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Research Article

The Effects of Information Communication Technologies on Human Capital: A Panel Data Analysis

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ABSTRACT

The transition to the information age with globalization has opened the doors of digital transformation all over the world. In this digital transformation process, each new day corresponds to new information. In addition, the dimensions of communication have started to change with new information. It has become inevitable that such developments in information and communication technologies will have an impact on human development. In this context, the effect of information and communication technologies on human capital in the academic field arouses curiosity. This study aims to investigate the effects of information and communication technologies on human capital with the panel data analysis method. Annual data based on the 2000-2019 period for 10 countries selected among the emerging economies were used in the study. The dependent variable was the human capital index; the control variables were the education index and life expectancy at birth, and the independent variable was the share of information and communication technologies exports in total exports in the study. According to the findings of the study, it was concluded that the share of information and communication technologies exports in total exports increased human capital along with the education index and life expectancy at birth.

Keywords: Information Communication Technologies, Human Capital, Education Index, Life Expectancy, Panel Data Analysis

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1. Introduction

Nowadays, humans live interactively with a digital life, a digital world, and a digital economy. At this point, it is possible to state that an irreversible process has been entered regarding the spread trend in digital transformation. In the process of digital transformation, the development of information and communication technologies has accelerated over time. Although the restrictions brought by the COVID-19 epidemic process, which started in China in 2019 and spread to the world in 2020, adversely affected many sectors, the IT sector continued to progress globally in this period.

Informatics is necessary to accept that the producer is a crucial element of the welfare society. A knowledge economy is an economy with a structure in which production is organized with knowledge and where knowledge can be used, as well as labor, capital, and technology as a production factor.

Economies that can use information well and produce information are seen as developed countries, and those living in these countries create an information society. In the information society, it is possible to specify information and communication technologies as the most important factors that improve international competition and contribute to countries' economic growth and development.

This article aims to investigate the effects of information and communication technologies on human capital by using the panel data analysis method. Annual data for the period 2000-2019 of 10 countries was selected among the emerging economies in the study. To sum up, briefly, the importance and originality of this study is the use of the Common Correlated Effects Mean Group (CCEMG) method within the scope of panel data analysis with ten countries selected from among emerging economies (Argentina, China, Brazil, South Africa, South Korea, Singapore, Poland, Russia, Thailand, and Turkiye) to investigate the impact of information and communication technologies on human capital. So, the contribution of this study to the literature emerges in the context of the variables determined by the applied method and theory.

In the study, first of all, a conceptual and theoretical framework was prepared for the effects of information and communication technologies on human capital in economic development. Then, the studies on this subject in the literature were discussed. Afterward, the econometric method used to examine the effects of information and communication technologies on human capital was explained, and the findings were interpreted. In the conclusion, general information on the subject of analysis was given, the findings were discussed, and various policy recommendations were presented in line with the findings.

2. Theoretical Framework

Economic development is accepted as a process that gained importance after the Second World War and is especially relevant to developing countries. Economic development requires the development of states in many aspects, such as economic, cultural, political, social, and so on. In this respect, in the economics literature, economic development refers to structural changes in environmental, political, and social contexts, together with increased economic efficiency and material welfare in a country. Therefore, economic development, as in economic growth, does not consider only the increase in income; it takes place depending on the practical and rational use of both physical and human resources of countries and includes structural transformations. Economic development represents countries' development level and position in the world.

Economic development involves a multidimensional process with long and significant efforts. According to Rostow, development is a five-stage social process with economic dimensions. In this context, for a country to develop economically, traditional society has to go through stages of preparation for takeoff, maturity, and the age of high mass consumption (Rostow, 1960).

In addition, in terms of the realization of economic development, human capital has emerged as a strategic element both for the transition of developed countries to the information-age society and for developing countries to industrialize and close the technological development gap between them and developed countries. With the globalization that accelerated towards the end of the 1980s, developed countries have become the leading producers and users of human capital, information, and technological progress by passing into the information society.

In the 1990s, interest in the development phenomenon increased even more thanks to the information society created by producing technological information, the rapid development of communication technologies, and the formation of qualified human capital. Later, development economists started to focus on sustainable development, which means using natural and human resources at a level that can meet the needs of future generations at least as much as they do now. Therefore, the orientation from natural resources to physical capital in the industrial society has left its place to human capital in the information society. It should be noted that in these recent periods when the COVID-19 epidemic process started in China in 2019 and spread to the whole world in 2020, the importance of human capital has been

understood more clearly, the progress in information and communication technologies has accelerated, and the new development story has reached the level to be written with digital transformation.

