8

Analyzing Science and Technology Indicators for Enhancing Economic Cooperation among the ECO Countries

Seyed Komail Tayebi*
Zahra Zamani*

1. Introduction

In recent years, many economists have questioned the ability of technological progress to keep driving the economy forward despite declining population growth and rising dependency ratios. A powerful scientific tool, for example, that has recently become available and that indicates progress is fast computing including practically unlimited data storage and search techniques. The impact of computers on science has gone much beyond analyzing large-scale databases and standard statistical analysis, being used in measuring economic indicators.[1] This great progress is particularly seen in international trade applying to a network of exports and imports between firms, industries, and nations.

Since the '60s, most contributions in the field of technology and trade have focused on the critical importance of technological change in explaining international trade patterns. Posner (1961)[2], Vernon (1966)[3], and Hirsch (1967)[4] considered the role of technology and innovation in trade. These authors believed that investments in technology and knowledge made and kept up comparative

* University of Isfahan, Iran.

1 David Weinberger, "Our Machines Now Have Knowledge We'll Never Understand", Wired, April 18, 2017, https://www.wired.com/story/our-machines-now-have-knowledge-well-never-understand/.

2 M.V. Posner, "International Trade and Technical Change." *Oxford Economic Papers* 13, no.3 (1961): 323-41.

3 R.Vernon, "International Investment and International Trade in the Product Cycle." *Quarterly Journal of Economics* 8, no.4 (1966): 190-207.

4 S. Hirsch, *Location of Industry and International Competitiveness*. (Oxford: Clarendon Press, 1967).

advantages. According to Posner, technology capacity is an important indicator of a region's export specialization.

The purpose of this study is first to set up the key science and technology (S&T) indicators for countries of the ECO region, while the indicators for S&T capacity are based on the factors that create knowledge on our assessment. Second, we investigate the effect of scientific and technological changes on bilateral trade flows between the ECO countries by specifying a trade gravity model over 1995-2017. Hence, our innovation is to analyze the trends of a number of proxies for S&T variables (for the period 2008-2017) that have been initially defined and measured by the World Bank. Then we specify an innovative version of a gravity trade model, in which we explore the effects of the selected S&T proxies on bilateral trade relations among the ECO members.

An overview of the trends of major economic indicators including trade, foreign investment, and labor movement allows us to analyze the main reasons for the present situation among the selected ECO member states. This provides us indeed with logical support to focus on the fact that scientific and technical cooperation can be realized through endorsing economic cooperation, which is an effective mean for deepening cooperation in the region. Therefore, the objective of this study is to prepare a background document in order to facilitate the discussion on using Science and Technology (S&T), to reach concrete economic cooperation among the selected ECO members, based on the availability of data.

In order to promote intra-trade and intra-investment, for instance, it is necessary to develop proper networking and increased connectivity among the economic agents in the ECO member countries. For this, a stocktaking of the status of trade and investment reforms, capacities, and potentials as well as a review of the existing facilities, initiatives, and efforts already underway at national, regional, and international levels would be necessary. Furthermore, the availability of the relevant data on trade and investment opportunities, market analyses, business practices, and other economic data as well as infrastructure facilities, production capacities, and S&T indicators (such as charges for the use of intellectual properties, research and development expenditure, patent applications, etc.) should be analyzed to demonstrate the prospects of broader economic connectivity in the region.

2. Conceptual Discussion: S&T and Economic Patterns

At a time of slowed growth and continued volatility, many countries are looking for policies that will stimulate growth and create new jobs. Information communications technology (ICT) is not only one of the fastest-growing industries – directly creating millions of jobs – but it also is an important enabler of innovation and development. Findings from various countries confirm the positive effect of ICT on growth. For example, a 10% increase in broadband penetration is associated with a 1.4% increase in GDP growth in emerging markets. In China, this number can reach 2.5%. The doubling of mobile data use caused by the increase in 3G connections boosts GDP per capita growth rate by 0.5% globally. The Internet accounts for 3.4% of overall GDP in some economies. Most of this effect is driven by e-commerce ICT has also contributed to the rise of entrepreneurship, making it much easier for self-starters to access best practices, legal and regulatory information, marketing, and investment resources.[5]

In OECD countries, more than 95% of businesses have an online presence. The Internet provides them with new ways of reaching out to customers and competing for market share. Over the past few years, social media has established itself as a powerful marketing tool. ICT tools employed within companies help to streamline business processes and improve efficiency. The unprecedented explosion of connected devices throughout the world has created new ways for businesses to serve their customers.[6]

In addition, accelerated worldwide technical change, based on intensive research and development in the industrialized countries, is modifying the conditions of comparative advantage in international trade. Comparative advantage is no longer defined only by the abundance and relative cost of the traditional factors of labor, capital, and certain natural resources; it is also defined by the technological capacity to produce and sell new or diversified products. Second, the development of science-based technologies has been modernizing modes of production. Microelectronics and informatics, biotechnology, and the production of materials with

5 Yinghui Chen, Xiaolin Gong, Chien-Chi Chu, Yang Cao, "Access to the Internet and Access to Finance: Theory and Evidence," *Sustainability, MDPI, Open Access Journal* 10, no.7 (July 2018): 1-38.

6 Meijers, H. "Does the Internet Generate Economic Growth, International Trade, or Both?" *International Economics and Economic Policy*, 11, (2014): 137–163.

special properties, among others, are changing the relative use of capital and labor in various productive sectors. Gonzalez[7] (1986) has pointed out that Latin America's comparative advantage in labor-intensive production and natural resources is being eroded by the introduction of new technologies in developed countries. Hence, it is essential to understand such technological transformations and to define the actions needed to support appropriate domestic activities that respond to the new situation and develop a more diversified export structure.

In practice, it is appropriate for the ECO region to choose a combination of various types of technologies. These would include certain state-of-the-art technologies (such as microelectronics, biotechnology, and new materials) and, at the other extreme, technologies to increase the use of labor and support marginal sectors.

