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INFORMATION AND COMMUNICATION TECHNOLOGIES AND HUMAN CAPITAL DEVELOPMENT: A PANEL DATA ANALYSIS

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Abstract
In this study, panel data for 143 countries from 1993 to 2014 are used to examine the association between ICT penetration and human capital development. Human Capital Index is utilized as a proxy for human capital development while ICT penetration is proxied by the penetration of internet users, fixed broadband subscriptions, and mobile phones. Each ICT indicator is considered in a separate model to avoid any potential multicollinearity problems. Bivariate and multivariate fixed time effect panel data estimation results suggest that there is a positive and strong relationship between ICT penetration and human capital development. Multivariate models are also estimated for developing countries sub-sample to check the robustness of estimation results. It is be observed that estimation results support the previous findings. Estimation results also indicate that individuals using the Internet as a percentage of population has the largest impact on the human capital among ICT indicators used in the study.

Keywords: Human Capital, Information and Communication Technologies, Panel Study
JEL Codes: O15, O33, C23

BİLGİ VE İLETİŞİM TEKNOLOJİLERİ VE BEŞERİ SERMAYE GELİŞİMİ: PANEL VERİ ANALİZİ

Öz
Bu çalışmada, 1993-2014 yılları arasında 143 ülkenin panel verileri kullanılarak, Bilgi ve İletişim Teknolojileri (BİT) ve insan sermayesi gelişimi arasındaki ilişkiyi incelenmiştir. Çalışmada, İnsan sermayesi gelişimini temsil eden değişken olarak İnsan Sermayesi Endeksi kullanılırken, BİT'lerin nüfuzu göstergeleri olarak internet kullanıcı sayısı, sabit geniş bant abonelikleri ve cep telefonu kullanıcı sayısı değişkenleri alınmıştır. Potansiyel çoklu bağlantı problemlerini önlemek için her bir BİT göstergesi ayrı bir model altında değerlendirilmiştir. Tek değişkenli ve çok değişkenli sabit zaman etkisi panel veri tahmin sonuçları, BİT penetrasyonu ile insan sermayesi gelişimi arasında pozitif ve güçlü bir ilişki olduğunu göstermektedir. Tahmini sonuçlarının sağlamlığını kontrol etmek için çok değişkenli modeller gelişmekte olan ülkeler alt örneklemi için de tahmin edilmiştir. Tahmin sonuçları önceki bulguları desteklemektedir. Ayrıca, tahmin sonuçları araştırmada kullanılan BİT göstergeleri arasında internet kullanıcıları sayısının beşeri sermaye üzerinde en büyük etkiye sahip olduğunu göstermektedir.

Anahtar Kelimler: Beşeri Sermaye, Bilgi ve İletişim Teknolojileri, Panel Veri Analizi
JEL Kodları: O15, O33, C23

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Introduction

Recently, human capital has been one of the most discussed concepts in economic theory. Developments in the endogenous growth theory stimulated the empirical research on human capital. The empirical research largely focuses on the effect of human capital on economic growth and development. Human capital improvement has become a matter of interest of policy makers as a result of empirical research pointing out positive outcomes of human capital. However, it is critical to know the determinants of human capital at the first place in order to develop policies towards improving human capital.

Although the empirical research largely focuses on the effect of human capital development on economic growth and development, the empirical research on the determinants of human capital is very limited. Previous empirical research finds that education, health, infrastructure and institutions are the most important potential determinants of human capital development.

Besides other determinants of human capital, ICT can contribute the human development. This study emphasizes the role of Information and Communication Technologies on the development of human capital. It is hypothesized that ICT is one of the important drivers of human capital developments and thus diffusion of ICT can help improvement in human capital. Another departure of this study from previous studies is the use of Human Capital Index as a proxy for Human Capital Development. Human Development Index is employed as a proxy for Human Capital Development by previous studies on the determinants of human capital. Unlike the previous empirical studies, this study utilizes Human Capital Index as a proxy for Human Capital Development.