Knowledge is a factor that allows the production of technology due to R&D activities and creates added value in economic growth. It produces labor, processes, and uses knowledge. Information and communication technologies have developed with the transition to the information society and emerged as essential determinants of development and growth. In this respect, advances in information and communication technologies provide a competitive advantage by reducing costs for both countries and companies and increasing productivity. At this point, the new economic structure is reflected in countries' development and growth strategies and turns into competitiveness through information and communication technologies.

Ultimately, this new era is named the network economy, networked economy, knowledge economy and knowledge-based economy, digital economy, learning economy, new economy, and innovation economy. Conceptually, for the first time, Machlup used the knowledge economy, and its spread became possible after Drucker's "*Age of Discontinuity*." According to the definition of Organization for Economic Co-operation and Development (OECD), a knowledge economy is "*the economy in which knowledge is used in production and distribution*" (OECD, 1996). In summary, what is meant by the knowledge economy is a society that allows the development of technology and science and where there is intensive knowledge-based production and service (Powell & Snelman, 2004). Therefore, the most essential feature of this new society is the intensive use of information in the production process. Applying science and technology to the production process reflects a new understanding of sustainable development by highlighting investments in information, information technologies, and human resources. Especially in the 21st century, the development of information technology and the use of this technology are catalysts for economic and social transformation. In this way, using technology in the production process leads to increased factor productivity by providing economic development.

Based on ICT, networks, decentralized computer workstations, electronics, telecommunications, software, and information media, it is considered a combination of firms and industries affecting the economy as a whole. In this respect, ICT defines computers and peripherals, computer software and other information-related office equipment (copiers, cash registers, and calculators), communication equipment, and tools (Farhadi, Ismail, & Fooladi, 2012). ICT refers to all technologies based on communication and computer technologies used in processes such as collecting and processing information, storing it, transmitting it from one place to another via networks, and making it available to users.

Reviewed the historical development process of ICT, Schumpeter, an Austrian economist and political scientist, appears before us with his studies on the contribution of knowledge diffusion effect to economic growth. Robert Solow, one of the essential names of the neoclassical approach in 1956, became a pioneering economist who argued that the surplus growth (Solow surplus), other than the increase in labor and capital, is due to technological progress (Solow, 1957). By the 1980s, approaches that included technology in growth models were developed. These approaches, advocated by economists like Romer, Lucas, and others, are called "*endogenous growth theories*." It has become possible to calculate the effects of ICT on the country's economies, thanks to the new approaches developed at the point of human capital and knowledge measurement with endogenous growth theories. Based on endogenous growth theories, it is possible to state that technological development consists of firms' R&D activities and capital accumulations and externalities (Ribeiro, 2003).

Nowadays, ICT appears to be an essential part of the economy. Almost all companies and consumers now use computers and internet connections for economic purposes such as presenting more diverse and customized products, improving product quality, and selling goods and services. Although ICT diffusion rates in terms of computer, cell phone, and internet users differ between countries and regions, the indicators of ICT usage show an increasing trend in recent years despite the global economic crisis (Farhadi, et al., 2012). With its widespread use in the sector and its effects on economic growth, ICT has increased rapidly in recent years in developed and developing countries.

3. Literature Review

Advances in technology, particularly in ICT, have significantly impacted the economy and other aspects of human life in recent years. It is almost impossible to imagine the efficient functioning of an individual, an economy, and a society that does not use ICT. These effects, especially with the effect of ICT, which has gained more importance in terms of the "*new normal*", have started to experience serious changes in many areas with the COVID-19 pandemic period. At this point, it should be noted that the health system, educational institutions, businesses, households, and even the whole world economy are developing depending on ICT (Aksentijevi'c, Ježi'c, & Zaninovi'c, 2021). In recent

years, information technology (IT), also known as ICT software and hardware in general, has become a subject of more interest to economists due to its rapid spread worldwide (Ketteni, Mamuneas, & Stengos, 2011). The study's literature review was made on the effects of information and communication technologies on human capital and economic growth in general.

