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TECHNO-LOGY & HUMAN DEVELOPMENT

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ABSTRACT
In this study, relationship between technology and development is examined comparatively under conceptual and econometric aspect. Data analyses and Vector Error Correction Model as the basis for the causality test is applied for 55 countries in a different development levels for the period 2000 to 2013. High technology export, ICT export, patent applications and individual internet usage is used as an indicator of the technology level in the analyses. It is concluded that there exists a considerable difference about the relationship between technology and development between developed and developing countries.

Keywords: Technology, Development, Knowledge, ICT, VECM, Patent.
JEL Classification: C33, D80, L96, O1, O3.

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Contribution/ Originality

This study contributes in the existing literature importance of relationship between technology and knowledge in the scope of etymological investigation and also it is emphasized that impacts of this relationship on human development.

1. INTRODUCTION

Technology and development have bilateral relationship. Both of them represent the improvement based on human consequently society. Especially with the globalization process impact of this relationship on human and society increase. Therefore, examinations on this relationship are considered the human and society jointly.

Technology beyond the socio, cultural character is accepted as an important factor of the economies. Because economies are taken advantage of technology in all areas related to technology. A connection between technology and economy loom large in the point of productivity. As a matter of fact, it is seen that priority works carried out by artisans has left in its place to technology with the development of science. This process has been accelerated by development of machines and the increasing importance of technology with the motivation of productivity in the economic processes.

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Development usually refers to economic progress, but it can also apply to political, social and technological progress as well. Therefore, development contains parameters related to human development instead of economic parameters unlike the concept of economic growth. However, it is seen that importance of economic parameters for development is irrefutable in a consequence development is directly associated with technology.

According to the literature relationship of technology between economic growth is vast instead of development. This difference results from the approach to *technology*. In neo-classical growth model of Solow (1956) technology is exogenous on the contrary, it is endogenous in new growth theory of Lucas (1988) and Romer (1990). Accordingly, in new growth theory technology is more closely to the indicators of human development (education, health, etc.).

On the other different variables are used as an indicator of technology in the studies related to development and technology. The study conducted by Fagerberg and Srholec (2008) on the relationship between technology and development consists of 75 countries in a different development levels and major of them are low and medium income level for the period 2000 to 2004. According to the results of their analyses there exists a strong relationship between technological capability, governance and social capital. Study of Hardy (1980) is one of the main studies that examined the relationship between economic development and per capita phone number as an indicator of technological development. It is concluded that effect of per capita number of phone on GDP is significant for 60 countries for the period 1960 to 1973. The other study on this subject conducted by Röller and Waverman (2001) on the relationship between per capita landline and investments on telecommunication is used the data for 21 OECD countries for the period 1970 to 1990. Findings of that study indicate that development of telecommunication investments effects the economic development. O'Mahony and Vecchi (2005) examined that ICT effect on growth of output for 55 non-agricultural market economy located in England and USA for the period 1976 to 2000. In that study it is used the pooled mean group estimator method. According to the results of the analysis information and telecommunication technologies has a positive effect on the growth of output.

On the other hand there exists studies on relationship between economic development, technology exports level and patent applications as an indicator of technological development. Atun *et al.* (2007) asserts that patents have an important effect on the economic growth. Moreover that study contains the explanations about patent has a positive effect on trade, productivity and profitability. Gani (2009) examined the relationship between technology exports and per capita economic growth for the countries with higher levels of technology. It is revealed that high technology exports exert a statistically significant positive effect on growth of the technological leader category of countries and a positive but statistically insignificant effect on the potential leader category of countries. Archibugi and Coco (2004) devise a new indicator (ArCo) for the technological capabilities that the index contains a number of variables associated with technological change. As a consequence, it is presented the correlation between ArCo & GDP. Edwards (1998) analysed the robustness of the relationship between openness and total factor productivity growth for 93 countries. According to the results it is suggested that more open countries experienced faster productivity growth.

According to the conclusion of the literature review, it is seen that variables related to technology are examined, however, results of the examinations have not been evaluated in the context of development. As a matter of fact that majority of the studies have been limited it selves by the reduction of technology to quantitative variable and also qualitative and methodological studies are not contained in these studies. In this study it is aimed to emphasize the importance of method and level of technology usage for development contrary to the approaches that accepted the accessibility of technology is necessary and enough for development. Therefore it is thought that this study included 55 countries in different development level contributes for the elimination of the deficiency in the literature.

Consequently technology is analysed regarding the etymological and the formation process. From this point it is applied econometric analysis used technology data for 55 countries in a different development level for the period 2000 to 2013 and also results of this analyses are evaluated in the scope of case studies in the previous section.

2. CONCEPTUAL FRAMEWORK OF TECHNOLOGY

Consideration about the evolution of technology is vital in order to examine the conceptual framework of technology. At this point Drucker (1993) has provided for us a chronological backround as quoted below:

"Then, beginning after 1700 – and within an incredibly short 50 years- technology was invented. The very word is a manifesto in that it combined téchne, that is, the mystery of a craft skill, with logy, that is, organized, systematic, purposeful knowledge. The first engineering school, the French Ecole des Ponts et Chaussées, was founded in 1747, followed around 1770 in Germany by the first school of Agriculture and in 1776 by the first school of Mining. In 1794 the first technical university, the French Ecole Polytechnique, was founded, and with it, the profession of engineer. Shortly thereafter, between 1820 and 1850, medical education and medical practice were reorganized as a systematic technology.