The structure of the paper is as follows. Section 1 reviews the literature on the determinants of human development. The data and methodology are explained in Section 2 while Section 3 provides empirical results. Section 4 presents concluding remarks and policy implications.

1. Literature Review

Although the empirical research largely focuses on the effect of human capital on economic growth and development, the empirical research on the determinants of human capital is very limited. This section reviews the previous empirical research on the determinants of human capital.

By using 77 countries and the period between 1990 and 2001, Bildirici, Orcan, Sunal and Aykaç (2005) analyzed determinants of human capital proxied by the Human Development Index (HDI) for different groups of countries. They found that education index and average life expectancy are positively associated with human capital while regional development differences are negatively related to human capital for the model including all countries in the sample. They used different models including different variables for each group of countries. Their results indicate that adult literacy rate, schooling rate, education investments, per capita income, and growth rate are also positively and significantly related to human capital.

Binder and Georgiadis (2011) analyzed the impact of macroeconomic policies (investment in physical capital, government consumption and trade openness) and institutional variables (an index of the quality of governance and gender inequality) on the development of the Human Development Index in a panel of 87 countries from 1970 and 2005. Their findings point out that investment in physical capital is the most robust determinant of human development.

Kusharjantoa and Kim (2011) examined the association between infrastructure and human development measured by the HDI in Java, Indonesia by using regional panel data for the period between 2002 and 2005. Infrastructure variables in their model are the share of households using electricity, the share of households with access to tap water, packaged water, water pumps or protected springs that are at least 10 m in distance from a septic system, and total road length per

square kilometer. Their model also includes the number of classrooms in senior high schools per total population from 16 to 18 years old. Estimation results suggest that electricity infrastructure has a greater effect on human development than other types of infrastructure whereby every 1% expand in the proportion of households with electricity, the HDI surge up by 0.2%.

Sapkota (2014) analyzed the impacts of three main infrastructure variables, namely access to electricity, access to clean drinking water sources, and road density on the HDI and its three component indexes (i.e., health, education, and income) in developing countries by utilizing a panel data including 91 developing countries and the period between 1995 and 2010. The results of Dynamic panel estimation of General Methods of Moments suggest that all three infrastructure variables have statistically significant positive effects on HDI.

Closest to our study, Shuaibu and Oladayo (2016) investigated the determinants of human capital development in 33 African countries over the period from 2000 to 2013. They modeled Human Development Index as a function of per capita income, public expenditure on education and health, regulatory quality, and infrastructure. They found that all variables significantly influence the HDI in the long run while institutional quality is the only variable that significantly affects the HDI in the short run.

As reviewed above, previous empirical research on the determinants of human capital points out education, health, infrastructure and institutions as a potential drivers/determinants of human capital development. Besides other determinants of human capital, the diffusion of Information and Communication Technologies such as the internet, broadband subscription, computers and phones can contribute the human development.

In fact, the broad definition of infrastructure consists of ICT infrastructure. The impact of infrastructure on human development is emphasized by the previous studies. The following variables are used by the previous empirical studies as the measure of infrastructure: access to electricity, access to clean drinking water sources, and road density (Sapkota, 2014), the share of households using electricity, the share of households with access to tap water, packaged water, water pumps or protected springs that are at least 10 m in distance from a septic system, and total road length per square kilometer (Kusharjantoa and Kim, 2011), liner shipping connectivity index (maximum value in 2004 = 100) (Koyuncu and Unver, 2017), internet users per 100 people (Shuaibu and Oladayo, 2016), fixed broadband subscriptions per 100 people (Koyuncu, Yilmaz and Unver, 2016), mobile-cellular telephone subscriptions per 100 inhabitants (Koyuncu and Unver, 2017).

This study emphasizes the role of Information and Communication Technologies on the development of human capital by using 3 ICT indicators. It is hypothesized that ICT is one of the important drivers of human capital development and thus diffusion of ICT can help improvement in human capital.