Montobbio and Rampa (2005)[8] indicated technological activity is related to export gains in high technology sectors if a country expands in industries with increasing technological opportunities, in medium technology sectors if it moves away from low opportunity sectors, in low technology sectors if it is initially specialized in growing sectors. In high-tech and low-tech sectors, export performance is also affected by the growth of technical capabilities, foreign direct investments, productivity, and the initial level of technical skills and in medium-tech by the growth rates of foreign direct investments.

Marquez and Zarzoso analyzed the effect of technological innovation on sectoral exports using a gravity model of trade.[9] The technological achievement index (TAI) and its four components - the creation of technology, diffusion of old innovations, diffusion of recent innovations, and human skills - are used as proxies for technological innovation. The first two components are considered proxies for knowledge acquisition and assimilation (potential

---

7 Norberto González, "Reactivation and development: the great commitment of Latin America and the Caribbean." CEPAL Review (December 1986)

8 Montobbio, F. and F. Rampa "The Impact of Technology and Structural Change on Export Performance in Nine Developing Countries." *World Development* 33, (2005): 527-547.

9 Laura Márquez-Ramos, and Inmaculada Martínez-Zarzoso. "The effect of technological innovation on international trade." *Economics: the open-access, open-assessment E-Journal* 4 (2010): 11.

absorptive capacity); whereas the last two are taken as proxies for knowledge transformation and exploitation (realized absorptive capacity). They hypothesize that the effect of technological innovation on trade could vary according to the technological achievement by generating a non-linear relationship between technological innovation and trade. The results indicate a positive and non-linear effect of technological innovation on export performance, which indicates that there are thresholds for positive signs to occur. They suggest fostering exports; countries have to consider not only acquisition and assimilation capabilities, but also transformation and exploitation capabilities once a minimum level of potential absorptive capacity has been achieved.

3. Definitions of the S&T Indicators

We set out to indicate the trends of the key S&T indicators in the ECO region, while the magnitude of the S&T capacity cannot be determined directly, and has to be approached using a number of relevant proxies. Thus, the indicators for S&T capacity are based on the factors that create knowledge on our assessment. Hence, we have collected data on the following ST variables, which have been obtained from the World Bank Data:

ST1: Charges for the use of intellectual property, payments (BoP, current US$)

ST1 stands for charges for the use of the intellectual property that are payments between residents and nonresidents for the authorized use of proprietary rights (such as patents, trademarks, copyrights, industrial processes and designs including trade secrets, and franchises) and for the use, through licensing agreements, of produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights (such as for live performances and television, cable, or satellite broadcast). Data on ST1 are in current U.S. dollars.

ST2: Charges for the use of intellectual property, receipts (BoP, current US$)

ST2 stands for charges for the use of the intellectual property that are receipts between residents and nonresidents for the authorized use of proprietary rights (such as patents, trademarks, copyrights, industrial processes and designs including trade secrets, and franchises) and for the use, through licensing agreements, of produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights (such as live performances and television, cable, or satellite broadcast). Data on ST2 are in current U.S. dollars.

ST3: Research and development expenditure (% of GDP)

ST3 stands for expenditures for research and development which are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.

ST4: Scientific and technical journal articles

ST4 stands for scientific and technical journal articles which refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

ST5: Patent applications, nonresidents

ST5 denotes patent applications which are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention (a product or process that provides a new way of doing something or offers a new technical solution to a problem). A patent provides protection for the invention to the nonresident owner of the patent for a limited period, generally 20 years.

ST6: Patent applications, residents

Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention (a product or process that provides a new way of doing something or offers a new technical solution to a problem) A patent provides protection for the invention to the resident owner of the patent for a limited period, generally 20 years.

ST7: Trademark applications, direct nonresident

ST7 denotes trademark applications filed which are applications to register a trademark with a national or regional Intellectual Property (IP) office. A trademark is a distinctive sign which identifies certain goods or services as those produced or provided by a specific person or enterprise. A trademark provides protection to the owner of the mark by ensuring the exclusive right to use it to identify goods or services. The period of protection varies, but a trademark can be renewed indefinitely beyond the time limit on payment of additional fees. Direct nonresident trademark applications are those filed by applicants from abroad directly at a given national IP office.

ST8: Trademark applications, direct resident

ST8 indicates trademark applications filed which are applications to register a trademark with a national or regional Intellectual Property (IP) office. A trademark is a distinctive sign which identifies certain goods or services as those produced or provided by a specific person or enterprise. A trademark provides protection to the owner of the mark by ensuring the exclusive right to use it to identify goods or services or to authorize another to use it in return for payment. The period of protection varies, but a trademark can be renewed indefinitely beyond the time limit on payment of additional fees. Direct resident trademark applications are those filed by domestic applicants directly at a given national IP office.

ST9: Trademark applications, total

ST9 indicates trademark applications filed are applications to register a trademark with a national or regional Intellectual Property (IP) office. A trademark is a distinctive sign, which identifies certain goods or services as those produced or provided by a specific person or enterprise. A trademark provides protection to the owner of the mark by ensuring the exclusive right to use it to identify goods or services or to authorize another to use it in return for payment. The period of protection varies, but a trademark can be renewed indefinitely beyond the time limit on payment of additional fees.

ST10: Researchers in R&D (per million people)

ST10 stands for researchers in R&D that are professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and the management of the projects concerned.

Postgraduate Ph.D. students (ISCED97 level 6), engaged in R&D, are included.

ST11: Technicians in R&D (per million people)

ST11 denotes technicians in R&D and equivalent staff that are people whose main tasks require technical knowledge and experience in engineering, physical and life sciences (technicians), or social sciences and humanities (equivalent staff). They participate in R&D by performing scientific and technical tasks, involving the application of concepts and operational methods, normally under the supervision of researchers.