In a parallel development, Britain, between 1750 and 1800, shifted from patents being monopolies to enrich royal favorites to patents being granted to encourage the application of knowledge, tools, products and processes, and to reward inventors provided they publish their inventions. This not only triggered a century of feverish mechanical invention in Britain; it finished craft mystery and secretiveness.

The great document of this dramatic shift from skill to technology –one of the most important books in history- was the Encyclopedia, edited between 1751 and 1772 by Denis Diderot (1713-1784) and Jean d' Alembert (1717-1783). This famous work attempted to together in organized and systematic form the knowledge of all crafts, and in such a way that the non-apprentice could learn to be a "technologist". It was by no means accidental that articles in the Encyclopedia that describe an individual craft (e.g. spinning or weaving) were not written by craftsmen. They were written by "information specialists": people trained as analysts, as mathematicians, as logicians – both Voltaire and Rousseau were contributors. The underlying thesis of the Encyclopedia was the effective results in the material universe - in tools, processes and products – are produced by systematic analyses, and by systematic, purposeful application of knowledge."

Technology is defined as a word "industrial science; the science of systematic knowledge of the industrial arts, especially of the more important manufactures, as spinning, weaving, metallurgy, etc."

On the other hand just the definition of the word is not enough for questioning the framework of technology, it would be also necessary etymological evaluation. Therefore etymological origin of technology is stated below:

Technology: 1610's, "a discourse or treatise on an art or the arts", from Greek technologia "systematic treatment of an art, craft or technique" originally referring to grammar, from tekhno (techno+logy). The meaning "study of mechanical and industrial arts" (Century Dictionary, 1902, gives examples of "spinning, metal-working, or brewing") is first recorded 1859. High technology attested from 1964; short form high-tech is from 1972.

- Techno: forming element meaning "art, craft, skill", later "technical, technology", from Latinized form of Greek tekhno-, combining form of tekhne "art, skill, craft in work; method, system, an art, a system or method of making or doing", from PIE *teks-na- "craft" (of weawing or fabricating), from suffixed form of root *teks- "to weave, fabricate, make" (source also of Sanskrit taksan "carpenter", Greek tekton "carpenter", Latin texere "to weave".

According to the etymological structure of the word "technology" it consists of *skill* and *knowledge* jointly. Therefore it must be approached to "techno" and "knowledge" respectively for the purpose of evaluating technology properly.

- Firstly "techno" is examined, it is seen that "techno" has already existed before the technology and the science in the historical process. This situation is declared by Ellul (1964) like that:

"The relation between science and technique is a standard subject for graduate theses-in all the trappings of nineteenth-century experimental science. Everyone has been taught that technique is an application of science; more particularly (science being pure speculation), technique figures as the point of contact between material reality and the scientific formula. But it also appears as the practical product, the application of the formulas to practical life.

This traditional view is radically false. It takes into account only a Single category of science and only a short period of time: it is true only for the physical sciences and for the nineteenth century. It is not possible therefore to base a general study on it nor, as we are attempting to do here, an up-to-date review of the situation. A few simple remarks suffice to destroy our confidence in these views. Historically, technique preceded science; even primitive man was acquainted with certain techniques. The first techniques of Hellenistic civilization were Oriental; they were not derived from Greek science. Thus historically speaking, the relationship between science and technique ought to be reversed. However, technique began to develop and extend itself only after science appeared; to progress, technique had to wait for science".

- Secondly "knowledge" is examined, it is seen that there is need a comprehensive analysis for the knowledge especially for the formation process of it. Therefore formation process and usage of knowledge will be examined.

It can be said that knowledge formation process differs or cannot be completed because of the fact that knowledge formation process arise from contact with subject and there exists differences related to quality and the transformation of this contact. According to this;

- When the subject extend beyond the contact with data there exists a transformation in the subject. In this process there exists knowledge formation process with the transformation of the subject.
- When the subject just contact with data but there is no more process, there is not exist a transformation in the subject. In this process, there exists just information formation process with the exception of subject transformation.

Diagram 1, stated below, is prepared for the purpose of understanding the knowledge formation process.

