KMÜ Sosyal ve Ekonomik Araştırmalar Dergisi (KMUSEKAD)
KMU Journal of Social and Economic Research
Yıl/Year: 2020, 22 (39): 239-249

Geliş/Received: 16.11.2020
Kabul/Accepted: 24.12.2020

The Relationship Between Human Capital And The Export of Information And Communication Technology: A Study of G7 Countries Based on A Panel Error Correction Model Analysis

Mehmet AKYOL*

Abstract

In today's information age the acceleration of technological advances increases the importance of information and communication technologies. Many countries increase their physical and human capital investments in the information and communication technologies sector to increase their production power and exports. In this study, the long and short-term relationships between exports of information and communication technology products and higher education graduate employment are analyzed by means of pooled mean group estimator, mean group estimator and dynamic fixed effects estimator. The study covers G-7 countries (Canada, Germany, France, Italy, England, Japan and the USA) and Japan is not included in the analysis due to lack of data. In the study evaluating the period between 2003-2018, it was concluded that the results of the Hausman test mean group estimator were valid. According to the pooled average group estimator results, the existence of a long-term relationship between information and communication technology products exports and higher education graduate employment has been confirmed.

Key Words: Human Capital, Information and Communication Technology, Panel Data

Article Type: Research Article

Bilgi ve İletişim Teknolojileri Malları İhracatı ve Beşeri Sermaye Arasındaki İlişki: G-7 Ülkeleri İçin Panel Hata Düzeltme Modeli Analizi

Öz

Bilgi çağının yaşandığı günümüzde teknolojik ilerlemelerin hız kazanması bilgi ve iletişim teknolojilerinin önemini arttırmaktadır. Birçok ülke bilgi ve iletişim teknolojileri sektöründe üretim gücü ve ihracat artışı sağlamak adına sektöre yönelik fiziksel ve beşeri sermaye yatırımlarını arttırmaktadır. Bu çalışmada bilgi ve iletişim teknolojileri ürünleri ihracatı ile yüksek öğretim mezunu istihdam arasındaki uzun ve kısa dönemli ilişkiler havuzlanmış ortalama grup tahmincisi, dinamik sabit etkiler tahmincisi ve ortalama grup tahmincisi aracılığı ile analiz edilmektedir. Çalışma G-7 ülkelerini (Kanada, Almanya, Fransa, İtalya, İngiltere, Japonya ve ABD) kapsamakta ve veri eksikliğinden dolayı Japonya analize dahil edilmemektedir. 2003-2018 yılları arası dönemin değerlendirildiği çalışmada Hausman testi ile havuzlanmış ortalama grup tahmincisinin sonuçlarının geçerli olduğuna kanaat getirilmiştir. Havuzlanmış ortalama grup tahmincisi sonuçlarına göre bilgi ve iletişim teknolojisi ürünleri ihracatı ve yüksek öğretim mezunu istihdamı arasında uzun dönemli ilişkinin varlığı doğrulanmıştır.

Anahtar Kelimeler: Beşeri sermaye, Bilgi ve İletişim Teknolojileri, Panel Veri

Makale Türü: Araştırma Makalesi

*Dr. Öğretim Üyesi, Gümüşhane Üniversitesi, İİBF, İktisat Bölümü, Mehmet_akyol81@hotmail.com, ORCID ID: 0000-0002-1173-200X

1. INTRODUCTION

During the last quarter of a century, developments in information and communication technology (ICT) have transformed the society we live in into what some have called a communication society (Yoon, 2019: 1). The development and technology achieved in this field plays an important role in shaping many sectors, including finance and manufacturing. Furthermore, with the process of digitalization, transformations of new sectors are expected to occur in the near future within the fields of agriculture, education and medicine (ILO, 2019: 10). The rapid advance of ICT, sometimes described as a digital revolution, has played an important role in increasing productivity and ensuring greater resource distribution. Countries that invest and develop their ICT pave the way for national companies to benefit from these technologies. Moreover, companies that use ICT extensively gain competitive advantages by improving their production processes, increasing their output levels, and typically are one step ahead in international trade (Wang and Li, 2017: 96). This technology, which accelerates the speed of communication and refines the process for obtaining information, also reduces production costs and encourages an increase in demand and investment in the sectors that it impacts. Therefore, the effects seen across all sectors show that ICT has made positive and substantial contributions to economic development through structural changes in the economy for both developed and developing countries (Yoon, 2019: 1).