ST12: High-technology exports (current US$)

ST12 stands for high-technology exports that are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. Data for ST12 are in current U.S. dollars.

ST13: High-technology exports (% of manufactured exports)

ST13 stands for high-technology exports that are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

3. An Overview of S&T in the ECO Region

The Economic Cooperation Organization (ECO) which was established in 1985, is an intergovernmental regional organization. Its purpose is to promote economic, technical, and cultural cooperation among the member states which include the Islamic Republic of Afghanistan, the Republic of Azerbaijan, the Islamic Republic of Iran, the Republic of Kazakhstan, the Kyrgyz Republic, the Islamic Republic of Pakistan, the Republic of Tajikistan, the Republic of Turkey, Turkmenistan, and the Republic of Uzbekistan. ECO's predecessor was the Regional Cooperation for Development which was founded in 1964 and ceased to exist in 1979. All the ECO states are also member states of the Organization of the Islamic Conference (OIC), while ECO itself has observer status in the OIC since 1995.

ECO is an organization that is thriving and growing. The member states have been collaborating over the past 12 years in order to accelerate the pace of regional development through their common endeavors. ECO has embarked on several projects in priority sectors of its cooperation including energy, trade, transportation, and agriculture. Over the past decade, the member countries have been working to harmonize measurements, classifications, and methodologies in an effort to ensure consistency regionally.

Table 8.1. reports the trends of the S&T variables for Azerbaijan during 2008-2017. ST1 (a proxy of payments for intellectual property) has increased substantially during the period 2008-2012, with a maximum value in 2012. However, ST2 has fluctuated within the period. The percentage share of R&D in GDP (denoted by ST3) approached 0.2, on average, while it fluctuated slightly during the period.

In Azerbaijan, the number of scientific and technical journal articles, denoted by ST4, has been fluctuated within the period and increased from 475 in 2008 to 684 in 2012 while it decreases to 480 in 2016. ST5 and ST6 stand for patent applications, associated with nonresidents and residents, where the trend of ST6 decreased unexpectedly during the period, indicating a deterioration rate of the patent in the country.

ST9, which sums up ST7 and ST8, shows the total trademark applications that captured the minimum value in 2009 while a maximum value in 2008, respectively; however, the numbers fluctuated since then. It is noted that ST10 is not analyzed due to the lack of observations for the whole of consideration. Meanwhile, Technicians in R&D (per million people) (ST11) had an increasing trend during 2008-2013 and reached the maximum value in 2013 while it declined during 2013-2017. However, the value of high-tech exports (ST12) has fluctuated within the period. High-technology exports % of manufactured exports (ST13) has varied during 2008-2017 while it is on average 4.5 throughout the period. Due to the low values, it is evident that the country's high-tech exports have been quite low; implying a weak position of such exports in the economy, subject to the GDP growth rates.

Table 8.1. Key S&T Variables in Azerbaijan during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	4,827	19,229	16,531	18,423	28,180	-	-	-	-	-
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)	13	1,800	149	23	28	-	-	-	-	-
ST3: Research and development expenditure (% of GDP)	0.17	0.25	0.22	0.21	0.21	0.21	0.21	0.22	0.21	0.19
ST4: Scientific and technical journal articles	475	616	605	646	684	481	400	421	480	-
ST5: Patent applications, nonresidents	7	17	17	12	-	-	-	-	19	-
ST6: Patent applications, residents	226	264	254	193	144	156	168	184	144	-
ST7: Trademark applications, direct nonresident	4,005	2,702	2,880	3,190	4,326	4,601	4,286	4,096	3,672	-
ST8: Trademark applications, direct resident	1,834	1,655	1,532	1,916	899	1,117	1,015	856	1,030	-
ST9: Trademark applications, total	5,839	4,357	4,412	5,106	5,225	5,718	5,301	4,952	4,702	-
ST10: Researchers in R&D (per million people)	-	-	-	-	-	-	-	-	-	-
ST11: Technicians in R&D (per million people)	7,425,965	4,537,422	7,200,494	10,676,252	45,374,670	73,400,927	37,909,594	15,948,624	11,900,634	14,069,403
ST12: High-technology exports (current million US$)	-	-	-	710,992,017	-	280,498,132	308,948,526		249,197,112	278,924,957
ST13: High-technology exports (% of manufactured exports)	1.06	1.01	1.37	1.79	7.94	13.71	8.14	4.20	2.72	3.05

Source: World Bank Data, www.worldbank.org

On the basis of data for S&T variables reported by Table 8.2., Kazakhstan benefited from a jump in receipts of intellectual property (ST2) in 2014 while it captured a decreasing trend to 2018. However, the share percentage of R&D expenditure to GDP was about 0.2, the same as Azerbaijan, while it decreased since 2010. The statistics reported by the table show that the number of journal articles (ST4) increased significantly during the period, while the table reports variations in patent applications (ST5 and ST6) in most years.

Table 8.2. Key indicators of the S&T in Kazakhstan during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	86,661	65,089	85,537	94,623	152,394	147,895	93,680	149,089	126,874	117,051
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)	-	-	-	-	-	267	1,776	886	1,090	695
ST3: Research and development expenditure (% of GDP)	0.22	0.23	0.15	0.15	0.17	0.17	0.17	0.17	0.14	-
ST4: Scientific and technical journal articles	226.8	270.4	324.4	382.7	478.9	1014.9	1065.5	1259.3	1563.8	-
ST5: Patent applications, nonresidents	189	314	273	317	-	378	271	232	231	173
ST6: Patent applications, residents	1,483	1,513	1,691	1,415	-	1,824	1,742	1,271	993	1,055
ST7: Trademark applications, direct nonresident	5,746	4,860	5,226	6,725	7,198	7,476	6,967	6,486	6,161	6,553
ST8: Trademark applications, direct resident	1,851	1,755	1,611	1,891	2,245	2,371	2,559	2,357	3,083	3033
ST9: Trademark applications, total	7,597	6,615	6,837	8,616	9,443	9,847	9,526	8,843	9,244	9586
ST10: Researchers in R&D (per million people)	373.2	345.6	367.2	382.3	606.0	729.5	790.2	769.4	687.6	-
ST11: Technicians in R&D (per million people)	30.7	30.0	27.7	27.9	63.5	175.0	182.0	160.2	147.9	-
ST12: High-technology exports (current million US$)	1,812,739,413	2,364,844,859	2,599,205,989	3,571,435,540	3,112,444,089	3,396,247,933	2,856,234,330	2,076,559,972	1,787,126,321	1,783,933,787
ST13: High-technology exports (% of manufactured exports)	-	30.15	34.27	24.78	30.24	37.22	38.01	41.36	30.67	22.90

