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# CAN INTERNET IN SCHOOLS AND TECHNOLOGY ADOPTION STIMULATE PRODUCTIVITY IN EMERGING MARKETS?

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**ABSTRACT**. This study investigates whether access to the Internet in schools and the share of its users stimulate productivity development in emerging markets in the period from 2007 to 2016. Following the rise of new endogenous theories, the opposition appeared in the empirical approaches related to the role of ICTs. The analysis is based on distinctive variables and various competitiveness pillars from the datasets published by the World Bank and the World Economic Forum. The empirical findings from the dynamic (GMM) regressions affirm that the interaction to the Internet access in schools, fixed broadband penetration and the latest available technologies affect productivity growth. However, mobile broadband subscription is negatively related to productivity. Hence, the support of competitiveness goals through larger access to the Internet in education, the improved fixed Internet broadband and the absorption of new technologies can make emerging markets more competitive and sustain productivity growth in the long run.

## Introduction

In recent years, information communication technologies (ICTs) have seen significant advances in the development of the global economy and the welfare of nations. Paul M. Romer and William D. Nordhaus have pioneered a conceptual framework for long-run technology and climate-driven changes (KVA, 2018). Understanding of the perspective of sustainable economic growth and human welfare over centuries may prove to be important for today's living standards and becomes a prevailing driver of the welfare appreciated by coming generations.

Increasing productivity is the essence of each industrial revolution (Pereira & Romero, 2017). The first industrial revolutions had their strong impact on industrial processes, allowing increased productivity and efficiency through the use of disruptive technological developments, such as the steam engine, electricity and digital technology (Ślusarczyk, 2019). Industry 4.0, which may eventually represent the fourth industrial revolution, is a complex technological system that has been widely discussed and researched and has a great influence on the industrial sector since it introduces relevant advances that are related to smart factories (Pereira & Romero, 2017). In order to accelerate economic growth and seize further opportunities for this industrial revolution, developed countries have proposed several manufacturing-based stimulating policies to promote the integration of ICT industries and the related advanced technologies (Yan et al., 2017; Bilan et al., 2019). Although development and application of novel technologies (e.g., the Internet of things) are risky and expensive, significant savings and revenue growth are achievable, and not only for early starters (Nagy, Oláh et al., 2018).

Much of the research in this regard has been focused on the relationship between economic environment and the implementation of novel technologies, but there is still no agreement about how have ICTs become the source of economic growth. A positive influence of competition on the application of new technologies can be found since the chance is given to outperform competitors (Zhu et al., 2003; Gál et al., 2013). Levine (1997) emphasized that ICTs improve access to information, which, in its turn, facilitates investment and economic performance. Bai and Yuen (2002) suggested it increases awareness, knowledge, consumer sophistication, etc., and the usage of ICTs in production value activities increases economic growth.

However, these rapid technological changes are having serious effects on economic development, and in particular, a negative correlation is revealed between competition and the adoption of online technologies (Rodríguez-Ardura & Meseguer-Artola, 2010). Some of the previous studies have reported adverse effects of ICTs in the case of developing countries. Maurseth (2018) found evidence of an unfavourable effect of the Internet on economic growth. In the case of developing countries, the lack of resources diverts the implication of such essential services, i.e. healthcare, education, clean water and electricity (Morawczynski & Ngwenyama, 2007). Moreover, the benefits of ICTs largely depend upon complementary factors, such as technical skills and financial back up to cover different transaction costs related to ICTs (Ngwenyama et al., 2006).

The research to date has tended to focus on developed rather than developing countries. This paper will review the research conducted on the influence of ICTs on productivity in the case of emerging markets. The paper attempts to show how access to and usage of the Internet, adoption of newly available technologies, fixed and mobile broadband penetration are related directly to the pace of output per capita changes. The rest of this paper is divided into sections. The next section gives a brief overview of the recent conceptual frameworks and empirical background for this research topic. Section two describes data and

the methodologies. The third section presents the findings of this research. Finally, the paper ends with conclusions and implications stemming from the results.