ICT is at the core of our information-oriented economic structure. Technological advances and innovation associated with this technology constitute one of the reasons behind the distinct economic growth differences between regions and countries. In other words, this technology is a significant determinant of these differences. The technological medium for information and communication play a key role in how world economies benefit from the opportunities offered by globalization (Murphy and Siedschlag, 2007: 2). The opportunities offered by developments in information and communication technologies to companies and national economies are closely related to the human capital factor. Although the concept of human capital started to be used with the emergence of economics, the idea that the human factor is a capital element gained more theoretical integrity after World War II. Especially after the 1960s, Denison (1962) and Schultz (1967) put forward studies emphasizing the importance of human capital. In this context; human capital is accumulated with skills and qualifications and emerges as a qualified workforce, especially through education. Human capital accelerates the process of technological progress by facilitating the adaptation of the workforce to technological development, as well as the production and use of technological knowledge (Çakmak and Gümüş. 2005). The opportunities provided to companies and national economies as a whole by developments in ICT particularly enhances the importance of labor or human capital. The development of this technology creates a web of knowledge and experience that can be obtained more efficiently through education and training. (Ahmed, 2009: 1). The demand for a qualified workforce is increasing rapidly in companies that operate in the field of ICT. This is a reality not just for economies where the production and use of information are commonplace but also for economies where the development of highly-skilled labor is still ongoing (Falk and Seim, 2000: 2).

For economies seeking to develop their information and communication technological industry, the workforce must be highly-skilled and qualified. For instance, when the workforce has the equipment and specialized knowledge to closely follow technological developments it not only directly enhances their efficiency and skills but it creates an increased potential for further innovation and development. Besides, growing leadership skills, strategy development skills and the ability to create organizational partnerships and other similar competencies can also be the product of highly-efficient ICT (Jevtic et al., 2013: 153). Naturally, the development of this technology is gaining momentum in countries who have strong assets in human capital or the ability to create human capital over time. With the advance of technology in general, ICT has continued to spread into all sectors of the economy. A skilled workforce employed in the field of ICT can be categorized in two different ways. The first refers to labor that is directly related to ICT and who specialize in this field such as a software engineer, etc. The second refers to labor that indirectly uses ICT not as a goal but as a tool with varying levels of expertise (Jevtic et al. 2013: 156).

The effect of technology on the demand for educated and skilled labor can be seen in a few ways. The first is that an educated and skilled workforce is more congruent with the technology-based production process. As technological progress accelerates, the demand for an educated and skilled workforce increases. So a sense of harmony and compatibility is necessary between the education process, general work experience, and the technology that is available in the field. Second, it is critical to understand the role of an educated and experienced workforce in how technology is adopted. Achieving success in implementing new technology and applying it to the production process certainly requires the employment of a trained and skilled workforce (Chun, 2003: 1). In this context, it has been argued that a complementary relationship between human capital and new technology –including ICT– plays a role in how an unskilled workforce can evolve to meet the industry demand for skilled labor (Falk and Seim, 2000: 2). One of the important prerequisites for obtaining the highest value from ICT is employing a highly qualified workforce that is solution-oriented, performs statistical process controls and is knowledgeable and experienced in computer systems. On the other hand, currently, computer-equipped systems can function in ways that often replace the human factor for making process-oriented decisions. Nevertheless, these systems still require skilled workers, managers and professionals to interpret the large amounts of data that are produced to maximize the value of the data that is obtained (Arvanitis, 2005: 229).

There is a unique type of development that occurs within different sectors when a workforce utilizes or is employed in ICT. In particular, various education and training investments are often made to obtain the highest level of efficiency from the potential workforce. These education investments play a major role in increasing the skills and experience of the workforce. Moreover, on-the-job training, in-service training can also be used to develop or refine skills that increase the potential productivity of the workforce. In addition to education and training activities, another way to benefit from a qualified workforce is to transfer resources through foreign investment to countries that are developed in the ICT sector and have a sufficient labor infrastructure (ILO, 2019). Advanced and skilled human capital makes it easier to benefit from ICT investments. Therefore, investments in ICT are increasing in economies where human capital continues to develop and where the supply of educated and skilled labor is high. In other words, there is both a high demand for ICT and a surge in the intensity of investments toward countries that produce a large number of higher education graduates (Karahan and Erçakar, 2018: 870).