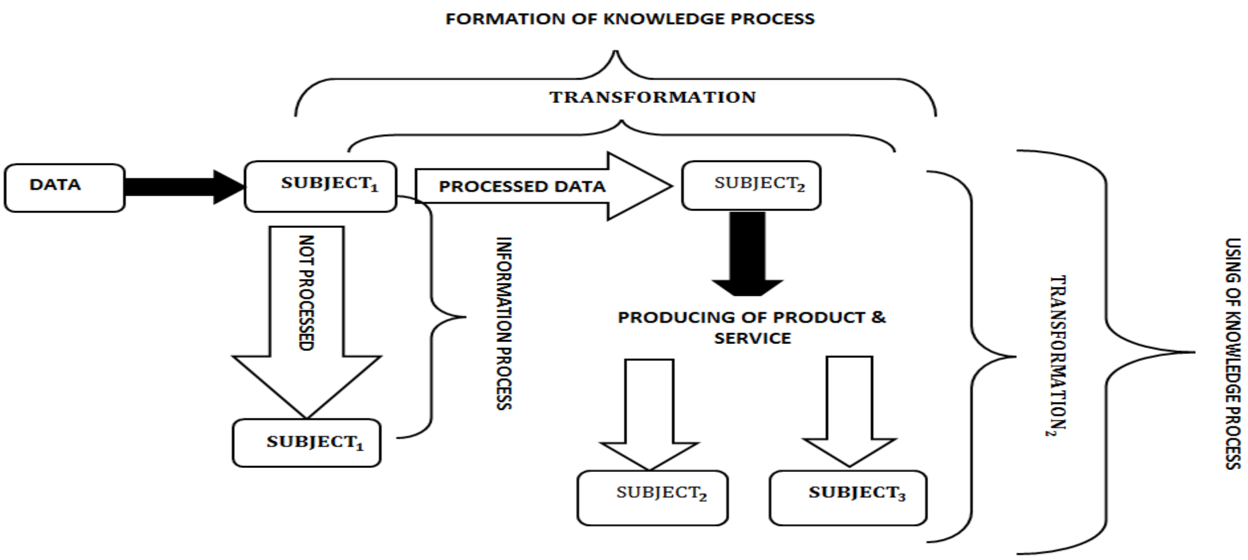


Diagram-1. Formation & Usage of Knowledge

Source: Doğan and Topuz (2016)

There exists a general explanation concerning the formation and usage process of knowledge at the Diagram 1, stated above. Based on this Diagram 1, if knowledge formation and usage process is accepted as the gradual and continual process it is seen that this process contains different cases in itself. These cases are included in the Table stated below.

Table-1. Formation & Usage of Knowledge: Case Study

PROCESS	PROCESS1				PROCESS2		
CASES	**INPUT**	**PROCESS**	**REFLECTION**	**RESULT1**	**PROCESS**	**REFLECTION**	**RESULT2**
CASE 1	DATA	-	-	INF1	-	-	INF1
CASE 2	DATA	-	-	INF1	+	-	KNOW1
CASE 3	DATA	-	-	INF1	+	+	KNOW2
CASE 4	DATA	+	-	KNOW3	-	-	KNOW3
CASE 5	DATA	+	+	KNOW4	-	-	KNOW4
CASE 6	DATA	+	+	KNOW4	+	-	KNOW5
CASE 7	DATA	+	+	KNOW4	+	+	KNOW6
CASE 8	INF	-	-	INF2	-	-	INF2
CASE 9	INF	-	-	INF2	+	-	KNOW7
CASE 10	INF	-	-	INF2	+	+	KNOW8
CASE 11	INF	+	-	KNOW9	-	-	KNOW9
CASE 12	INF	+	+	KNOW10	-	-	KNOW10
CASE 13	INF	+	+	KNOW10	+	-	KNOW 11
CASE 14	INF	+	+	KNOW10	+	+	KNOW12
CASE 15	KNOW	-	-	INF3	-	-	INF3
CASE 16	KNOW	-	-	INF3	+	-	KNOW13
CASE 17	KNOW	-	-	INF3	+	+	KNOW14
CASE 18	KNOW	+	-	KNOW15	-	-	KNOW15
CASE 19	KNOW	+	+	KNOW16	-	-	KNOW16
CASE 20	KNOW	+	+	KNOW16	+	-	KNOW17
CASE 21	KNOW	+	+	KNOW16	+	+	KNOW18

Note: INF: Information, KNOW: Knowledge; "+": process or reflection realized, "-": process or reflection is not realized.

Source: Doğan and Topuz (2016)

Table essentially consists two process. Both of these process is prepared based on the different levels of process and reflections of inputs. First process contains 9 different cases by itself and independent from the Process 2. Second process that consists new cases arise from different information and knowledge level in each cases, arise from the end of Process 1. Therefore, it contains 21 different cases.

- Process 1 ranges according to the differentiation of basic input of formation of knowledge and information. Information and knowledge in different levels result from the formations like "from data to information or knowledge" and "from information to information and knowledge" and "from knowledge to information and knowledge".
- Process 2 ranges according to differentiation of knowledge and information process due to processing or reflection of inputs in the Process 1.

When Process 1 and Process 2 is evaluated together, it is said that Process 2 is continuation of Process 1 and also Process 2 consists of comprehensive repetition of acts and increase of processing of inputs. Therefore differentiated information and knowledge level arise because of the differentiation of processing level of information and knowledge in each Step. According to this;

- First seven case consists of the formation of information and knowledge process from the data. In these cases it is accepted that production of information and knowledge capacity is high. Because in these cases addition to the usage and transformation of formed information and knowledge, it is also gained information and knowledge quality to the data. The favorite case is Case7 which data is processed and reflected in each step.
- Case 8-14 consists of the formation of information and knowledge process from the information. In these cases it is accepted that production of information and knowledge capacity is lower than the first seven case. Because in these cases formation of information and knowledge is based on information instead of data. The favorite case is Case14 which information is processed and reflected in each step.

- Case 15-21 consists of the formation of information and knowledge process from the knowledge. In these cases it is accepted that production of information and knowledge capacity is lower than the first fourteen case. Because in these cases formation of information and knowledge is based on knowledge instead of data or information. The favorite case is Case21 which knowledge is processed and reflected in each step.

When all of the 21 cases are evaluated together it is accepted that the favorite case is Case7 because of the processing and reflection capacity.