In his study, Pohjola (2000) aimed to investigate the impact of ICT investments on economic growth in 39 countries. In this study, regression analysis was conducted from 1980-1995. According to the analysis results, it was found that while ICT investments strongly affected the economic growth of developed countries, they did not have a significant effect when developed and developing countries were evaluated together.

O'Mahony, Robinson, & Vecchi (2008) in their studies, a used panel data analysis method aimed to investigate whether the effects of ICT on skilled labor demand are permanent or temporary for the USA, England, and France on the 1979-2000 period. According to the findings obtained in the analysis, it was concluded that the effect of ICT on the skilled workforce in the USA is temporary.

Moshiri & Nikpoor (2010) aimed to investigate the effect of ICT on productivity in developed and developing countries in their study. This effect was analyzed by a panel data analysis method for 69 countries from 1992 to 2006. Based on the findings obtained as a result of the analysis, information technologies positively affect productivity on a global scale.

Ketteni, et al. (2011) investigated the interaction of human capital and average years of schooling with ICT and their joint effects on economic growth. An econometric analysis of the study was carried out using a semiparametric regression model with data collected from OECD databases for various countries selected based on ICT and human capital data availability during the 1980-2004 period. Based on the findings obtained in the analysis, it is concluded that the output elasticities of human capital are more significant at higher levels of ICT investments and that output elasticities of ICT are higher when there are more educated workers in a country.

Yousefi's (2011) study aimed to investigate the impact of ICT on economic growth based on 62 high, upper-middle, low-middle, and low-income countries. The study used the panel data analysis method between 2000 and 2006. According to the findings obtained in the analysis, it is concluded that ICT plays a vital role in the economic growth of high and upper-middle-income countries but does not contribute to the economic growth of low-middle-income countries.

Niebel's (2012) study aimed to estimate the effect of ICT on economic growth using the panel data regression model based on data from 59 developed and developing countries between 1995 and 2010. According to the estimation results, a positive relationship has been determined between information and communication technologies and economic growth.

Farhadi, et al. (2012) aimed to investigate the effect of ICT use on economic growth. This effect was analyzed with the GMM estimator under the dynamic panel data approach for 159 countries from 2000 to 2009. According to the findings obtained in the analysis, it was determined that the ICT usage index (the number of fixed broadband internet subscribers and the number of mobile subscriptions per 100 capita as measured by the number of internet users) positively affected economic growth. However, it was higher in high-income groups compared to other groups.

Ishida (2015) aimed to investigate the effect of ICT on economic growth and energy consumption in Japan for the period 1980-2010 with the ARDL limit test in the study. According to the findings obtained from the analysis, it was concluded that ICT reduced energy use in the relevant period and did not contribute to economic growth.

Hodrab, Maitah, & Luboš (2016) investigated the effects of ICT on economic growth from 1995-2013 through a sample of 18 Arab countries. In this study, panel regression analysis was applied within the framework of 341 observations for the basic model and 331 observations for the extended model, which includes other important macroeconomic variables. According to the findings obtained in the analysis, countries should invest more in ICT capital and labor as they positively affect economic growth.

In their study, Asongu & Roux (2017) aimed to investigate whether increasing ICT improves human capital in a sample of 49 countries in Sub-Saharan Africa for the period 2000-2012. Probit regression analysis was used as an econometric method in the study. According to the findings of this analysis, although there is evidence of synergy in mobile phone penetration, it is concluded that non-oil exporting countries drive this synergy.

In their study, Bahrini & Qaffas (2019) aimed to investigate the effects of ICT on the economic growth of selected developing countries in the Middle East and North Africa (MENA) region and the Sub-Saharan Africa (SSA) region. In the study, the GMM model was applied within the scope of the panel data analysis method from 2007 to 2016. According to the findings obtained in the analysis, technologies such as mobile phones, internet usage, and broadband usage are the main drivers of economic growth in MENA and SSA developing countries for the 2007-2016 period.

Aksentijevi'c, et al. (2021) investigated the effects of ICT use on human development among high, middle-upper, lower-middle, and low-income countries according to the 2020 World Bank classification. In the empirical analysis of

this study, which includes 130 countries, the dynamic panel data regression method was used for 2007-2019. Within the scope of this analysis, the Generalized Method of Moments (GMM), in other words, the two-stage system, was estimated by the GMM method. The findings obtained from the analysis have proven that ICT has significant and positive effects on human development, especially in low-middle-income and low-income countries. However, significant effects are not seen in high and middle-income countries.