Another departure of this study from previous studies is the use of Human Capital Index instead of Human Development Index as a proxy for Human Capital Development. Thus, unlike the previous empirical studies, this study utilizes Human Capital Index as a proxy for Human Capital Development.

2. Data and Methodology

This study intends to investigate the relationship between ICT penetration and human capital. For this purpose, we examined the effect of ICT diffusion on human capital by using 3 ICT indicators.

The time span of the is between 1993 and 2014. The largest sample of the study contains 143 countries.[11]

Bivariate and multivariate fixed time effect panel data models (FEM)[12]

$$HUMANCAPITAL_{it} = (\alpha + \tau_t) + \beta_1 ICT_{it} + u_{it} \quad (1)$$

$$HUMANCAPITAL_{it} = (\alpha + \tau_t) + \beta_1 ICT_{it} + \beta_2 EDUCATION_{it} + \beta_3 HEALTH_{it} + \beta_4 GDPPC_{it} + \beta_5 VOICE_{it} + u_{it} \quad (2)$$

and bivariate and multivariate random time effect models (REM)

$$HUMANCAPITAL_{it} = \alpha + \beta_1 ICT_{it} + (\tau_t + u_{it}) \quad (3)$$

$$HUMANCAPITAL_{it} = \alpha + \beta_1 ICT_{it} + \beta_2 EDUCATION_{it} + \beta_3 HEALTH_{it} + \beta_4 GDPPC_{it} + \beta_5 VOICE_{it} + (\tau_t + u_{it}) \quad (4)$$

implemented by the studies of Binder and Georgiadis (2011) and Shuaibu and Oladayo (2016) are employed to assess the impact of ICT penetration on human capital. All variables are expressed in logarithmic forms as such parameters on explanatory variables represent elasticity.

The dependent variable of our model is human capital. Human Capital Index is used as a proxy for human capital development. Human Capital Index is an index of human capital per person based on years of schooling and returns to education. The data is taken from Penn World Tables (PWT).

Our main explanatory variable of interest in this study is ICT penetration. Three variables are used to represent ICT penetration in above models. Table 1 presents definition and data source of variables representing ICT diffusion. As explained in the first section of the study, the expected signs of the coefficients on ICT variables are positive.

[11] The sample includes the following countries: Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Bahrain, Bangladesh, Barbados, Belgium, Belize, Benin, Bolivia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Congo Dem. Rep., Congo Rep., Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt Arab Rep., El Salvador, Estonia, Eswatini, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Guatemala, Haiti, Honduras, Hong Kong SAR, China, Hungary, Iceland, India, Indonesia, Iran Islamic Rep., Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea Rep., Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Lesotho, Liberia, Lithuania, Luxembourg, Macao SAR, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia, Sierra Leone, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Yemen Rep., Zambia, Zimbabwe.

[12] We used time effect model for two reasons. Firstly, as the period of estimation (1993–2014) is one in which interest in ICT products has been rising quite rapidly all over the world, we used period effect model instead of country-specific effect model in order to capture the impact of this particular fact on human capital. Secondly, since country-specific effect model requires estimation of quite more coefficients (i.e., country-specific coefficients which are 143 in our largest sample) than period effect model (i.e., time-specific coefficients which are just 22 in our largest sample), thus reducing degrees of freedom and potentially draining statistical power of estimators, the period-effect model is chosen.

Table 1: *Variables Representing Information and Commutation Technologies*

Variables	Definition	Data Source
INTER	(Individuals using the Internet as a percentage of population/100)* Total Population	The World Development Indicators (WDI)
CELLPHONE	Mobile cellular subscriptions.	The World Development Indicators
FXBROADBAND	Fixed broadband subscriptions.	The World Development Indicators

In addition to ICT variable, four control variables suggested by previous studies (Binder and Georgiadis, 2011; Shuaibu and Oladayo, 2016) are also used to analyze the association between human capital and ICT penetration. Table 2 provides definition and sources of other explanatory variables in the model.