It can be said that differentiations of skill and knowledge level covered by technology is determining on itself. However, it is expected that this differentiation is determining not only on technology level but also other parameters related to technology. One of the parameters associated with technology is economic growth. On the other hand it can be accepted that technological development level is much more related to knowledge instead of techno. Thus relationship between technology & development is more than the relationship between technology & economic growth due to the correlational and social features of knowledge. Consequently, there exists an econometrical analysis for the evaluation of relationship between development and technology.

3. ECONOMETRICAL METHOD AND DATA ANALYSIS

3.1. Data

The data used in this paper are annual and consist of 55 countries for the period 2000 to 2013. Countries and years have been selected according to the accessibility of the data. These countries are divided into two groups according to the ranks of Human Development Index and ICT Index in consideration of relationship between technology and human development. First group consists of 33 countries, with high ranking (a low numerical rank) and the second group consists of 22 countries, with low ranking (a high numerical rank). These countries are stated Table 2, as follows

Table-2. Country List

Group	Countries
Group 1	Austria, Canada, Chile, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Japan, Korea Republic, Latvia, Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Russian Federation, Singapore, Slovak Republic, Spain, Sweden, Switzerland, UK, USA.
Group 2	Armenia, Brazil, Bulgaria, China, Colombia, Georgia, Guatemala, India, Jamaica, Jordan, Madagascar, Malaysia, Mexico, Moldova, Peru, Philippines, Romania, South Africa, Thailand, Tunisia, Turkey, Ukraine

Source: These countries are grouped by the authors according to UNDP Human Development Index and ITU Global ICT Development Index.

Symbols and definitions of the variables are as follows, Table 3.

Table-3. Details of Variables

Variable	Definition
HTER*	High Technology Exports Ratio (% of total goods exports)
ICTE*	ICT Goods Exports Ratio (% of total goods exports)
PR*	Patent Applications (Residents)
IIR**	Individual Internet Usage Ratio (Percentage of Individuals using the Internet)

Source: (*) World Bank Data, (**) ITU Data.

IIR is obtained from statistics of International Telecommunication Union and all of the other variables are obtained from World Bank Data.

3.2. Methodology

In this analysis firstly it is examined the panel cross-section dependence before the examination of relationship between the variables. Lagrange multiplier tests proposed by Breusch and Pagan (1980); Pesaran (2004) and Pesaran *et al.* (2008) are used for the cross section dependence. Series are examined with second generation Cross-Section Augmented Dickey-Fuller (CADF) test statistics formed by Pesaran (2007) contained cross-section dependency and Cross-Section Augmented IPS (CIPS) test statistics calculated by taking the averages. After the examination of stationary of the series, panel co-integration test is applied for the purpose of analyzing the long term relationship between the series. Finally, Vector Error Correction Model (VECM) is applied in order to ascertain the direction of relationship between the variables.

3.3. Panel Cross-Section Dependence Test

Panel cross-section dependence test ascertain the affection level of all cross-sections by reason of shocks. Ignorance of cross-sectional dependence might be problematic in the next step for selection of unit root tests. First generation unit root tests ignore the cross-sectional dependency, however second generation unit root tests take into consideration the cross-sectional dependency. Therefore ignorance of cross-sectional dependency causes the results being biased and inconsistent.

Lagrange multiplier (LM) test statistic proposed by Breusch and Pagan (1980) is based on the following LM statistic:

$$CDLM_1 = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{\,2} \sim \chi^2_{N(N-1)/2} \qquad (1)$$

LM test statistic ascertain the cross-sectional dependence in case of $T>N$, shows χ^2 distribution with N fixed and as $T \to \infty$.

Cross-sectional dependence is controlled with Pesaran (2004) $CDLM_2$ test statistics in case of $T=N$ and Pesaran (2004) $CDLM$ test statistics in case of $T<N$. However $CDLM_1$ test statictics is biased if average of group is zero but average of individuals is not zero. As a solution of this problem Pesaran *et al.* (2008) shows the reformulated CDLM test statistics like that:

$$CDLM_{adj} = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left[\hat{\rho}_{ij}^{\,2}\left(\frac{(T-K-1)\hat{\rho}_{ij}-\hat{\mu}_{Tij}}{v_{Tij}}\right)\right] \sim N(0,1) \qquad (2)$$

Hypothesis of the test is H_0: No cross section dependence. H_1: Cross section dependence.

In this paper results of $CDLM$ test statistics are used because of the the existence of the case $N>T$. According to this it is ascertained that probability values of the variables are smaller than 0,05 except for the variable “PR”. Therefore it is concluded that there is a cross-sectional dependence in the series. Test results are reported Table 4.

3.4. Panel Unit Root Test

In this study stationarity of the series is analyzed by CADF and CIPS test statistics. Second generation unit root tests are used depending on the results of the analysis in the previous section. Pesaran (2007) presents an alternative test that contains cross sectional averages and first differences of ADF regression. Regression model of this test is as follows:

$$\Delta y_{it} = \alpha_i + b_i y_{i,t-1} + c_i\bar{y}_{t-1} + d_i\Delta\bar{y}_t + e_{it} \qquad (3)$$

Variables “$\bar{y}_{t-1}$” and "$\Delta\bar{y}_t$“ are calculated like that:

$$\bar{y}_{t-1} = (1/N)\sum_{i=1}^{N} y_{i,t-1} \text{ and } \Delta\bar{y}_t = (1/N)\sum_{i=1}^{N}\Delta y_{i,t} \qquad (4)$$

Existence of these variables demonstrates that cross-sectional dependence is considered in the model. Pesaran (2007) declared that results of these tests are reliable in case of small samples (N=T=10) and high cross-sectional dependence (Pesaran, 2007). Test statistics of coefficient b_i shows CADF statistics. These test statistics compare with the critical values of Pesaran (2007) and it is decided that cross sectional data are stationary or not.