4. Econometric Analysis

4.1. Data Set and Model

This study investigated the effects of information and communication technologies on human capital using the panel data analysis method. The research hypothesis is "*ICT exports increase human capital*." In the analysis part of the research, depending on the availability of data, ten emerging economies were studied (N=10 and T=20) as "*Argentina, China, Brazil, South Africa, South Korea, Singapore, Poland, Russia, Thailand, and Turkiye*" based on the 2000-2019 period. The country data used in the study were taken from the World Bank (WB), United Nations Development Program (UNDP), and Penn World Table Version 10.0 (PWT) databases.

In the study, while the dependent variable was the human capital index, the control variables were the education index and life expectancy at birth, and the independent variable was the share of information and communication technologies exports in total exports. The contribution of this study to the literature emerges within the scope of the variables determined by the applied method and theory.

Table 1 presents the variables, their explanations, and the sources from which they were obtained. The equation of the model established with these variables [HCI=F(EDU, LE, ICT)] is given below:

$$HCI_{i,t}=\alpha_{0i}+\beta_1(EDU)_{i,t}+\beta_2(LE)_{i,t}+\beta_3(ICT)_{i,t}+\varepsilon_{i,t}$$

Table 1. Variables Used in the Model

Dependent Variable		
Variable	**Symbol**	**Data Source**
Human Capital	**HCI**	Penn World Table, version 10.0-PWT
Control Variables		
Education Index	**EDU**	The United Nations Development Program-UNDP
Life Expectancy at Birth	**LE**	World Bank-WB
Independent Variable		
Share of Information and Communication Technologies Exports in Total Exports (%)	**ICT**	World Bank-WB

Table 2 presents descriptive (summary) statistics. Table 3 presents the correlation matrix and significance tests of the correlation coefficients. According to this table, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. In this case, the existence of serial correlation is proved.

Table 2. Descriptive Statistics

Variable	**Observation**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
HCI	200	.769125	.0840094	.594	.938
EDU	200	.71252	.1072593	.481	.869
LE	200	73.46441	6.465248	53.444	83.49756
ICT	200	11.90457	13.34849	.0599616	54.97448

Table 3. Correlation Matrix

Correlation Matrix					
Variable		***HCI***	***EDU***	***LE***	***ICT***
HCI		1.0000			
EDU		0.8301	1.0000		
LE		0.7749	0.3618	1.0000	
ICT		0.2831	0.0685	0.4908	1.0000
		HCI	***EDU***	***LE***	***ICT***
Bias-Corrected Born and Breitung (2016) Q(P)-test	**Q(P)-Stat**	28.41*	32.08*	53.46*	33.27*
	P-value	0.000	0.000	0.000	0.000
Heteroskedasticity-Robust Born and Breitung (2016) HR-test	**HR-stat**	5.09*	4.00*	7.36*	6.06*
	P-value	0.000	0.000	0.000	0.000
Bias-corrected Born and Breitung (2016) LM(k)-test	**LM(k)-stat**	5.19*	3.48*	3.73*	5.52***
	P-value	0.000	0.000	0.000	0.063

4.2. Econometric Methodology

The panel data analysis method, which increases the ability of economic interpretation by facilitating information, consists of using time series data and horizontal section data together. Compared to cross-section and time-series analysis, it is possible to define that panel data regression models based on the assumption of cross-section independence between units have some advantages. First, in panel data models, the number of observations increases significantly due to using cross-section and time series data together. A high number of observations reduces the likelihood of a highly linear relationship between explanatory variables by increasing the degrees of freedom. In this context, the panel data method allows for obtaining more reliable results from econometric estimations (Hsiao, 2003).

Before proceeding to the unit root tests in panel data analysis, the case of whether or not the cross-section units that make up the panel are handled independently of each other is examined. Under the assumption that the cross-sectional units are independent of each other, panel unit root tests called "*first generation tests*" are constructed, while panel unit root tests called "*second generation tests*" are constructed under the assumption that the cross-section units are not independent of each other. The cross-section dependency allows it to determine whether an economic shock in one country affects other countries. Ignoring the cross-sectional dependence may cause the analysis results to be biased (misleading) and inconsistent. For this reason, it is necessary to examine the cross-sectional dependence separately for each variable and each model. Within the framework of panel data analysis, various theses can be used to test the cross-sectional dependence. In this study, the Breusch-Pagan CD_{LM} (1980) test was applied because the cross-section dependence was T>N.