2. LITERATURE REVIEW

While studies in the literature often examine the relationship between ICT and economic growth, only a limited number of studies analyze the relationship between ICT and human capital. For example, Ketteni et al. (2006) analyzed the economic effects of ICT combined with highly educated human capital between 1980 and 2004 in the OECD countries. They concluded that highly educated human capital, which was measured by the average education level, played an important role in increasing productivity in this sector. In other words, according to the study, the output level in the ICT sector is higher in economies that have a greater concentration of skilled human capital. Similarly, Chun (2003) conducted a study that analyzed the effects of ICT on the demand for educated labor in 56 industries operating in the US from 1960 to 1996. The analysis shows that an educated workforce has a comparative advantage through the widespread use of ICT in these sectors. In addition, the results show that the increase in ICT also affected a 40% increase in the demand for educated labor. Galve-Gorriz and Castel (2010) analyzed the relationship between human capital and ICT on 1,269 companies from Spain. The results of the study show a correlation between companies that invest heavily in ICT and companies that have a high rate of employing educated and experienced workers. The results of the analysis also confirm that there is a positive relationship between ICT and having a workforce that is highly skilled, experienced, educated and produces effective research and development. Falk and Seim (2001), in their study with cross-sectional data on 1,000 West German companies in 1996, concluded that information technology and a highly-skilled workforce are complementary. Companies that achieve high output levels in the field of information technology often employ a highly-skilled workforce rather than unskilled workers. Further, the results of their study indicate that a company's expectations for the potential size of a future highly skilled workforce are closely related to the level of initial investment in information technology. Beyond that, the analysis also shows that companies that implement ICT into the production process need qualified and well-trained personnel to increase their productivity. Murphy and Siedschlag (2013) analyzed the development of human capital and ICT-intensive industries for open economies from 1980 to 1999. According to the analysis results, human capital and ICT plays an important role in the development of ICT-intensive industries for open economies. The research suggests that in economies where the assets of human capital are quickly accumulating the additional value, labor productivity and labor employment in ICT-intensive industries are increasing rapidly. In the same way, Asongu and Roux (2017) analyzed the impact of ICT on human capital for 49 African countries from 2000 to 2012. Again, according to their results, the development of ICT in these countries promoted the development of human capital.

In a study conducted by OECD (2016), the relationship between employment and ICT was examined in a few selected OECD countries between 1990 and 2012. The results found that the investments in ICT from 1990 to 2007 increased total labor productivity. However, the total labor demand from the investments made in the post-2007 period decreased, while the demand for a high and medium-skilled workforce increased. The reduction in total labor demand in situations like this occur through an inter-industry reallocation process. It is estimated that ICT investments, in general, tend to decrease the total labor demand in the manufacturing industry, services, trade, transportation, accommodation, information and communication and financial services sectors. Arvanitis (2005), in his analysis of 1,667 Swedish companies in 1999, concluded that ICT, new organizational practices and human capital positively affect production efficiency and the overall performance of these companies. Besides, a strong and reciprocal relationship was also identified between ICT and human capital.

3. DATA SET AND METHOD

The effect of human capital on the export of ICT products was analyzed using the panel error correction model. The data used in the model were obtained from statistical data published by the World Bank. In the model, the set of countries often called the G7 countries were selected for the study. They consist of Canada, Germany, France, Italy, Japan, England and the US, but because some data related to Japan was not published or available, Japan was excluded from the analysis and the remaining six countries were included in the model. The model covers the period between 2003 and 2018. The dependent variable of the model is the export of ICT products (BITEXP) as a share of the total exports. ICT exports include computers and hardware equipment, communication equipment, consumer electronic equipment, electronic components and other types of information and technology products. Since the software is classified as a service, it is typically not included among ICT products and is excluded for the purposes of this study. The independent variable of the model is the highly educated workforce (HEG) among the working population. Higher education in this study includes a bachelor's degree or equivalent education level, master's degree or equivalent education level, or doctoral degree or equivalent education level as well as short-term higher education that is classified according to the 2011 International Standard Education Classification. The panel data regression model is shown in the figure below:

$$BITEXP_{it} = \alpha_{it} + \beta_1 HEG_{it} + u_{it} \quad (1)$$

The factors of the model include the share of ICT exports with respect to total exports (BITEXP), the constant value (α), the slope parameter (β), the rate of higher education graduates among the total working population (HEG), the unit size of the panel (i), the time dimension of the panel (t) and the error term (u).