Table-4. Test Results of *Cross-Sectional Dependence*

Group	Variable	Breusch-Pagan ($CDLM_1$)	Pesaran scaled LM ($CDLM_2$)	Bias-corrected scaled LM	Pesaran CD (CDLM)
Group 1	HTER	936,8034 (0,0000)	11,56455 (0,0000)	10,18955 (0,0000)	12,22170 (0,0000)**
	ICTE	726,7405 (0,0000)	5,100311 (0,0000)	3,725311 (0,0002)	6,742713 (0,0000)**
	PR	557,3481 (0,1821)	-0,112378 (0,9105)	-1,487378 (0,1369)	0,680213 (0,4964)
	IIR	1028,246 (0,0000)	14,37849 (0,0000)	13,00349 (0,0000)	13,50126 (0,0000)**
Group 2	HTER	247,3353 (0,2196)	-0,263544 (0,7921)	-1,180211 (0,2379)	3,822477 (0,0001)**
	ICTE	297,1774 (0,0021)	2,055320 (0,0398)	1,138653 (0,2548)	5,519674 (0,0000)**
	PR	280,7619 (0,0140)	1,291603 (0,1965)	0,374936 (0,7077)	0,637818 (0,5236)
	IIR	409,5249 (0,0000)	7,282198 (0,0000)	6,365531 (0,0000)	5,401992 (0,0000)**

Note: p values in parentheses. (**) significant at the %5 level.

CIPS (Cross-Section Augmented IPS) is an unit root test statistics for all of the panel and it is calculated by taking averages of CADF test statistics. It is as follows:

$$CIPS = N^{-1} \sum_{i=1}^{N} CADF_i \quad (5)$$

Results of CIPS are evaluated according to the critical values calculated by simulation and contained in the table by Pesaran (2007). Null hypothesis and the alternative hypothesis are the same in each test. H_0:Non Stationary and H_1:Stationary. It is concluded that panel data series are non stationary if test statistics values of CIPS are bigger than critical values. The test results of unit root tests for levels and first differences are summarized in Table 5.

Table-5. Test Results of *CIPS*

		Group		Critical Value		
	Variables	Group 1	Group 2	% 10	% 5	% 1
LEVEL	HTER	-1,807	-2,238	-2,66	-2,76	-2,96
	ICTE	-2,086	-2,356	-2,66	-2,76	-2,96
	PR	-2,385	-2,348	-2,66	-2,76	-2,96
	IIR	-2,537	-1,925	-2,66	-2,76	-2,96
FIRST DIFFERENCE	DHTER	-2,969	-3,186	-2,14	-2,25	-2,45
	DICTE	-3,208	-3,570	-2,14	-2,25	-2,45
	DPR	-3,501	-3,335	-2,14	-2,25	-2,45
	DIIR	-3,513	-2,720	-2,14	-2,25	-2,45

Source: Author's estimations.

According to Table 5, in no case we can find evidence against the null hypothesis that the series contain unit roots for levels. However, we reject the null hypothesis at first differences. Results of the test are stationary with trend at the first difference level. Panel co-integration test and the vector error correction model is applied due to the fact that all of the series are stationary at first differences.

3.5. Panel Co-integration Test

It is used panel co-integration analyses for the presence of long-run relationships among integrated variables with both a time-series dimension and a cross sectional dimension. Johansen (1988) has developed two different likelihood ratio test in order to ascertain co-integration relation in the non-stationary series.

$$J_{Max} = -T ln\left(1 - \hat{\lambda}_{r+1}\right) \quad (6)$$

$$J_{Trace} = -T \sum_{i=r+1}^{p} ln(1 - \hat{\lambda}_i) \quad (7)$$

Equations relating to Maximum eigenvalue and trace test are respectively stated Equation 6 and Equation 7. The null hypothesis for the trace test is that the number of co-integration vectors is r=r*<k, and the alternative that r=k. The null hypothesis for the Maximum eigenvalue test is that the number of co-integration vectors is r=k, and the alternative that r=r*+1.

Johansen Fisher panel co-integration test uses Johansen co-integration test results in order to calculate the co-integration relation. Maddala and Wu (1999) define Fisher type test statistics is as follows:

$$\lambda = -2 \sum_{i=1}^{N} log_e(p_i) \quad (8)$$

p_i value refers to individual test statistics for country *i*. Test statistic value has *2N* degree of freedom and χ^2distribution.

Trace and Max Eigenvalue test statistics are both of them used for analyses, however, Johansen results do not contain equal number of co-integration vector. If it is concluded different results from each of the test statistics, maximum eigenvalue test results are preferred. Because it consists an advantage obtaining different test result in each eigenvalue (Lee and Brahmasrene, 2013).