The test hypotheses are "H_0*: There is no cross-sectional dependence*." and "H_1*: There is a cross-section dependency*." The H_0 hypothesis is rejected if it is less than 0.05, and in this case, the existence of horizontal cross-section dependence is proven. In this case, second-generation unit root tests are used. Otherwise, there is no cross-section dependency; in this case, first-generation unit root tests are applied. As a matter of fact, in the panel data analysis method, whether the series satisfies the stationarity condition is extremely important in terms of the reliability of the estimates. Whether the series is stationary or not strongly affects its quality and behavior. If the variables in the regression model are not stationary, the standard assumptions valid for the asymptotic analysis become invalid, and the estimation results become biased (misleading).

The panel cointegration test of Westerlund & Edgerton (2007), which can be used under heterogeneous and horizontal cross-section dependence conditions, is used to investigate the cointegration relationship between the series. In econometric analyses, the detection of long-run relationships is considered extremely important. For this reason, there are many cointegration tests in the econometrics literature to analyze long-run relationships. Westerlund & Edgerton (2007) developed a method for panel data models. The hypotheses for the Westerlund & Edgerton (2007) cointegration test are as follows:

H_0: There is a cointegration relationship in the model.

H_1: There is no cointegration relationship in the model.

For the decision of the hypotheses, it is necessary to check the bootstrap probability values of the asymptotic and/or

bootstrap critical values of the LM Test statistics (Kırca & Akkuş, 2020: 585). After determining the cointegration relationship between the variables included in the analysis, the long-run coefficients of the explanatory variables should be estimated. This study applies the CCEMG method Pesaran (2006) developed for heterogeneous panels under horizontal cross-section dependence. This method, on the one hand, assumes that unobservable common effects are stationary and exogenous along with the explanatory variables. On the other hand, it allows for consistent and asymptotically normally distributed parameter estimates when T is fixed, $N\rightarrow\infty$ or N, $T\rightarrow\infty$. In the CCEMG method, long-run coefficients for explanatory variables are calculated by taking the arithmetic average of the coefficients for each horizontal cross-section in the panel.

4.3. Empirical Findings

Cross-sectional dependence was first tested in the analysis of the study. Panel unit root test and cointegration test were applied depending on the cross-section dependency test results obtained. Then, the CCEMG estimation method was used to test the heterogeneity of the slope coefficients.

Table 4. Cross-Section Dependency Test Results

Test	Cross-Section Dependency Test Results	
	Breusch-Pagan CD_{LM}	
	Statistic	*P-value*
HCI	839.6910*	0.000
EDU	761.0197*	0.000
LE	858.5284*	0.000
ICT	329.7921*	0.000
MODEL: [HCI=F(EDU, LE, ICT)]	157.2025*	0.000

According to Table 4, when the results of the horizontal cross-section dependence test are followed, the presence of horizontal cross-section dependence in both variables and models is recognized. For this reason, it is possible to explain that in the continuation of the study, unit root tests and estimation methods that consider the cross-section dependency will be used. Table 5 includes the CIPS panel unit root test results:

Table 5. CIPS Panel Unit Root Test Results

CIPS Statistics				
Variables	**Level**	**Difference**	**Critical Values**	
HCI	-1.849	-3.934		
EDU	-2.009	-4.111	1%	-2.210
LE	-2.197	-2.809	5%	-2.340
ICT	-1.985	-3.593	10%	-2.600

In the rest of the analysis part of the study, according to the results of the horizontal cross-section dependence test, whether the series has a unit root or not is investigated with the CIPS statistic developed by Pesaran (2006), which considers the horizontal cross-section dependence. The test hypotheses are "H_0*: There is a unit root in the series*." and "H_1*: There is no unit root in the series*." As can be seen from Table 5, the variables of human capital (HCI), education index (EDU), life expectancy at birth (LE), and share of ICT exports in total exports (ICT) were stationary in I(1) (at the first difference). Therefore, the conditions for Westerlund & Edgerton's (2007) panel cointegration analysis have been formed.