Table 2: *Explanatory Variables*

Variables	Definition	Data Source
EDUCATION	[(Government expenditure on education as a percentage of GDP/100)* GDP (current US$)]/ Total Population	WDI
HEALTH	[(Domestic general government health expenditure as a percentage of GDP/100)* GDP (current US$)]/ Total Population	WDI
GDPPC	GDP per capita (constant 2010 US$)	WDI
VOICE	Voice and Accountability	WGI Data Set of WB

The explanatory variables and their expected signs are described below.

EDUCATION represents government expenditure on education. Human capital development rise as people become better educated. Surge in the government expenditures on education leads to increased access to education, knowledge and skills which enhance human capital. Hence, the positive association is expected between government expenditure on education and human capital.

HEALTH represents government expenditure on health. Increase in the government expenditures on health cause to increased access to health and well-being which enhance human capital. Thus, we expect a positive association between government expenditures on health and human capital.

GDPPC is the GDP per capita at 2010 constant US$. Improvements in per capita income play an important role on human development by providing great opportunity for training and capacity building activities. Hence, the expected relationship between per capita income and human capital development is positive.

VOICE refers to the voice and accountability indicator of the Worldwide Governance Indicators. It captures the impact of institutionalization on human capital development. The value of voice and accountability variable is between -2.5 and 2.5 as such higher scores corresponds to higher governance performance. Strong institutions provide a favorable environment for programs for human development and capacity building programs. Thus, the expected relationship between VOICE variable and human capital is positive in our model.

Meanwhile when calculating variable's logarithmic value is impossible, we added the same constant value to the observations of relevant variable in order to be able take its logarithmic value without loss of any information in the variable.

3. Estimation Results

Table 3 provides bivariate estimation results for three different ICT indicators. Table 3 includes 3 columns (models) for each ICT indicator. Each ICT indicator is considered in a separate model to avoid any potential multicollinearity problems. Hausmann statistics are used to choose between Fixed Effect Model and Random Effect Model at 5% significance level. Table 1 also provides Hausmann statistics at significance level of 5%.

As seen in Table 3, all coefficients of INTER, CELLPHONE and FXBROADBAND variables are positive and highly significant in all models. Bivariate estimation results show a strong positive association between ICT indicators and human capital. Estimation results also indicate that INTERNET has the largest impact on the human capital among ICT indicators used in the study.

Table 3: *Estimates for Bivariate Model (All Countries)*

	I	II	III
Constant	0.007333	0.390080*	0.254892*
S. Error	0.023557	0.019248	0.020487
INTER	0.065074*		
S. Error	0.001803		
CELLPHONE		0.032956*	
S. Error		0.001414	
FXBROADBAND			0.056268*
S. Error			0.001704
Num. of Obs.	2917	3129	1772
Num. of Count.	143	143	142
R^2	0.325431	0.175143	0.393074
Model	Fixed Effect Model	Fixed Effect Model	Fixed Effect Model
Hausman St.	177.559543	72.617376	98.529214

*Notes: *** p<0.01, ** p<0.05, * p<0.1.*

As a part of robustness checks, a number of control variables suggested by previous studies (Binder and Georgiadis, 2011; Shuaibu and Oladayo, 2016) are included in the bivariate models to test the validity and robustness of the bivariate estimation results. Consisting of 3 columns (models) for each ICT indicators, Table 4 provides the results of the multivariate estimation.

The coefficients of INTER, CELLPHONE and FXBROADBAND variables are 0.020, 0.010 and 0.016, respectively. They are all positive and highly significant. Hence, multivariate estimation results indicate that there is a robust positive association between ICT indicators and human capital. In other words, results indicate that the diffusion of ICT enhances human capital. Similar to bivariate estimation results, INTER has the largest impact on the human capital among ICT indicators used in the study. Specifically, a 10% percent increase in the individuals using the Internet is associated with a 0.2 percent increase in the human capital index per person.

In regard to other control variables, the coefficients on HEALTH, GDPPC and VOICE variables are all positive and statistically significant in all models while the coefficient on EDUCATION isn't significant in any model. Results suggest that surge in per capita health expenditure and GDP per capita as well as improvement in institutions help to enhance human capital.