Table-6. Test Results of Co-integration

Group	Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
Group 1	None	148.0	0.0000	148.0	0.0000
	At most 1	522.7	0.0000	522.7	0.0000
	At most 2	242.6	0.0000	207.2	0.0000
	At most 3	146.5	0.0000	146.5	0.0000
Group 2	None	115.7	0.0000	115.7	0.0000
	At most 1	371.2	0.0000	371.2	0.0000
	At most 2	215.5	0.0000	177.6	0.0000
	At most 3	126.2	0.0000	126.2	0.0000

Note: Co-integration test is applied under the condition of "intercept and no trend".

According to Johansen Fisher Co-integration test results stated above Table 6, there is a long term co-integration between the series.

3.6. Vector Error Correction Model

Next step is determination of the direction of causality after examination of the long term relationship between the series. Engle and Granger (1987) shows that a bivariate co-integrated system must have a causal ordering in at least one direction. Co-integration test just shows that there is a relationship between the variables however it does not show the direction of the relationship. Therefore direction of relationship is determined by VECM for the variables which are not stationary at the level and have long term relationship. Also this model contains short and long term effects. If the dependent variable is driven directly by this long-run equilibrium error, then it is responding to this feedback. If not, it is responding only to short-term shocks to the stochastic environment. F test contains short term causality and T test derive from long term co-integration, contains lagged error correction term provide an information. The coefficient of the lagged error-correction term, however, is a short-term adjustment coefficient and represents the proportion by which the long-run disequilibrium (or imbalance) in the dependent variable is being corrected in each short period (Masih and Masih, 1997).

Vector Error Correction Model is as follows:

$$\Delta X_{it} = \theta + \sum_{k=1}^{m}\theta_{ik}\Delta X_{it-k} + \sum_{k=1}^{m}\theta_{ik}\Delta Y_{it-k} + \sum_{k=1}^{m}\theta_{ik}\Delta Z_{it-k}\sum_{k=1}^{m}\theta_{ik}\Delta T_{it-k} + \lambda_i ECT_{it-1} + e_{1it} \quad (9)$$

In the equation λ represents error correction parameter; Δ denotes first differences; k is the optimal lag length determined by the Akaike and Schwarz Criterion; ΔX , ΔY, ΔZ and ΔT represent effects of the divergences arised in the short term; ECT (Error Correction Term) represents the error terms derived from the long run co-integrating relationship. Therefore the model allows to test for short run and long run causality. The empirical model is represented by the following 4 equation VECM.

$$\Delta PR_{it} = \theta_{1j} + \sum_{k=1}^{m}\theta_{11ik}\Delta PR_{it-k} + \sum_{k=1}^{m}\theta_{12ik}\Delta HTER_{it-k} + \sum_{k=1}^{m}\theta_{13ik}\Delta ICTE_{it-k}\sum_{k=1}^{m}\theta_{14ik}\Delta IIR_{it-k} + \lambda_{1i}ECT_{it-1} + e_{1it} \quad (10)$$

$$\Delta HTER_{it} = \theta_{2j} + \sum_{k=1}^{m}\theta_{21ik}\Delta HTER_{it-k} + \sum_{k=1}^{m}\theta_{22ik}\Delta PR_{it-k} + \sum_{k=1}^{m}\theta_{23ik}\Delta ICTE_{it-k}\sum_{k=1}^{m}\theta_{24ik}\Delta IIR_{it-k} + \lambda_{2i}ECT_{it-1} + e_{2it} \quad (11)$$

$$\Delta ICTE_{it} = \theta_{3j} + \sum_{k=1}^{m}\theta_{31ik}\Delta ICTE_{it-k} + \sum_{k=1}^{m}\theta_{32ik}\Delta PR_{it-k} + \sum_{k=1}^{m}\theta_{33ik}\Delta HTER_{it-k}\sum_{k=1}^{m}\theta_{34ik}\Delta IIR_{it-k} + \lambda_{3i}ECT_{it-1} + e_{3it} \quad (12)$$

$$\Delta IIR_{it} = \theta_{4j} + \sum_{k=1}^{m}\theta_{41ik}\Delta IIR_{it-k} + \sum_{k=1}^{m}\theta_{42ik}\Delta PR_{it-k} + \sum_{k=1}^{m}\theta_{43ik}\Delta HTER_{it-k}\sum_{k=1}^{m}\theta_{44ik}\Delta ICTE_{it-k} + \lambda_{4i}ECT_{it-1} + e_{4it} \quad (13)$$

The causality pattern between the variables evaluated with the VECMs are reported in Table 7.

According to results of Vector Error Correction Model;

- For Group 1: There is a bi-directional Granger Causality between DHTER, DICTE, DIIR and there is an one directional Granger Causality from DHTER, DICTE, DIIR to DPR.
- For Group 2: There is a bi-directional Granger Causality between DHTER, DIIR and there is an one directional Granger Causality from DICTE to DHTER and DICTE to DIIR.

Table-7. Test Results of VECM

Group	Independent Variables	Dependent Variables			
		DHTER	**DICTE**	**DPR**	**DIIR**
Group 1	DHTER	-	-1,052609 (0,0000)	-1,069045 (0,0000)	-1,011339 (0,0000)
	DICTE	-0,033044 (0,0000)	-	-0,901932 (0,0000)	-0,659545 (0,0000)
	DPR	-0,002684 (0,5097)	0,001864 (0,5917)	-	-0,007322 (0,1385)
	DIIR	-0,092119 (0,0014)	-0,294243 (0,0000)	-0,717795 (0,0000)	-
Group 2	DHTER	-	-0,036725 (0,4347)	0,000804 (0,6447)	-0,464510 (0,0000)
	DICTE	-1,262025 (0,0000)	-	0,000667 (0,8539)	-1,234462 (0,0000)
	DPR	0,950604 (0,0000)	0,949859 (0,0000)	-	0,952807 (0,0000)
	DIIR	-0,240354 (0,0000)	-0,004209 (0,5779)	-0,000578 (0,8134)	-

Note: Values represent C (1) and p values in parentheses.