A three-stage process was used to analyze the relationship between the export of ICT products and a highly-educated workforce. The first stage is to analyze what is called the stationarity of the panel data series in order to prevent false regression. The stationarity of the series is tested by the unit root tests. In the second stage, when the series is stationary, the existence of a cointegration relationship within the series in the long run is tested by the cointegration test developed by Pedroni (1999). Finally, in the third stage, the analysis is completed by using the mean group estimator (MG), the pooled mean group estimator (PMG) and the dynamic fixed effects estimator (DFE), which provide estimates of the short-term and long-term coefficients as a result of the existence of a cointegration relationship within the series.

In the study, the data from 2003 to 2018 was analyzed by the unit root tests as to whether the series was stationary or not. When conducting an econometric analysis, one of the vital issues to consider in order to avoid errors is whether a series is stationary. If the mean and variance of the time series are constant over time and the covariance between the two periods does not depend on the time of the observed variables but depends on the distance between the two periods, then the time series is considered stationary. When the series is not stationary, the series cannot maintain its average in the long run, and both the time and variance approach infinity. On the other hand, as the number of lags increases, it is observed that auto-correction values also move away from zero. Furthermore, when the t statistic values are significant, the R2 value is also high. In the light of these outcomes, it is clear that the model's predictions in the long term have given inaccurate results. Again, in addition to inaccurate results, a false regression problem is also seen and as a result, there is a need to stabilize the series (Güven and Mert, 2016: 139-140). Table-1 contains the unit root test and its results for the BITEXP and HEG variables that are part of the model.

Table 1: Panel Unit Root Test Results

Tests	**BITEXP**		**HEG**	
	Level	**Difference**	**Level**	**Difference**
Levin, Lin and Chun Test	0.1928	0.0000*	0.0127	0.0000*
Breitung Test	0.9147	0.0000*	0.7367	0.0005*
Im, Pesaran and Shin W Test	0.9134	0.0000*	0.5634	0.0006*
ADF - Fisher Test	0.9418	0.0000*	0.6157	0.0016*
PP - Fisher Test	0.9663	0.0000*	0.8242	0.0000*

*, %1 expresses the significance level.

According to the results of the series shown in Table-1, the HGE variable, the level values of the Levin, Lin and Chu test statistics are smaller than $p < 0.05$ critical value and stationary at the level. According to these results, both variables are not stationary at these levels. However, looking at the initial difference in the series, it is concluded that the series is stationary, since according to the results of the whole unit root test the probability values at the 1% significance level are $p < 0.01$. In the unit root test, the length of the lag was automatically selected according to Akaiki Information Criteria.

After determining that the series is stationary with respect to the difference, the cointegration relationship between the series is then tested by the cointegration test developed by Pedroni (1999, 2004). Pedroni proposed a total of 7-panel cointegration tests with the basic hypothesis that there is no cointegration. Four of these tests are panel tests and three are group tests. From these statistics, four of them are within the sections as it were, and take homogeneity into account, while three of them are cross-sections statistics. Furthermore, Panel-v, Panel-rho, and Panel-PP test statistics are not parametric tests, while the fourth statistic, Panel-ADF, is parametric (Topal, 2017: 11). Two classifications are made in the test that allow for heterogeneity under the alternative hypothesis. In the first classification, cointegration tests of the time series are performed for all the units and the test averages are then obtained. In the second classification, the averages are obtained from each part and the limit distributions are established through the limits of the numerator and denominator terms (Tatoğlu, 2013: 235). If the results of test statistics are greater than the critical value, the H0 hypothesis, which states that there is no cointegration, is rejected. The rejection of the H0 hypothesis means a cointegration relationship exists between the variables (Topal, 2017: 11). Below, the panel cointegration test (Pedroni, 1999: 656) is estimated with some residuals as

$$Y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1i}, t + \beta_{2i} x_{2i}, t + \cdots + \beta_{Mi} \Delta X_{Mit} + e_{it} \quad (2)$$

for t = 1, ..., T; i = 1, ..., N; and m = 1, ..., M.

In the equation, T expresses the number of observations over time, N is the number of individual observations in the panel and M is the regression variables. Since there are N units in the panel, N is the number of different equations that can be considered, each of which is an M regressor. The slope parameters $\beta_{1i}, \beta_{2i}, \dots \dots \dots \beta_{Mi}$, are given a value according to their units, α_i denotes the effects of the constant that is particular to the units and it is also given a value according to its units and δ_i shows the parameter of the deterministic trend. Under the H_0 hypothesis, which states that there is no cointegration, the error term is I(1) when the dependent and independent variable is assumed to be I(1) (Tatoğlu, 2017: 195).