Source: World Bank Data, www.worldbank.org

Table 3 reports data of S&T activities in the Kyrgyzstan Republic during 2008 - 2017. In comparison with Azerbaijan and Kazakhstan, the data for most S&T variables are seen in a lower level of values, indicating a poor condition of S&T in this country. ST1 and ST2, for instance, captured high values of 7,756 and 3,270 thousand US$ in 2012 and 2013, respectively, much less than those of Azerbaijan and Kazakhstan.

The share percentage of R&D to GDP (ST3) reached 0.14, on average. In addition, the table reports the numbers of scientific journals (ST4) and resident patent applications (ST6) respectively around 54 and 124, on average. Patent application for both residents and nonresidents (ST7 and ST8) experienced fluctuations during the period, indicating instability in protection of the owners of marks and their property rights. Finally, the table shows the maximum value of about 88 million US$ for high-tech exports in 2016, which is quite low.

Table 8.3. Key indicators of the S&T in Kyrgyzstan Republic during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	-	5,662	2,587	6,189	7,756	6,927	4,981	5,955	7,539	5,302
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)	-	1,690	1,095	1,450	2,745	3,207	1,406	1,392	2,683	805
ST3: Research and development expenditure (% of GDP)	0.19	0.16	0.16	0.16	0.17	0.15	0.13	0.12	0.11	0.11
ST4: Scientific and technical journal articles	51.40	33.80	34.20	49.90	49.20	62.70	55.90	50.90	100.80	-
ST5: Patent applications, nonresidents	3	3	6	5	1	3	7	4	5	9
ST6: Patent applications, residents	135	146	134	124	110	111	132	122	84	137
ST7: Trademark applications, direct nonresident	3,204	-	-	2,960	3,104	3,062	2,705	2,866	2,654	2978
ST8: Trademark applications, direct resident	239	-	-	180	184	232	274	243	187	310
ST9: Trademark applications, total	3,443	-	-	3,140	3,288	3,294	2,979	3,109	2,841	3288
ST12: High-technology exports (current million US$)	11,019,696	2,970,808	11,909,204	16,118,188	17,236,761	6,232,732	43,740,657	67,844,909	88,959,757	39,500,666
ST13: High-technology exports (% of manufactured exports)	3.12	5.04	1.23	3.96	4.78	5.43	2.05	12.25	19.93	17.62

Source: World Bank Data, www.worldbank.org

Table 8.4. reveals the poor conditions of S&T activities in Tajikistan in accordance with the data compiled by the World Bank (see trends of ST5 and ST6). Additionally, the share percentage of R&D expenditures to GDP (ST3) reached roughly 0.1, on average, during 2008- 2017, which is quite low. A maximum number of scientific and technical journals of about 62 have been reported for 2013, which is quite low compared to ECO members (except for Turkmenistan). According to Table 8.4, Tajikistan has strongly supported trademark applications (ST9) with a number of about 2466, on average, looking compatible with the other members. Finally, the table does not comprise the trends for variables ST10- ST13, due to the lack of data.

Table 8.4. Key indicators of the S&T in Tajikistan during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	320.0	82.8	-	-	-	-	-	-	-	88.9
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)	1036.7	623.0	-	-	-	-	-	-	-	-
ST3: Research and development expenditure (% of GDP)	0.07	0.09	0.09	0.12	0.11	0.12	0.11	0.11	0.11	0.12
ST4: Scientific and technical journal articles	30	23.3	40.6	42.8	47.5	62	37.8	54	47.5	
ST5: Patent applications, nonresidents		1	3	1	3	2		1		
ST6: Patent applications, residents		11	7	4	3	2				
ST7: Trademark applications, direct nonresident	2,375	1,930	1,841	2,565	2,569	2,542		2,423	2,175	
ST8: Trademark applications, direct resident	259	205	194	161	141	137		109	103	
ST9: Trademark applications, total	2,634	2,135	2,035	2,726	2,710	2,679		2,532	2,278	

Source: World Bank Data, www.worldbank.org

Table 8.5. reports data only for some types of S&T Turkmenistan achieves, namely ST3. As reported, Research and Development expenditure (% of GDP) (ST3) has increased from 2.6 in 2008 to 13.3 in 2012, while facing sharp decrease in 2013. However, such a trend is quite low in comparison with some ECO members.

Table 8.5. Key indicators of the S&T in Turkmenistan during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST3: Research and development expenditure (% of GDP)	2.6	5	5.3	12.2	13.3	6.9	20.1	6	3.5	-

Source: World Bank Data, www.worldbank.org

Despite the lack of data for some S&T variables for Uzbekistan, Table 8.6. indicates a better condition of S&T achievement than those of the members like Turkmenistan and Tajikistan. Scientific journals, ST4 for example, captured a maximum number of 388 in 2010. ST9, which denotes total trademark applications, received a maximum number of 5,977 in 2017.