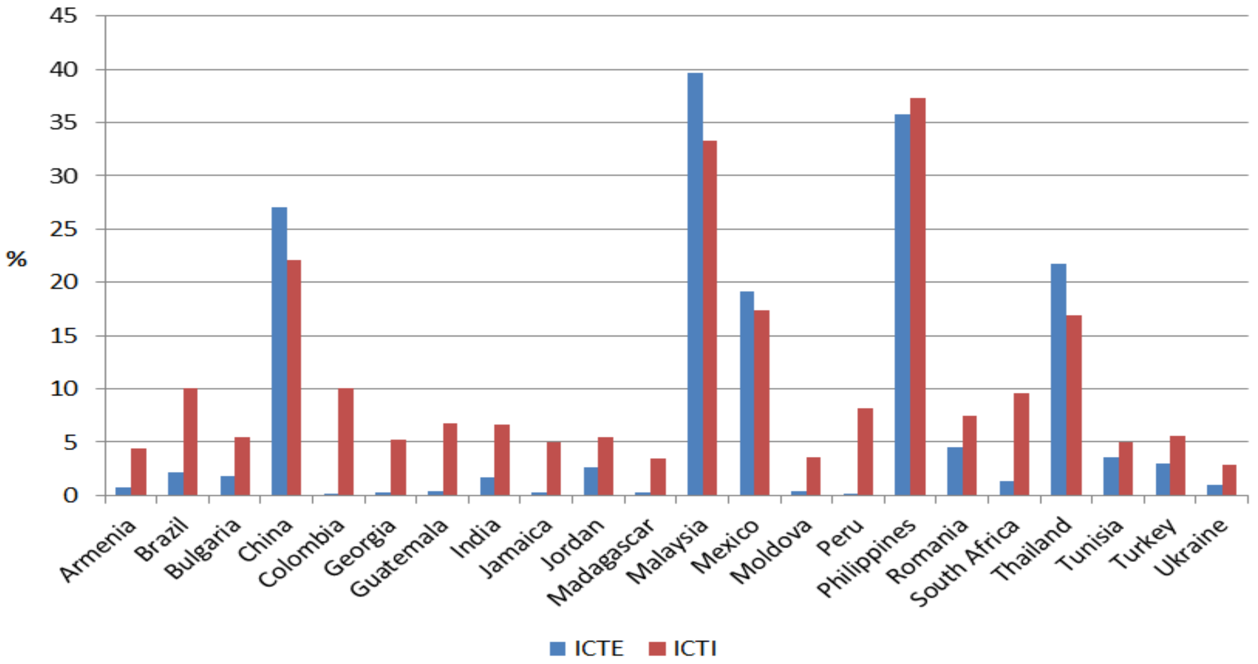
4. EVALUATION

In this study based on evaluation of relationship between technology and development, it is examined that required technology level and the usage method of technology beyond the requirement of technology for development. This examination contains relationship between High Technology export ratio, ICT ratio, patent applications as an indicator of knowledge and usage of individual internet ratio as an indicator of techno for 55 countries different development and technology level. According to the analysis it is concluded that there is a relationship between the indicators of knowledge (DHTER, DIIR, DPR) for the developed countries in opposition to the developing countries. Moreover it is seen that relationship between indicator of techno (DIIR) and the indicators of knowledge is more in the developed countries than the developing countries. These results are examined according to Table 1 as follows;

- Variables tests formation of techno and knowledge based on data are not included in this analysis. Therefore analysis represent these cases cannot be examined in this study (Case: 1-7).
- For Developed Countries (Group 1) it can be concluded that
- Formation of knowledge based on techno is realized due to the existence of relationship from individual internet usage ratio to high technology export ratio, ICT ratio and patent applications (Table 1: Case: 11-14).
- Formation of knowledge from knowledge is realized due to the existence of relationship from high technology export ratio and ICT ratio to patent applications (Table 1: Case: 18-21).
- For Developing Countries (Group 2) it can be concluded that formation of knowledge based on techno is realized due to the existence of relationship from individual internet usage ratio to high technology export ratio (Table 1: Case: 11-14).