Table 6. Slope Heterogeneity Test (Pesaran & Yamagata, 2008)

Slope Heterogeneity Test (Pesaran & Yamagata, 2008)	**MODEL: [HCI=F(EDU, LE, ICT)]**	
Test Statistic	***T Statistic***	***P-value***
Delta_tilde	7.832*	0.000
Delta_tilde_adj	9.044*	0.000

Table 6 contains the slope heterogeneity test (Pesaran & Yamagata, 2008). As can be seen from Table 6, where the homogeneity (heterogeneity) of the slope parameters was tested, it is observed that the H_0 hypothesis was rejected, and the alternative hypothesis was accepted. These results have proven that the slope coefficients are heterogeneous.

The cointegration test developed by Westerlund & Edgerton (2007) was used. This test determines whether a long-run relationship exists between variables with the LM statistic. It also allows a cointegration test for both the model with constant and the model with trend. The null hypothesis (H_0) of the test states that there is a cointegration relationship between the variables. The decision rule of the test is that if the probability values of the calculated LM statistics are above significance levels, such as 5%, the null hypothesis (H_0) cannot be rejected; that is, it is stated that there is a long-run relationship between the variables. In this test, two probability values for the LM statistic are calculated. The first is the bootstrap probability value, and the second is the asymptotic probability value. The bootstrap probability value is considered in the case of horizontal cross-sectional dependence in the variables or model. In contrast, the asymptotic probability value is considered when there is no horizontal cross-sectional dependence. In this study, the hypotheses are evaluated by considering the bootstrap probability values since there is horizontal cross-section dependence in the variables.

Table 7. Westerlund & Edgerton (2007) LM Bootstrap Panel Cointegration Test Results

Constant	
Test	LM_N^+
Statistic	7.207
Bootstrap P-value	0.934

The results of the Westerlund & Edgerton (2007) cointegration test used due to the heterogeneous structure of the model in the analysis are shown in Table 7. Considering the bootstrap probability values, it is seen that the H_0 hypothesis cannot be rejected. For this reason, the results of the Westerlund & Edgerton (2007) test prove that there is a cointegration relationship between the variables. In Table 8, the long-term coefficients for the relationships between the series and the CCEMG estimation results in which the direction of these coefficients are determined are evaluated:

As observed in Table 8, where CCEMG estimation results are analyzed for the long term, an increase in the education index (EDU), life expectancy at birth (LE), and the share of ICT exports in total exports (ICT) also increases human capital (HCI).

Reviewing the analysis results in detail, it has been determined that a 1% increase in the education index, in the long run, increases the human capital by 0.24. In addition, it is seen that there is an increase of 0.0019 in human capital with an increase in life expectancy at birth in the long run. In addition, due to the 1% increase in the share of ICT exports in total exports, it was determined that there was an increase of 0.0031 in human capital in the long run. In this respect, the study supported the finding in question that Aksentijevi'c, et al. (2021). A significant and positive relationship at the level of 1% was found between the dependent variable, the human capital index, and all of the independent variables (EDU, LE, ICT). According to the results of the long-term effects based on countries, the group-specific coefficients were positive and statistically significant for all countries (Argentina, China, Brazil, South Africa, South Korea, Singapore, Poland, Russia, Thailand, and Turkiye).

5. Conclusion

In a digital world where technology is advancing rapidly, there is nothing more natural than changing the dimensions of communication. During the COVID-19 epidemic, which started in China in 2019 and spread to the whole world in 2020, the change in the dimensions of information and communication has become a regular flow of economic and social life. Now, many fields, including education and health, keep up with the pace of developments in information and communication technologies and are faced with a digital transformation process. Nowadays, information and communication technologies have emerged as one of the fastest-growing sectors in the world.

This study uses the panel data analysis method to investigate the effects of information and communication technologies on human capital. The research hypothesis is "*ICT exports increase human capital*." In the analysis part of the research, ten emerging economies (N=10 and T=20) were studied based on the 2000-2019 period regarding data availability. The dependent variable was the human capital index; the control variables were the education index and life expectancy at birth, and the independent variable was the share of information and communication technologies exports in total exports in the study.