Table 8.6. Key indicators of the S&T in Uzbekistan during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	-	-	-	-	-	-	-	-	6,417	31,372
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)	-	-	-	-	-	-	-	-	906	719
ST3: Research and development expenditure (% of GDP)	0.19	0.20	0.20	0.19	0.20	0.20	0.20	0.21	0.22	0.19
ST4: Scientific and technical journal articles	300.5	336.3	388.9	379.2	325.3	353	332.2	287.8	357.4	
ST5: Patent applications, nonresidents	186	174	262	274	253	258	223	219	202	196
ST6: Patent applications, residents	262	238	370	282	257	299	345	288	353	357
ST7: Trademark applications, direct nonresident	3158	2665	2776	3027	3089	3102	2933	2835	2518	2702
ST8: Trademark applications, direct resident	1,204	1,431	1,750	1,720	2,007	1,523	1,884	2,260	2,688	3,195
ST9: Trademark applications, total	4362	4096	4526	4747	5096	4625	4817	5095	5206	5897
ST10: Researchers in R&D (per million people)	578.6	571.2	543.2	573.0	511.5	505.6	500.0	496.7	506.0	496.3
ST11: Technicians in R&D (per million people)	62.5	64.4	66.4	58.3	60.9	57.1	58.4	59.2	62.3	45.8

Source: World Bank Data, www.worldbank.org

Table 8.7. reports data of S&T activities in Iran during 2008- 2017. ST4 which stands for scientific and technical journal articles has an increasing trend and it its highest value, 40,975 in 2017.

In addition, the table reports patent applications, nonresidents (ST5) and residents (ST6) around 5,660 and 38,982 on average, respectively. Patent application for both residents and nonresidents (ST6 and ST7) experienced fluctuations during the period, indicating instability in protection of the owners of marks and their property rights. Finally, the table shows the maximum value of about 4.48 % of manufactured exports for high-tech exports in 2011, which is quite low.

Table 8.7. Key indicators of the S&T in Iran during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST3: Research and development expenditure (% of GDP)	0.65	0.27	0.26	-	0.32	0.25	-	-	-	-
ST4: Scientific and technical journal articles	16,842	20,594	25,209	31,419	32,195	33,761	36,311	36,749	40,975	
ST5: Patent applications, nonresidents	552	516	528	489	432	338	119	-	702	995
ST6: Patent applications, residents	15,403	12,184	11,108	11,529	10,622	11,305	13,683	-	14,930	15,264
ST7: Trademark applications, direct nonresident	3,939	3,834	4,130	4,340	3,977	7,235	-	-	5,426	12,398
ST8: Trademark applications, direct resident	30,711	23,465	25,388	26,825	24,879	31,732	-	-	51,622	97,236
ST9: Trademark applications, total	34,650	27,299	29,518	31,165	28,856	38,967	55,401	62,949	57,048	109,634
ST10: Researchers in R&D (per million people)	745	709	735	-	689	671	-	-	-	-
ST11: Technicians in R&D (per million people)	-	-	-	-	186	187	-	-	-	-
ST13: High-technology exports (% of manufactured exports)	-	-	-	4.48		1.60	1.59		1.38	1.34

Source: World Bank Data, www.worldbank.org

Table 8.8. reveals the conditions of S&T activities in Turkey in accordance with the data compiled by the World Bank. The ratio of R&D expenditures to GDP (ST3) reached roughly 0.88, on average, during 2008- 2015. A maximum number of scientific and technical journals of about 33,902 have been reported for 2017, which is quite high compared to ECO members. According to Table 8.8, Turkey had on average 101,091 trademark applications (ST9) looking compatible with the other members.

Table 8.8. Key indicators of the S&T in Turkey during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	729,000	648,000	816,000	680,000	741,000	785,000	677,000	682,000	764,000	767,000
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)										9,000
ST3: Research and development expenditure (% of GDP)	0.69	0.81	0.80	0.80	0.83	0.82	0.86	0.88		
ST4: Scientific and technical journal articles	21,735	24,447	25,584	26,808	28,501	31,147	31,674	33,113	33,902	
ST5: Patent applications, nonresidents	176	177	177	228	232	269	331	489	618	380
ST6: Patent applications, residents	2,221	2,555	3,180	3,885	4,434	4,392	4,766	5,352	6,230	8,175
ST7: Trademark applications, direct nonresident	12,541	10,515	11,467	12,881	13,298	13,873	14,093	13,663	13,759	13,133
ST8: Trademark applications, direct resident	60,598	59,820	73,142	103,750	97,304	93,342	97,139	95,914	94,574	106,099
ST9: Trademark applications, total	73,139	70,335	84,609	116,631	110,602	107,215	111,232	109,577	108,333	119,232
ST10: Researchers in R&D (per million people)	750	810	890	982	1,101	1,175	1,164	1,216		
ST11: Technicians in R&D (per million people)	108	123	143	172	190	198	209	221		
ST12: High-technology exports (current million US$)	1,583,107,140	1,948,819,658	2,206,768,903	2,337,357,015	2,651,883,539	2,825,810,286	2,773,458,779	2,703,152,465	3,500,896,134	3,116,828,012
ST13: High-technology exports (% of manufactured exports)	1.86	2.02	2.20	2.11	2.16	2.29	2.33	2.58	2.51	2.90

Source: World Bank Data, www.worldbank.org

Table 8.9. reports the trends of the S&T variables for Pakistan during 2008-2017. ST1 (a proxy of payments for intellectual property) has increased substantially during the period 2013-2017, with a maximum value in 2017. However, ST2 has fluctuated within the period. The percentage share of R&D in GDP (denoted by ST3) approached 0.3, on average, while it changed slightly during the period.

In Pakistan, the number of the scientific and technical journal articles, denoted by ST4, increased twofold from 4,045 in 2008 to 9,181 in 2017, much more than those of other ECO members (except Turkey). ST5 and ST6 stand for patent applications, associated with nonresidents and residents. The trend of ST6 decreased unexpectedly during the period, indicating a deterioration rate of the patent in the country.