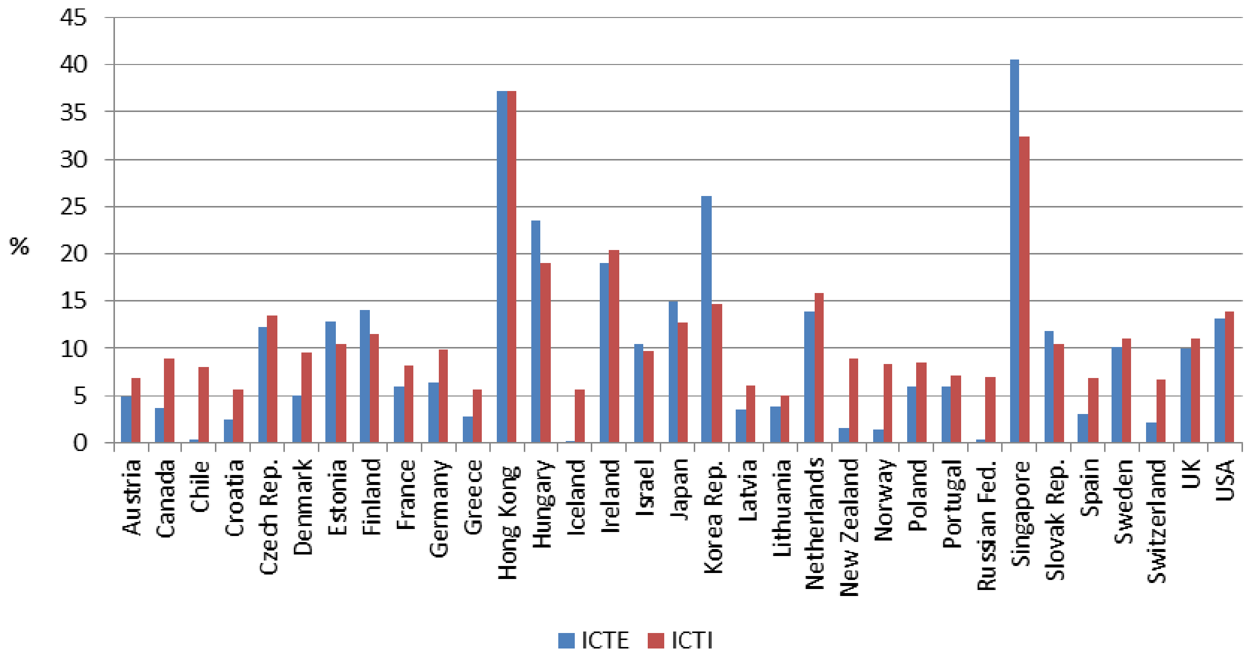
It is seen that there is an important differences between the country groups in the scope of level of technology usage transformed to knowledge beyond the existence and accessibility of technology. This situation can be construed that usage of technology as an input beyond the usage of technology without transformation of knowledge and the commodity character, supports to development. Nonetheless it can be said that transformation to knowledge provided development cannot be realized addition to the extension of an accessibility to technology in the developing countries in opposition to the developed countries. Reason of this situation is technology is used just as the final product and accepted as the commodity.

On the other hand Graphs, stated below, are prepared for the purpose of questioning the approaches based on *technology is the basic motivation of development* and *developed countries have high technology level.*



Graph-1. ICT Exports & Imports Ratio (as a percentage of total exports & imports) for Developing Countries
Source: It is prepared by the authors via calculation of the data from World Bank Data.

According to Graph 1 there is a dramatic difference between ICT imports and ICT exports in favor of imports against to exports. However, four countries (China, Malaysia, Mexico, Thailand) opposed to the overall position.



Graph-2. ICT Exports & Imports Ratio (as a percentage of total exports & imports) for Developed Countries
Source: It is prepared by the authors via calculation of the data from World Bank Data.

According to Graph 2 there is not crucial difference between ICT imports and ICT exports level. However, six countries (Chile, Iceland, Korea, New Zealand, Norway, Russian Federation) opposed to the overall position.

When Graph 1 and Graph 2 is evaluated together, it is examined that the countries in a high ICT international trade level are included in the developing countries and also the countries in a low ICT international trade level are included in the developed countries. Therefore these graphs show that technology by itself cannot be the motivation of development and the technology level of developed countries is more than the developing countries. Technology obviously is an important indicator of development. If technology is crucial for the development as it is supposed, the 4 country (China, Malaysia, Mexico, Thailand) within the developing countries would be within the developed countries and also some of the countries like New Zealand, Norway would be within the developing countries. Consequently, it can be said that technology cannot provide development by itself, for the development technology is necessary but the most important thing is using the technology in the process of knowledge formation and provides the transformation of technology to knowledge.

5. CONCLUSION

When the studies related to technology and development are examined, it is seen that technology is reduced to quantitative element and also examined with economic growth instead of development. The reason of this situation is that technology consisting of a combination of skills and knowledge, is accepted just as the skill (techno) instead of knowledge. In this study initially it is examined the conceptual framework of technology.

Then technology, data which contains skill (techno) and knowledge is analyzed for the countries of different development level. According to the analyses it is concluded that technology should be examined with the formation of knowledge and also evaluations in the scope of development, accepted the technology just as the quantitative data cannot be acceptable.

In this context it can be said that differences between the developed and developing countries result from approaches to technology instead of accessibility to technology. For the detection of this situation causality analyses is applied used the data High Technology Export Ratio, ICT export ratio, patent applications and individual internet usage ratio for 55 countries in a different development level for the period 2000 to 2013.

Results of this analyses are evaluated with the graphs related to ICT exports and ICT imports level. According to the evaluations developed and developing countries both of them can access to the technology, however technology is used as an input in developed countries; on the contrary technology is used just as a final good in developing countries.

Finally, it is suggested that technology should be used as a process provided the transformation of technology to knowledge in opposition to be used just as the quantitative input of development. Therefore relationship between technology and development is examined in the scope of knowledge. Moreover development policies of the states also contains the measurements provided the increase of skilled labor instead of the technicians just use the technology.

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