In nonparametric statistics the regression is estimated under this equation: $\hat{u}_{it} = \hat{y}_i \hat{u}_{it-1} + \hat{e}_{it}$. In this regression, the residuals $\hat{e}_{it}$ roots are used to estimate the unit-specific long-term variance($\hat{\sigma}_i^2$). $\hat{s}_i{}^2, \hat{e}_{it}$ denotes the unit-specific variance and the equation is expressed as $\hat{\lambda}_i = \frac{1}{2}(\hat{\sigma}_i^2 - \hat{s}_i^2)$.

However, in parametric statistics, the regression is estimated as $\hat{u}_{it} = \hat{y}\hat{u}_{it-1} + \sum_{k=1}^{K_i} \hat{y}_{ik} \Delta\hat{u}_{it-k} + \hat{e}_{it}^{*}$ and the residuals are used to estimate the $\hat{e}_{it}^{*}$ variance ($\hat{s}_i^{*2}$). Table-2 contains results of the Pedroni panel cointegration test.

Tablo 2: The Pedroni Panel Cointegration Test Results

Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v- statistic	-0.717545	0.7635	0.536789	0.2957
Panel rho- statistic	-1.954145	0.0253**	0.039110	0.5156
Panel PP- statistic	-17.35814	0.0000*	-3.306006	0.0005*
Panel ADF- statistic	-10.31404	0.0000*	-4.063825	0.0000*
	Statistic	Probability		
Group rho- statistic	1.477892	0.9303		
Group PP- statistic	-4.717304	0.0000*		
Group ADF- statistic	-2.292062	0.0110**		

*,**, denotes statistical significance at the 1% and 5% level respectively.

According to the Pedroni cointegration test results in Table-2, there is no cointegration relationship between the variables for the Panel v, weighted Panel v and Panel rho and the Group rho statistics. Since the probability values of these statistics are p> 0.0500, according to the results of the test, the H0 hypothesis cannot be rejected. On the other hand, since the probability values of 7 out of the 11 test statistics are p <0.05, the H0 hypothesis, which states that there is no cointegration relationship between variables, is rejected. Thus, the results of these values show the existence of a long-term cointegration relationship. In the cointegration analysis, the Akaiki Knowledge Criterion was used to determine the maximum lag length. After the cointegration test is applied to the BITEXP and HEG series, whose differences are stationary, the test demonstrates that the BITEXP and HEG series have a long-term cointegration relationship. And therefore, the next step is then to determine the long-term and short-term relationships between the series.

To estimate long-term and short-term parameters, the pooled mean group estimator (PMGE), the mean group estimator (MGE) and the dynamic fixed effects estimator (DFE) are used. These estimators calculate the long and short term parameters with the help of the error correction model. The MGE estimator developed by Pesaran and Smith (1995) produces long-term estimates by using the long-term parameter averages of the ARDL, that is, by using the autoregressive distributed lag models specific to each unit. The PMGE estimator developed by Pesaran, Shin, and Smith (1999) estimates the parameters by pooling and averaging the data simultaneously. The PMGE estimator allows for changes in the short-term coefficients and error correction coefficients of MG within the fixed and slope parameters according to the units. The fixed-effects model also allows for changes in the constant based on the unit but does not allow for variability in the slope parameters. While PMGE has limits on the changes of the long-term coefficient on a unit basis, it still allows for changes in short-term parameters and error variances by units (Tatoğlu, 2011: 82). Finally, the dynamic fixed effects (DFE) estimator allows for the constant parameter to change from unit to unit and uses the pooling method for the other parameters. However, when the slope coefficients are not the same for each unit, the results obtained from the DFE estimator are inaccurate and inconsistent (Güven and Mert, 2016: 141). On the other hand, since the DFE produces estimates for the error correction model which assumes fixed effects, it does not make calculations on a unit basis since all the parameters are kept constant (Tatoğlu, 2013: 244). The PMGE estimator is based on the ARDL delay model and is given as follows:

$$y_{it} = \sum_{j}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (3)$$

In the model, xit (kx1) is the vector for the explanatory variables specific to the units, μ_i is the delayed values coefficient of the dependent variable in the fixed effects model, λ_ij is the numerical values and δij (kx1) is the coefficient vectors. It is important that T is large enough to make model estimates on a unit basis. In this case, the model is rewritten as follows:

$$\Delta y_{it} = \emptyset_i y_{i,t-1} + \beta'_i x_{it} + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta'_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (4)$$