ST9, which sums up ST7 and ST8, shows the total trademark applications that reached the minimum value in 2008 while a maximum value in 2017, respectively; however, the numbers fluctuated since then. However, the value of high-tech exports (ST12) increased from 233,457,654 million US$ in 2008 up to 380,368,407 million US$ in 2017. The country’s high-tech exports have been 1.8 on average implying a weak position of such exports in the economy, subject to the GDP growth rates.

Table 8.9. Key indicators of the S&T in Pakistan during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	117,000	90,000	124,000	127,000	161,000	126,000	160,000	180,000	221,000	227,000
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)	38,000	5,000	4,000	7,000	7,000	6,000	12,000	15,000	10,000	10,000
ST3: Research and development expenditure (% of GDP)		0.45		0.33		0.29		0.25		
ST4: Scientific and technical journal articles	4,045	4,917	5,661	6,445	7,079	8,078	8,065	8,337	9,181	
ST5: Patent applications, nonresidents	1,375		980	861	798	783	776	677	636	505
ST6: Patent applications, residents	170		114	92	96	151	146	209	204	193
ST7: Trademark applications, direct nonresident	4,686	3,297		4,475	4,342	5,114	4,691	4,512	9,109	7,793
ST8: Trademark applications, direct resident	10,186	12,437		14,003	15,323	15,708	20,576	23,544	27,017	30,632
ST9: Trademark applications, total	14,872	15,734		18,478	19,665	20,822	25,267	28,056	36,126	38,425
ST10: Researchers in R&D (per million people)		165		151		166		294		
ST11: Technicians in R&D (per million people)		66		59		72		71		
ST12: High-technology exports (current million US$)	233,457,654	268,284,611	330,173,896	316,873,000	354,220,535	264,492,175	267,621,853	311,291,847	362,376,598	380,368,407
ST13: High-technology exports (% of manufactured exports)	1.91	1.76	1.73	1.84	1.71	1.91	1.44	1.61	1.95	2.18

Source: World Bank Data, www.worldbank.org

Table 8.10. reports data only for certain types of S&T Afghanistan achieves, namely ST1, ST2 and ST4. As reported, charges for the use of the intellectual property (ST1) were about 2,547, on average, meanwhile, its trend fluctuated during 2005-2014. In addition, the number of scientific journals (ST4) has increased from 12.5 in 2008 to 80.43 in 2016, despite a decrease in 2012-2013. However, such a trend is quite low in comparison with some ECO members.

Table 8.10. Key indicators of the S&T in Afghanistan during 2008-2017

Variable	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ST1: Charges for the use of intellectual property, payments (BoP, current thousand US$)	308.41	94.76	27,577.85	47,084.26	10,738.03	10,944.02	107.89	242.48	36.80	180.66
ST2: Charges for the use of intellectual property, receipts (BoP, current thousand US$)	643.17	744.28	626.71	433.68	-	-	463.66	12.81	-	-
ST4: Scientific and technical journal articles	12.5	23.3	33.9	42.7	35	27.3	33.3	23.5	80.4	-

Source: Word Bank Data, www.worldbank.org

4. Effects of S&T on the Regional Trade Relations: A Gravity Model Specification

The first economists who applied the first gravity equation to analyze international trade flows are Tinbergen (1962)[10] and Poyhonen (1963)[11]. Since then, the gravity model has become a popular instrument in empirical foreign trade analysis. The general gravity model applied in bilateral trade has the following form:

$$T_{ij} = A\frac{Y_i Y_j}{D_{ij}} \quad (1)$$

10 J. Tinbergen, "Shaping the World Economy: An Analysis of World Trade Flows," *New York Twentieth Century Fund* 5, No. 1, (1962): 27-30.

11 P. Poyhonen, "A Tentative Model for the Volume of Trade between Countries." *Weltwirtschaftliches Archiv* 90, no.1 (1963): 93-100.

where A is a constant term, T_{ij} is the total trade flow from origin country i to destination country j, Y_i and Y_j are the economic sizes of two countries i and j. Y_i, Y_j are usually gross domestic product (*GDP*) or gross national product (*GNP*). D_{ij} is the distance between two countries i and j, typically the geographical distance between two capital cities.[12] A simple gravity model to estimate the trade flows from country to country can be expressed as:

$$T_{ij} = f(Y_i, Y_j, N_i, N_j, DIS_{ij}) \qquad (2)$$

where Y_i (Y_j) indicates the GDP of the exporter i (importer j), a proxy for the size of the economy, N_i (N_j) is the number of population of the exporter (importer), a proxy for the size of the market, and DIS_{ij} measures distance between two countries' capitals, which is a proxy for transportation costs in trade flows. We developed an augmented gravity model in order to examine the effects of specific explanatory variables on ECO members' trade flows. According to the generalized gravity model of trade, the volume of exports between pairs of countries as a result of trade expansion, T_{ij} (total trade flow from origin country i to destination country j), is a function of their incomes (*GDPs*), their populations (*Ns*), their geographical distance and a set of S&T proxies ($S\&T_l$, l=1,2,3), represented in Equation (3):

$$T_{ij} = f(Y_i, Y_j, N_i, N_j, DIS_{ij}, S\&T_l) \qquad (3)$$

based on Equation 3, we redefine the model in form of a log-linear form for a single year (t) as follows:

$$LT_{ijt} = \beta_0 + \beta_1 LGDP_{it}{*}LGDP_{jt} + \beta_2 LEX_{it} + \beta_3 LEX_{jt} + \beta_4 DIS_{ijt} + \beta_5 S\&T_{lit} + \beta_6 \beta_5 S\&T_{ljt} + U_{ijt} \qquad (4)$$

where LT_{ijt} denotes log of exports from country i to country j at time t. $LGDP_{it}{*}LGDP_{jt}$ is the product of the (log of) GDPs per capita (GDPit p. cap.×GDPjt p. cap.) of country i and country j in time t. LEX_{it} and LEX_{jt} denote respectively the exchange rates of county i and country j at time t. In addition, DIS_{ij} indicates the distance between the two countries. $S\&T_{lit}$ *and* $S\&T_{ljt}$ show the S&T proxy for country i and j, respectively. Science and technology are supposed to have a positive effect on sustainable development to motivate innovation which plays a crucial role in the trade and growth of