Table 4: *Estimates for Multivariate Model (All Countries)*

	1	2	3
Constant	-0.357626*	-0.322777*	-0.115619
S. Error	0.073411	0.075573	0.073715
INTER	0.020897*		
Standard Error	0.003115		
CELLPHONE		0.010599*	
S. Error		0.002804	
FXBROADBAND			0.016782*
S. Error			0.002644
EDUCATION	-0.006172	-0.005690	-0.007725
S. Error	0.014686	0.013015	0.015804
HEALTH	0.033164*	0.031393*	0.034907*
S. Error	0.007383	0.007287	0.007349
GDPPC	0.089228*	0.099793*	0.072460*
S. Error	0.016274	0.013328	0.017587
VOICE	0.059345**	0.074450*	0.068366*
S. Error	0.018612	0.018070	0.019294
Num. of Obs.	1243	1247	1077
Num. of Count.	132	132	131
R^2	0.648794	0.637379	0.633964
Model	Random Effect Model	Random Effect Model	Random Effect Model
Hausman St.	3.882321	3.423714	11.262676

Multivariate models are also estimated for developing countries sub-sample to check the consistency and robustness of the estimation results. Table 5 provides multivariate estimation results for developing countries sub-sample. The estimated coefficients of variables are very identical to multivariate estimation results for all countries. Hence, multivariate estimation results for developing countries sub-sample support the previous findings.

Table 5: *Estimates for Multivariate Model (Developing Countries)*

	1	2	3
Constant	-0.604519*	-0.636201*	-0.384779*
S. Error	0.076992	0.086514	0.077711
INTER	0.027025*		
S. Error	0.002996		
CELLPHONE		0.019841*	
S. Error		0.003116	
FXBROADBAND			0.018126*
S. Error			0.002480
EDUCATION	-0.000851	0.002539	-0.018284
S. Error	0.014772	0.015264	0.016856
HEALTH	0.027610**	0.025638**	0.030592**
S. Error	0.012356	0.012650	0.013776
GDPPC	0.098114*	0.108751*	0.101743*
S. Error	0.014548	0.015009	0.016170
VOICE	0.108257*	0.120380*	0.116542*
S. Error	0.017612	0.017770	0.018639
Num. of Obs.	708	711	621
Num. of Count.	87	87	86
R^2	0.685547	0.666476	0.645026
Model	Random Effect Model	Random Effect Model	Random Effect Model
Hausman St.	4.349118	5.222809	8.406298

Overall, our findings highlight that penetration of ICT improves human capital development between 1993 and 2014. The findings in this study also demonstrate that among ICT variables, the strongest impact is generated by INTERNET variable. Our conclusions support previous studies finding of "electricity infrastructure has a greater influence on human development than other types of infrastructure" (Kusharjantoa and Kim, 2011) since ICT use stimulates electricity consumption in both short and long run (Salahuddin and Alam, 2016).

4. Conclusion

The association between ICT penetration and human capital development for the period between 1993 and 2014 is analyzed in this study by using the panel data of 143 countries. Bivariate and multivariate estimation results as well as sub-sample estimation results point out that there is a robust positive relationship between penetration of internet users, fixed broadband subscriptions, and mobile phones and human capital development. Hence, empirical evidence indicates that ICT penetration plays a positive and significant role in human capital development. The empirical evidence on this relationship suggests several policy implications.

Catching up with ICT penetration of more developed countries should be top priority of countries which desire to improve their human capital development level. ICT products and services can't be operated without electricity. That is why, electricity infrastructure and investment in electricity infrastructure is very important for the human development. Accordingly, education system should be reformed in accordance with the diffusion of ICT.

Estimation results also indicate that per capita internet use has the largest impact on the human capital among ICT indicators used in the study. The larger effect of the penetration of the internet on human capital development suggests that promoting the internet presence is more urgent and strategically more important for human capital development in relative to fixed broadband and mobile phones.

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