## 1. Literature review of the nexus between ICTs and productivity growth

One of the greatest mysteries in the history of economics was the Industrial Revolution in the 1760s when a prompt growth in per capita income occurred all over the world. The potential reasons offered is that transaction costs are involved in inventions. An innovation (R&D) might not be sustained by the inventors without the gains of efficient allocation in the form of profit (Coase, 1937). Later, the contribution of economic growth formalized firstly by Solow (1956) became especially popular in historical research following the rise of human capital theories promoted by Schultz (1961). The neoclassical model of exogenous growth has been extended since then to include several indicators of social development, such as health, life expectancy and educational enrolment (Becker, 1993).

In the 1980s, the new endogenous economic growth literature offered a technique to clarify differences in economic performance in the long run (Romer, 1986).The treatment of knowledge spillovers assumed that each unit of capital investment increases not only the stock of physical capital, but also the level of technology for all firms in the economy (Poór et al., 2018). This approach is based on the idea that the higher level of human capital leads to more innovations and facilitate the efficiency of technology, which finally causes a higher growth rate in the aggregate income (Romer, 1990). In these endogenous models, the knowledge of firms is assumed to be extended by novel research technologies that exhibit diminishing returns and explain economic growth (Meyer et al., 2017). In this sense, ICTs, i.e. access to the Internet, as a spillover, can spread knowledge directly and fast in an economy (Noh & Yoo, 2008), (Lechman, 2018), including their obvious positive influence on knowledge management systems development (Mishchuk et al., 2016; Gavurova et al., 2019).

Successful adaptation involves tailoring to individual needs, a series of modifications, and the improvement of technology to change resources and meet the increasing needs of developing countries (Adao et al., 2017; Vasa et al., 2012). Developing countries can be considered passive technology importers. These countries can simply take the appropriate and necessary technologies available from off the shelf and apply them around the rest of the world (Nagy et al., 2018). The rapid technology development and application of ICTs have accelerated drastically over the last century (Comin & Hobijn, 2010). The diffusion is mainly due to the intensification of international trade and direct investment, which are not only the carriers of globalization but also the essential spillover channels for the spread of novel technologies (Keller, 2004). Consequently, greater Internet access in schools may accelerate the distribution of novel ideas and information, and the available knowledge can intensify competition among business producers and force economic growth. Moreover, access to the information and its dissemination encourages the adoption of new technologies and stimulates economic growth by their diffusion (Benhabib & Spiegel, 2005).

Although the majority of empirical results (Choi & Hoon Yi, 2009), (Najarzadeh et al., 2014), (Salahuddin & Gow, 2016) earlier claimed that the usage of the Internet could affect economic growth per capita positively, scepticism was also present when extended time-periods studied. For example, Maurseth (2018) indicated a significant negative (counter-evidence) effects of the Internet on income growth from 2000 to 2015. Noh and Yoo (2008) also studied the controversial influence of Internet adoption and income inequality on economic growth. Based on a panel data set for 60 countries for the period 1995 to 2002, their results implied a negative effect of the Internet on productivity growth for countries with

high-income inequalities and the benefits of the ICT investments had been restructured in the less developed economies (Stiroh, 2002).

Previous research findings into the economic effect of fixed and mobile broadband on economic growth have also been inconsistent and contradictory. Qiang et al. (2009) implied a cross-sectional analysis to examine the influence of various ICTs including, i.e. fixed broadband on GDP per capita growth during the period 1980-2006 for 120 developing and developed countries. The evidence is inconclusive about whether fixed broadband has a greater effect on economic development compared to other ICTs (i.e. mobile broadband, Internet usage). In the same vein, Katz & Koutroumpis (2014) found that in the case of low-income economies, mobile has a superior influence in terms of basic subscriptions. Conversely, Thompson & Garbacz (2011)highlighted that mobile broadband has a negative correlation, possibly due to its complementarity effect and non-productive application.

