Dynamic Adopters	0,334	1205	1.126,47	0,686903	9,7	27.220	0,45
83	Indonesia	Dynamiz Adopters	0,308	1411	787,68	0,709421	7,6	31.102j	0,37
84	Egypt, Arab Rep.	Dynamic Adopters	0,308	1183,5	1.697,47	0,721564	6,5	36.228	0,34
85	Sri Lanka	Dynamic Adopters	0,308	1258	525,88	0,626073	10,8	19.796	0,47
86	El Salvador	Dynamic Adopters	0,307	1599,5	915,00	0,767238	6,5	28.852j	0,31
87	Peru	Dynamic Adopters	0,306	1192,1	1.269,77	0,69498	9	0	0,29
88	Morocco	Dynamic Adopters	0,304	1334,2	866,24	0,698229	4,4	28.143	0,2
89	Bolivia	Dynamic Adopters	0,275	1001,7	705,29	0,571091	8,2	0	0,25
90	Cuba	Dynamic Adopters	0,256	411,7	1.425,48	0,31194	11,5	36.280	0,57
91	Guatemala	Dynamic Adopters	0,25	1220,5	555,04	0,62028	5,6	18.325l	0,22
92	Nepal	Dynamic Adopters	0,248	997,3	128,15	0,828465	3,3	14.940	0,09
93	India	Dynamic Adopters	0,229	800,5	765,00	0,496045	5,4	25.535j	0,24
94	Honduras	Dynamic Adopters	0,226	1014,4	720,98	0,577986	5,5	21.184j	0,22
95	Zimbabwe	Dynamic Adopters	0,207	870,1	531,75	0,490323	7,3	8.433	0,25
96	Cote d'Ivoire	Marginalized Countries	0,195	1206,1	252,38	0,536408	4,3	9.155	0,11
97	Cameroon	Marginalized Countries	0,181	763,6	278,06	0,37648	6	17.478	0,23
98	Bangladesh	Marginalized Countries	0,157	824,4	293,02	0,410208	5,1	13.440j	0,17
99	Senegal	Marginalized Countries	0,154	1019,6	219,25	0,459859	2,5	10.386	0,04
100	Pakistan	Marginalized Countries	0,151	688	449,97	0,386309	4,7	9.927	0,14
101	Mozambique	Marginalized Countries	0,147	745,7	435,60	0,412935	3,2	5.974j	0,05
102	Sudan	Marginalized Countries	0,124	708,3	158,66	0,291998	3,1	16.320j	0,09
103	Togo	Marginalized Countries	0,104	684,4	147,50	0,271903	4,5	10.625	0,13
104	Tanzania	Marginalized Countries	0,098	761,3	89,48	0,261036	5,1	3.647	0,13
105	Ethiopia	Marginalized Countries	0,028	436,6	64,62	0,021795	2,4	8.126j	0,02

Notes:

a Related to the year of 2015 data is obtained from European Patent Office

b Data on patents and royalties are missing for these countries. Lack of data for these countries generally indicates little formal innovation occurring. Therefore, a value '0' for the missing indicates has been used for these countries in the present study. Related to the year of 2015 data is derived from World Bank Database

c Related to the year of 2015 data is derived from World Bank Database.

d In TAI-02 (Desai et al.2002), data of high and medium technology exports as percentage of manufactured export was used. However, in spite of extensive internet search data for medium tecnology exports could not be traced. Related to the year of 2015 data is derived from World Bank Database.

e For purposes of calculating the TAI, the nearest available data of year 2014 was used for countries for which no data were available.
Related to the year of 2014 is derived from World Bank Database

f Related to the year of 2015 derived from International Telecommunication Union (ITU). For purposes of calculating the TAI, the weighted average value for OECD countries (1583,034) was used.

g For purposes of calculating the TAI, the nearest available data of year 2013 was used for countries, and the weighted average value for OECD countries (9204) was used. Related to the year of 2013 is derived from World Bank Database

h Related to the year of 2014 derived from United Nation Devolepment Programme (UNDP).

j Related to the year of 2014 derived from International Telecommunication Union (ITU).

k Related to the year of 2015 derived from International Telecommunication Union (ITU).

l Related to the year of 2013 derived from International Telecommunication Union (ITU).

m The nearest available data of the year 2011 was used. Tha data derived from 2014 Human Devolopment Report.