Reviewed in the economic empirical literature, it is generally argued that ICT has become the basis of social and economic progress in developed and developing countries. In addition, as can be seen from the literature on this

Table 8. CCEMG Estimation Results

MODEL: [HCI=F(EDU, LE, ICT)] Wald chi2=9.573 P-value=0.000					
ΔHCI		***Coefficient***	***Standard Error***	***Z-value***	***P-value***
EDU		.2400958*	.195534	1.23	0.000
LE		.0005495*	.0106632	0.05	0.000
ICT		.0001165*	.0073987	0.02	0.000
Group-Specific Coefficients					
Argentina	***EDU***	.4131374*	.1333368	3.10	0.002
	LE	.0019739**	.0235249	0.08	0.033
	ICT	.043887***	.0235466	1.86	0.062
China	***EDU***	.0678307**	.1014658	0.67	0.004
	LE	.0485892*	.0057506	8.45	0.000
	ICT	.0002031**	.0019482	2.19	0.028
Brazil	***EDU***	.0246888*	.1226447	0.20	0.000
	LE	.0096814*	.0018788	5.15	0.000
	ICT	.0314656*	.0100482	3.13	0.002
South Africa	***EDU***	.0982735***	.0879729	1.12	0.064
	LE	.0010765***	.0027718	0.39	0.098
	ICT	.0031064*	.0004952	6.27	0.000
South Korea	***EDU***	.1113892**	.0720279	1.55	0.012
	LE	.0015642**	.0013174	1.19	0.023
	ICT	.0110222*	.0021221	5.19	0.000
Singapore	***EDU***	.2814216***	.1596357	1.76	0.078
	LE	.049578**	.023972	2.07	0.039
	ICT	.0037995**	.0017249	2.20	0.028
Poland	***EDU***	.0374955**	.0357464	1.05	0.025
	LE	.0223504*	.001244	2.24	0.000
	ICT	.0031356*	.0010452	3.0	0.003
Russia	***EDU***	.2437804*	.1087417	7.97	0.008
	LE	.0004076**	.0236707	0.15	0.040
	ICT	.0018992***	.000981	1.94	0.053
Thailand	***EDU***	.2437804*	.2352179	2.08	0.007
	LE	.003639**	.0258021	0.49	0.020
	ICT	.011467*	.0073777	1.55	0.000
Turkiye	***EDU***	1.524364**	.7320139	2.08	0.037
	LE	0308245**	.0886415	0.35	0.028
	ICT	.0004642***	.0033063	0.14	0.088
Note: *, ** and *** denote significance at the 1%, 5% and 10% levels, respectively.					

subject, it is possible to indicate that ICT, which has positive effects on human development, is a resource that helps poor countries' economic development. In empirical studies in both national and international literature, it is frequently emphasized that the export of information and communication technologies has a positive effect on economic growth. The importance and originality of this study is that it uses the CCEMG method within the scope of panel data analysis with ten countries selected from emerging economies to investigate the impact of information and communication technologies on human capital. So, the contribution of this study to the literature emerges in the context of the variables determined by the applied method and theory.

It is possible to list the findings obtained as a result of the analysis made in the study as follows, according to the CCEMG estimation results for the long term: an increase in the education index (EDU), life expectancy at birth (LE) and the share of ICT exports in total exports (ICT) also increases human capital (HCI). Reviewing the analysis results in detail, it has been determined that a 1% increase in the education index, in the long run, increases the human capital by 0.24. In addition, it is seen that there is an increase of 0.0019 in human capital with an increase in life expectancy at birth in the long run. In addition, due to the 1% increase in the share of ICT exports in total exports, it was determined that there was an increase of 0.0031 in human capital in the long run. In this respect, the study supported the finding in question that Aksentijevi'c, et al. (2021). It has been proven that there is a significant and positive relationship at the level of 1% between the dependent variable, the human capital index, and all of the independent variables (EDU, LE, ICT). According to the results of the long-term effects based on countries, the group-specific coefficients were positive and statistically significant for all countries (Argentina, China, Brazil, South Africa, South Korea, Singapore, Poland, Russia, Thailand, and Turkiye).

As a result, qualified human capital, which has become inevitable with the advances in ICT, creates a competitive environment for countries. Various policy recommendations can be given in the context of the effects of ICT on human

capital. It is essential to support entrepreneurs, academics, and technology suppliers in terms of developments in ICT. Countries should take essential steps such as disseminating technology workshops and increasing their quality, ensuring knowledge production with extremely high added value, and equipping their human capital in the light of knowledge. For this, it is necessary to create a qualified workforce by transferring information to human resources through training and seminars to increase information literacy, digital literacy, internet, and computer literacy, which are developed quantitatively and qualitatively with each new information. Therefore, developments in the IT sector and making the workforce durable and qualified in digital competencies also profoundly contribute to economic growth and development.

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