## 2. Data and methodologies

Different sources of listed country-groups as emerging economies have various socio-economic features, but there are no strict criteria for classification. Controversially, a developed market is often identified by a high level of GDP per capita, export diversification (Bilan & Yamko, 2010), a high degree of integrated financial market systems and a substantial level of industrialization (Mody, 2004). Meanwhile, an emerging market is a group of countries that are progressing to become an advanced market with physical, financial infrastructure, and with banks, a stock exchange and unified currencies, but with a lower level of market efficiency, accounting regulation that is found in developed ones.

Although various institutions measure a country's development in many ways, to support investor needs with an objective and consistent approach to the taxonomy of developing markets, there is no consensus. For instance, each of the International Monetary Funds' (IMF)and the FTSE Russel's country classifications include 23, but different emerging economies. The IMF list includes, in alphabetical order, Argentina, Bangladesh, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, Ukraine, and Venezuela. Although Taiwan is represented in the list of FTSE, it is still omitted from the countries examined because of the lack of databases. The last group includes Brazil, Chile, China, Colombia, the Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Kuwait, Malaysia, Mexico, Pakistan, Peru, Philippines, Qatar, the Russian Federation, Saudi Arabia, South Africa, Thailand, Turkey, and the United Arab Emirates. In order to enhance the robustness of the results related to each group, the maximum number of available countries are utilized for the period 2007 to 2016.

Data were collected using a unique database of The World Development Indicators (WDI) has been constructed by the World Bank to support the gathering of relevant, high-quality, and internationally comparable statistics about global development and the fight against poverty (The World Bank, 2019). This Databank aims to create a balanced panel, which includes measures of, for example, output per capita, employment, capital formation, etc. at the country level from 1960 onwards. Other ICT uses and adoption variables are collected from the World Economic Forum's Database (World Economic Forum, 2019). The 5$^{th}$pillar of the Global Competitiveness Index (GCI) related to higher education and training includes Internet access in schools, in order to determine the quality of education (1-7 best). The 9$^{th}$pillar of technological readiness also measures the individual usage of the Internet (% of the population), Fixed Internet and Mobile broadband subscriptions/100 population, and the adoption of the latest technologies (1-7 best) as a control variable.

Table 1. Description, abbreviations, and sources of examined variables

| Variable | Abbreviation | Description | Source |
|---|---|---|---|
| GDP per person employed (constant 2011 PPP $) | ***Y*** | GDP per person employed is the gross domestic product (GDP) divided by total employment in the economy. Purchasing power parity (PPP) GDP is GDP converted to 2011 constant international dollars using PPP rates. | (The World Bank, 2019) |
| Gross capital formation (% of GDP) | $s_k$ | Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. | (The World Bank, 2019) |
| Total employment, total (ages 15+) | ***N*** | Total employment shows the total number employed aged 15 and over. | (The World Bank, 2019) |
| Higher education | ***Internet Access*** | Internet access in schools, 1-7 (best) | (World Economic Forum, 2019) |
| ICT use | ***Individual*** | Individuals using the Internet, % | (World Economic Forum, 2019) |
| | ***Fixed Internet*** | Fixed broadband Internet subscriptions/100 population | (World Economic Forum, 2019) |
| | ***Mobile broadband*** | Mobile broadband subscriptions/100 population | (World Economic Forum, 2019) |
| Technology adoption | ***Availability*** | Availability of latest technologies, 1-7 (best). | (World Economic Forum, 2019) |

Source: *authors' compilation based on (World Economic Forum, 2019) and* (The World Bank, 2019)

The technology of Internet broadband can be characterized as high-speed, always-on connectivity began to appear in some high-income countries in the late 1990s. The first high-speed mobile networks were launched in 2001, and commercialized mobile broadband networks reach download speeds of 300 Mb/s over a fourth-generation (4G). Then, as a powerful ICTs innovation, broadband has driven widespread changes enabling services, i.e. cloud computing, Internet of Things (IoT) and other mobile applications. Similarly, its technological evolution is influencing invention across many other sectors, including health, transport and E-government (Majeed, 2018; Vovk, 2016).