12 Tri Do Thai "A gravity model for trade between Vietnam and twenty-three European countries" (Master diss., Dalarna University, School of Technology and Business Studies, Economics, 2006)

all countries. International trade theory highlights the importance of innovation in explaining the international competitiveness of a country.[13] Ricardian Trade Theory considers technology changes as international trade determinants. The Heckscher-Ohlin model indicates that trade will increase the demand for goods produced by the country's abundant resources. Since the abundant resource in most developing countries is labor, the prediction is an increase in demand for labor-intensive goods. On the other hand, making trade provides a developing country the opportunity to learn from the more advanced technologies of the developed world. This technological exchange is expected to help developing countries catch-up with the developed countries more rapidly. However, to study the role of science and technology on trade it is necessary to find a good proxy which is difficult to find. Kuznets (1962)[14] observed that the greatest obstacle to understanding the economic role of technological change was the clear inability of scholars to measure it.

Measures of technological change have typically involved one of the three major aspects of the innovative process: (1) a measure of the inputs into the innovation process, such as R&D expenditures; (2) an intermediate output, such as the number of inventions which have been patented; or (3) a direct measure of innovative output. We follow the second approach in this paper. Archibugi and Coco (2004)[15] and UNDP (2001)[16] applied the number of patents as a proxy for S&T. In addition, high-technology exports could be another proxy for the S&T variable.[17]

5. Empirical Results

Table 8.11. summarizes the empirical results for bilateral trade between ECO member countries. Data (1995-2018) have been obtained from the World Development Indicators (WDI) database of

---

13 J. Fagerberg, "International Competitiveness." *The Economic Journal* 98 (1988): 55-374.

14 S. Kuznets, "How to Judge Quality", *The New Republic* 1147, no.16 (1962): 29–31.

15 D. Archibugi, and A. Coco, "A New Indicator of Technological Capabilities for Developed and Developing Countries (ArCo)" *World Development* 32, no. 4 (2004): 629-654.

16 "UNDP Human Development Report", (New York: Oxford University Press. 2001).

17 A. Ghanbari and M. Ahmadi. "The Effect of Innovation on International Trade: Selected Medium-High-Technology Industries, Evidence on Iran+3." *Iranian Economic Review* 21, no. 1 (2017): 21-44.

the World Bank.[18] The results are analyzed to show the effects of the main determinants of trade relations in this region. They indicate that the product of the (log of) GDPs per capita (GDPit p. cap.×GDPjt p. cap.) of member countries (proxied by $LGDP_{it}$*$LGDP_{jt}$) has a positive effect on trade, and as expected, is statistically significant at the 1% significance level. The country's GDP per capita GDPP is commonly used as a proxy for a country's standard of living, purchasing power, and stage of economic development. It means that the size of economies approximated by the scale variable has a positive and significant incidence on the bilateral trade of ECO members. The implication is that a large market increases opportunities to a higher rate of trade flow between trade partners, that is, a large income raises the demand for differentiation.

The exchange rate of ECO members is considered as major determinants of foreign trade[19], while Frankle and Rose[20] contend that exchange rate volatilities have a limited effect on bilateral trade. The literature suggests that currency appreciation lowers export values while increasing the demand for imports. According to our results reported by Table (8.11.), the empirical results show that exporters' exchange rate, LEX_{it}, affects members' bilateral trade negatively while statistically significant at 1% significance levels in all cases. It implies the higher countries' currencies, the lower countries' bilateral trade. However, importers' exchange rate, LEX_{jt}, does not have a statistically significant effect on bilateral trade.

Although the estimated coefficient of the geographical distance has a negative sign, it is not statistically significant except for case 3. As reported in Table 8.11, case 3, DIS_{ijt} has a negative and significant sign that implies the existence of the negative effect of transportation cost on bilateral trade in the ECO region. In fact, export to the region's distant markets will depend on transport costs, market-entry costs, risk aversion, and the distribution of exchange rates. Based on empirical results $S\&T_{lit}$ and $S\&T_{ljt}$ ($l=1,2,3$) have a

18 "World Development Indicators", The World Bank, http://data.worldbank.org/data-catalog/world-development-indicators.

19 W.W. Koo, D. Karemera and R. Taylor "A Gravity Model Analysis of Meat Trade Policies." *Agricultural Economics* 10, no. 1 (1994): 81-88.

20 J. Frankle, and A. Rose, "An Estimate of the Effect of Common Currencies on Trade and Income." *Quarterly Journal of Economics* 117, no. 2 (2002): 437–466.

significant positive effect on ECO member countries. S&T proxied by 3 variables include Patent applications, nonresidents (Case 1), Patent applications, residents (Case 2), and High-technology exports (% of manufactured exports) (Case 3).