In the model, Ø represents the general error correction parameter and the error correction parameter (Ø_i) is expressed below as:

$$\emptyset_i = -\left[1 - \sum_{j=1}^{p} \lambda_{ij}\right],\ \beta_i = \sum_{j=0}^{q} \delta_{ij},\ \lambda^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im},\ \delta^*_{ij} = -\sum_{m=j+1}^{q} \delta_{im} \quad (5)$$

If Ø = 0, it means that there is no long-term relationship between the variables. If Ø_i is negative and thus significant, it is concluded that there is a long-term relationship between the dependent and independent variables. βi is the long term parameters and λ and δ are the short term parameters. The PMGE estimator produces estimates through the maximum probability method. Also, the homogeneity of the slope parameters is evaluated by what is called the Hausman Test Statistic. The long-term and short-term relationship between the variables is shown in Table-3.

Tablo 3: Long-Term and Short-Term Panel Coefficients

Long-Term Coefficients				**Hausman Test Statistic**
BITEXP	**PMGE**	**MGE**	**DFE**	
HEG	0.256	1.750	0.928	0.43
	(0.000)*	(0.059)**	(0.000)*	(0.5107)
Error Correction	-0.279	-0.524	-0.616	
Coefficient	(0.003)*	(0.042)**	(0.000)*	
Short-Term Coefficient				
ΔHEG	-0.179	-0.329	0.063	
	(0.426)	(0.121)	(0.787)	

Unit-Specific Long-Term Coefficients and Error Correction Coefficients

	PMGE		**MGE**		
	Short-Term Coefficient	**Error Correction Coefficient**	**Long-Term Coefficient**	**Short-Term Coefficient**	**Error Correction Coefficient**
Canada	0.535	-0.129	0.591	0.357	-0.427
	(0.095)***	(0.303)	(0.000)*	(0.326)	(0.078)***
Germany	-0.268	-0.157	1.457	-0.359	-0.213
	(0.347)	(0.090)***	(0.332)	(0.313)	(0.120)
France	-0.576	-0.160	0.423	-0.599	-0.164
	(0.061)***	(0.114)	(0.766)	(0.145)	(0.186)
Italy	-0.127	-0.650	0.252	-0.126	-0.645
	(0.018)**	(0.000)*	(0.000)*	(0.044)**	(0.000)*
Englad	0.313	-0.477	1.515	-0.078	-1.720
	(0.659)	(0.025)**	(0.000)*	(0.880)	(0.000)*
US	-0.951	-0.100	6.259	-1.170	0.027
	(0.103)	(0.173)	(0.763)	(0.059)***	(0.795)

*, **, *** indicate statistical significance at 1%, 5% and 10% levels, respectively.

The figures above include the pooled mean group estimator (PMGE), mean group estimator (MGE) and dynamic fixed effects estimator (DFE) of the panel error correction model. Also, the figures include the Hausman test results, which is used to decide between using the pooled mean group estimator and mean group estimator. As mentioned before, the pooled mean group estimator states that all the units of the long-term parameters are homogeneous, while the mean group estimator states that the long-term parameters are heterogeneous. According to the Hausman test results, the H0 hypothesis cannot be rejected, and it was concluded that the pooled mean group estimator (PMGE), which typically yields more reliable results in line with the H0 hypothesis, was valid. According to the PMGE estimator, the error correction parameter is negative and thus statistically significant at the 1% level. It can therefore be shown that there is a long-term relationship between the variables of ICT exports (BITEXP) and the employment of higher education graduates (HEG). The error correction parameter shows the speed at which short-term deviations reach equilibrium in the next period for the non-stationary series. When the coefficient of the error correction parameter is analyzed, the results show that approximately 28% of the imbalances that occur within a certain period will be balanced in the next period. Moreover, the long-term parameter of the HEG variable is indeed statistically significant at the level of 1%, whereas the short-term parameter is insignificant. Consequently, a 1% increase in the long-term employment of higher education graduates (HEG) increases the exports of ICT products (BITEXP) by approximately 26%.

It is also observed that a single long-term parameter is estimated by the pooled mean group estimator (PMGE) according to the unit-specific results. However, the error correction coefficients and short-term and fixed parameters take different values based on the units. According to these results, the error correction parameters have negative values and are significant at 10%, 1% and 5% levels in Germany, Italy and England, respectively. It is concluded that there is a long-term relationship between employment for higher education graduates (HEG) and the export of ICT products (BITEXP) in these countries. Furthermore, the findings show that the error correction parameter in Italy is much larger than the parameters in both England and Germany. In other words, the elimination of imbalances in Italy in the short term is much faster than in the UK and Germany.

4. RESULTS AND FINDINGS

Developments in ICT, which are at the core of technological innovation, have gained momentum in the last few decades. The fact that computer systems are now used throughout the entire production process plays an important role in how information is collected, processed, stored and transferred quickly and reliably from one place to another. In today's world, where international competition continues to increase, countries are closely following developments in ICT to increase overall productivity and to gain competitive advantages. This process in turn contributes to more broad national welfare and development as the use of information in modern society has become a virtual necessity. Furthermore, investments in the information and communication sector also contribute to overcoming problems and challenges even in the employment sector. The advancement of information and communication systems is critical for a country that seeks an experienced, well-educated and skilled workforce and the development of its human capital.

Rapid and recent developments in technology have made information one of the main factors of production. In fact, as ICT expands, the importance of physical capital is more frequently reduced to the background. In its place, the importance of human capital that is highly-trained and well-educated and can develop technical knowledge and innovation through the efficient use of information is now at the forefront. In this context, there is now a strong demand to increase one's international market share by gaining a competitive advantage in the information and communication sector. Consequently, this has dramatically accelerated the importance of investments in this sector. As a result, through this process, the countries that have a considerable demand for these types of highly-valued exports have built an economic infrastructure of human capital that significantly contributes to the national welfare.

This study analyzes the effects of the employment of higher education graduates in the export of ICT products from G7 countries that include Canada, Germany, France, Italy, England and the USA. The results of the analysis prove that a skilled and well-trained workforce with higher education credentials who are employed in the information and communication sector in these countries have a positive effect on the exports that occur in that sector. Although the analysis results are in line with expectations, it continues to highlight the importance of human capital in the production of ICT. In this direction, human capital investments that play an important role in accelerating the development of the sector should be given considerable priority. Necessary training investments should be accelerated to follow the developments of this type of technology closely, to encourage studies for the future, and to facilitate the conditions necessary for a highly-skilled workforce that can create, use and share information effectively in this sector. Moreover, to create a highly-skilled human capital infrastructure that can positively influence a country's ICT sector, it is important to create new undergraduate and graduate programs within higher education institutions, to expand the scope of existing programs and to enable the creation of vocational education programs in both the public and private sector.

Ethical Statement

The rules of Research and Publication Ethics have been complied with during the writing and publication of the study. and no falsification was made to the data obtained for the study. Ethics committee permission for the study not required.

Contribution Rate Statement

The author of the study, from the writing of the study to the creation of the draft. It contributed to the processes and confirmed its final form by reading.

Conflict Statement

This work does not cause any conflict of interest, whether individual or institutional/organizational.

REFERENCES

Ahmed, E.M. (2009). ICT And Human Capital Intensities Impact on Asean 5 Productivity. *The Journal of Knowledge Economy and Knowledge Management*, 4, 1-8.

Arvanitis, S. (2005). Computerization, Workplace Organization, Skilled Labour and Firm Productivity: Evidence for the Swiss Business Sector. *Economics of Innovation and New Technology*, 14(4), 225-249.

Asongu, S. A. and Roux, S. L. (2017). Enhancing ICT for Inclusive Human Development in Sub-Saharan Africa. *Technological Forecasting and Social Change*, 118, 44-54.

Çakmak, E. and Gümüş, S. (2005). Türkiye'de Beşeri Sermaye ve Ekonomik Büyüme: Ekonometrik Bir Analiz. *Ankara Üniversitesi SBF Dergisi*, 60(01), 59-72.

Chun, H. (2003). Information Technology and The Demand for Educated Workers: Disentangling the Impacts of Adoption Versus Use. *The Review of Economics and Statistics*, 85, 1-8.

Denison, E. F. (1962). *Sources of United States Economic Growth, Readings in Economics*. New York: MeGraw-Hill Book Company.