Table 8.11. Estimated Results for ECO members' Bilateral Trade (1995-2018)

Variable	Case 1	Case 2	Case 3
Cons.	34.95 [0.12]	41.96 [0.293]	-226.64 [0.04]**
$LGDP_{it}$* $LGDP_{jt}$	0.016 [0.00]***	0.02 [0.00] ***	0.04 [0.00]***
LEX_{it}	-.39 [0.00]***	-0.74 [0.00] ***	-1.87 [0.00]***
LEX_{jt}	-0.98 [0.129]	-0.93 [0.423]	-5.18 [0.03] **
DIS_{ijt}	-0.0003 [0.204]	-0.0003 [0.484]	-0.002 [0.04]
$S\&T_{1it}$	0.79 [0.00] ***	-	-
$S\&T_{1jt}$	0.36 [0.00] ***	-	-
$S\&T_{2it}$	-	0.45 [0.00]***	-
$S\&T_{2jt}$	-	1.44 [0.00]***	-
$S\&T_{3it}$	-	-	0.09 [0.768]
$S\&T_{3jt}$	-	-	16.43 [0.01]***
Diagnostic Tests	Waldchi2=426.93 LRchi2= 39.31	Waldchi2=98.20 LRchi2=101.54	Wald chi2=51.56 LRchi2=147.76

*** 1% Significance, ** 5% Significance and * 10% Significance.

Source: Authors

6. Conclusion

Our findings have confirmed the importance of science and technology in the ECO region to improve the connectivity of economic relations among the members. To implement the goals of sustainable development in the region, in accordance with our findings, we are now able to raise important recommendations for both economic and S&T cooperation in the ECO region.

The ECO countries have opportunities and potentials to improve their economic capacities via S&T cooperation implementation. To achieve this, they should ensure the effectiveness and coherence of all the constituent elements of the integration plans. For successful implementation of these tasks, they need to:

1) Enhance the practice of qualitative assessment of the activities of government agencies and development institutions in the ECO region.

2) Strengthen the role of universities and research institutions by improving their ability to transform ideas into innovative projects and focus their work on the needs of the industrial sector.

3) Carry out scientific research and commercialize the investigations. Usually scientific and research works are very expensive and it is recommended to develop the closest cooperation in this sphere in the frame of ECO.

4) Establish appropriate mechanisms for monitoring and evaluating the performance of innovation programs and policies and take into account the results of such evaluations in the process of identifying new initiatives and implementation of corrective measures.

5) Maintain their increasing investments in the information and communication technologies sector, particularly with a focus on human resources and entrepreneurship development programs.

6) Adopt a comprehensive policy in the field of power generation which also encompasses the integration of conventional and renewable technologies such as coal-solar based power generation so as to assure higher efficiencies in power generation with lower costs and achieve lower levels of carbon dioxide emissions.

7) Increase the international competitiveness of the high-tech industries by providing long-term incentives to producers to allocate more resources to R&D.

8) Implement joint projects and programs focusing on important areas such as renewable energy.

9) Create common information funds, libraries of reference and information literature, the fulfillment of analytical reviews on advanced achievements, and application experience of the energy generation installations and systems.

10) Publish scientific journals, working out regional manuals, reference books, and leaflets on ECO development.

11) Conduct conferences and seminars for experts, specialists, and the community, giving special importance to training programs directed towards specialists and decision-makers in state authorities, and to wide cooperation with representatives of science, education, civil public, and mass media.

12) Implement trade patterns such as PTA, FTA, and IIT for broad trade connectivity among the ECO nationals.

References

Archibugi, D. and A. Coco, "A New Indicator of Technological Capabilities for Developed and Developing Countries (ArCo)" *World Development* 32 no. 4 (2004): 629–654.

Chen, Y., X. Gong, C.C. Chu and Y. Cao "Access to the Internet and Access to Finance: Theory and Evidence," *Sustainability, MDPI, Open Access Journal* 10, no.7 (July 2018): 1-38.

Fagerberg, J. "International Competitiveness." *The Economic Journal* 98. (1988): 55-374.

Frankle, J. and A. Rose. "An Estimate of the Effect of Common Currencies on Trade and Income." *Quarterly Journal of Economics* 117, no.2 (2002): 437–466.

Ghanbari, A. and M. Ahmadi. "The Effect of Innovation on International Trade: Selected Medium-High-Technology Industries, Evidence on Iran+3." *Iranian Economic Review* 21, no.1 (2017): 21-44.

González, Norberto, "Reactivation and development: the great commitment of Latin America and the Caribbean." CEPAL Review (December 1986).

Hirsch, S. "Location of Industry and International Competitiveness". Oxford: Clarendon Press, 1967.

International Bureau. "Archive Web Portals". http://www.increast.eu.

Koo, W.W., D. Karemera and R. Taylor. "A Gravity Model Analysis of Meat Trade Policies." *Agricultural Economics* 10, no. 1 (1994): 81-88.

Kuznets, S. "How to Judge Quality". *The New Republic* 147, no.16 (1962): 29–31.

Márquez-Ramos, Laura and Inmaculada Martínez-Zarzoso. "The effect of technological innovation on international trade." *Economics: the open-access, open-assessment E-Journal* 4 (2010): 11

Meijers, H. "Does the Internet Generate Economic Growth, International Trade, or Both?" *International Economics and Economic Policy* 11, (2014): 137–163.

Montobbio, F. and F. Rampa "The Impact of Technology and Structural Change on Export Performance in Nine Developing Countries." *World Development* 33 (2005): 527-547.

Posner, M.V. "International Trade and Technical Change." *Oxford Economic Papers*,13, no.3 (1961): 323-41.

Poyhonen, P. "A Tentative Model for the Volume of Trade between Countries." *Weltwirtschaftliches Archiv* 90, no.1 (1963): 93-100.

Thai, Tri Do "A gravity model for trade between Vietnam and twenty-three European countries" Master diss., Dalarna University, School of Technology and Business Studies, Economics, 2006.

The World Bank. "World Development Indicators". http://data.worldbank.org/data-catalog/world-development-indicators.

Tinbergen, J. "Shaping the World Economy: An Analysis of World Trade Flows". *New York Twentieth Century Fund* 5, No. 1, (1962): 27-30.

Vernon, R., "International Investment and International Trade in the Product Cycle." *Quarterly Journal of Economics* 8, no. 4 (1966): 190-207.

Weinberger, D. "Our Machines Now Have Knowledge We'll Never Understand", Wired, April 18, 2017, https://www.wired.com/story/our-machines-now-have-knowledge-well-never-understand/.

"UNDP Human Development Report". New York: Oxford University Press. 2001.