Falk, M. and Seim, K. (1999). The Impact of Information Technology on High-Skilled Labour In Services: Evidence from Firm Level Panel Data. *ZEW Discussion Papers*, No. 99-58, Zentrum für Europäische Wirtschaftsforschung.

Falk, M. and Seim, K. (2001). Workers' Skill Level and Information Technology: A Censored Regression Model. *International Journal of Manpower*, 22(1/2), 98-120.

Galve-Górriz, C. and Castel, A.N. (2010). The Relationship Between Human Resources and Information and Communication Technologies: Spanish Firm-Level Evidence. *Journal of Theoretical and Applied Electronic Commerce Research*, 5(1), 11-24.

Güven, S. and Mert, M. (2016). Uluslararası Turizm Talebinin Eşbütünleşme Analizi: Antalya İçin Panel Ardl Yaklaşımı. *C.Ü. İktisadi ve İdari Bilimler Dergisi*, 17(1), 133-152.

ILO (2019). Skills Shortages and Labour Migration in The Field of Information and Communication Technology in India, Indonesia and Thailand. Switzerland: ILO Publishing.

Jevtic, B., Dedianski, S., Beslac, M., Grozdanic, R. and Papic, Z. (2013). The Impact of Skilled Workers in Implementing ICT On Firm Performance. *Metalurgia International*, 18, 152-161.

Karahan, Ö. and Erçakar, M.E. (2018). Bilgi İletişim Teknolojileri ve İnsan Sermayesi Arasındaki Karşılıklı İlişkinin Analizi. Bedriye Tunçsiper ve Ferhan Sayın (Ed.) *Birinci Uluslararası Sosyal Bilimlerde Kritik Tartışmalar* bildiri kitabı içinde (ss. 866-876), 5-7 Ekim, İzmir.

Ketteni, E., Mamuneas, T. and Stengos, T. (2006). The Effect of Information Technology and Human Capital on Economic Growth. *Rimini Centre for Economic Analysis Working Paper,* 03-07.

Murphy, G. and Siedschlag, I.T. (2007). The Effect of Human Capital on Output Growth in ICT Industries: Evidence from OECD countries. *ESRI Working Paper,* No. 184.

Murphy, G. and Siedschlag, I.T. (2013). Human Capital and Growth of Information and Communication Technology-intensive Industries: Empirical Evidence from Open Economies. *Regional Studies*, 47(9), 1403–1424.

OECD (2016). Icts and Jobs: Complements or Substitutes? The Effects of Ict Investment on Labour Demand by Skills and By Industry in Selected OECD Countries. DSTI/ICCP/IIS (2016)1/Final.

Pedroni, P. (2004). Crıtıcalvalues For Cointegration Tests in Heterogeneous Panels with Multiple Regressors. *Oxford Bulletin of Economics and Statistics: Special Issue,* 0305-9049, 653-670.

Pesaran, M., Shin, H.Y. and Smith, R.P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association,* 94, 621-634.

Pesaran, M.H., and Smith, R.P. (1995), Estimating Long-Run Relationships from Dynamic Heterogeneous Panels. *Journal of Econometrics,* 68, 79-113.

Schultz, T. W. (1967). Investment in Human Capital, Readings in Economies (5th Edition). New York: MeGraw Hill Book Company.

Tatoğlu, F.Y. (2013). *İleri Panel Veri Analizi: Stata Uygulamalı* (2. Baskı). İstanbul: Beta Yayıncılık

Tatoğlu, F.Y. (2017). *Panel Zaman Serileri Analizi: Stata Uygulamalı*, İstanbul: Beta Yayıncılık.

Tatoğlu, F.Y. (2011). The Relationship Between Human Capital Invesment and Economic Growth: A Panel Error Correction Model, *Journal of Economic and Social Research*, 13(1), 77-90.

Topal, M.H. (2017). Çifte Kazanç Hipotezinin OECD Ekonomileri İçin Testi: Panel Eşbütünleşme ve Nedensellik Analizi. *Uluslararası Bilimsel Araştırmalar Dergisi*, 2(4), 2-20.

Wang, Y. and Li, J. (2017). ICT's Effect on Trade: Perspective of Comparative Advantage. *Economic Letters*, 155, 96-99.

Yoon, S.C. (2019). The Impact of ICT Goods Imports on Economic Growth: Evidence from Asia-Pacific Countries. *Journal of Korea Trade,* 23(7), 1-12.