Critics of the original Solow model highlighted the discrepancies of the evidence and predictions, including its strong underestimation of population growth, saving and a substantial overestimation of convergence, etc. to the steady-state level of economies (Lucas 1988). The differences between developed and emerging countries in terms of the delay in the diffusion of new (ICT) technologies as extensive components were spectacularly reduced, as was quantified by the use of economic operators (Comin & Hobijn, 2010).

Therefore, the aggregate income [$Y_t$] in period *t*, the amounts of physical capital [$K_t$], and labour [$L_t$], predetermined by past accumulation is the following in the case of a Cobb-Douglas production function:

$$Y_t = K_t^{\propto}(A_t L_t)^{1-\propto} \quad (1)$$

where the notation is the standard. α and (1-α) are the output elasticities of capital and labour, respectively, and the model assumes constant returns to scale ($0<\alpha<1$). [$A_t$] is the residual of Total Factor Productivity (TFP) becomes the portion of the growth in output not explained by growth inputs of labour and capital used in production. This variable follows an exogenous path of a constant [g] growth rate of technical progress. Hence, $A_t = A_o(1+g)^t$ for all t. According to the suggestion of Mankiw et al. (1992), both sides of the (1) equation should be divided by [$L_t$] using the definition of output per worker $y_t=Y_t/L_t$. Hence, the per capita production function is transformed:

$$y_t = k_t A_t^{1-\propto} \quad (2)$$

For the computation of the steady-state level of productivity [y*] the rate of investment in physical capital [$s_k$] and the rate of employment growth [n] is expressed. Thus, assuming that there is no strong reason to expect depreciation rates [δ], and [g] reflects the rate of long-run technological change which differs substantially across countries, a constant value (0.05) is substituted and added to employment growth (n+δ+g). The steady-state level of productivity follows this arrangement:

$$y *_t = A_t\left(\frac{s_k}{n+\delta+g}\right)^{\propto/(1-\propto)} \quad (3)$$

In order to test (3) empirically, the steady-state prediction takes logs from both sides of the equation. The relationship between the explanatory variables is now linear:

$$lny *_t = lnA_t + \frac{\propto}{(1-\propto)}[lns_k - (n+\delta+g)] \quad (4)$$

After the transformation and arrangement of (4) in a linear regression formula:

$$lny_{i,t} *= \beta_o + \beta_1 lns_{k_{i,t}} - \beta_2 ln(n+\delta+g)_{i,t} + \beta_3 lns_{h_{i,t}} + \beta_4 lnA_{i,t} + \varepsilon_{i,t} \quad (5)$$

where the dependent variable $lny_{i,t}$ is the log of GDP per capita in constant prices, $lnsk_{i.t}$ denotes an index of gross capital formation per GDP, *ln(*n+δ+g) is calculated by the sum of employment growth rates. $lnA_{i,t}$ is proxied by the ratio of Internet users (% of the population), the availability of the latest technologies, etc. ε is the error term.

In this dynamic approach, the economy tends toward long-run equilibrium (Arellano & Bond, 1991). Generally, this kind of methods employs the lagged levels of the dependent and predetermined variables among the repressors. A dynamic specification requires exceptional instrumentation of these lagged endogenous variables and GMM estimators are reflected, which allows for covariates. Consequently, internal instruments are adopted, as some of the lagged explanatory variables may influence the dependent variable to exclude biases. The set of instruments are limited to avoid the overestimation problem (Roodman, 2009). After taking the logarithm of first differences of the dependent productivity variable, the following formula is tested in the case of emerging markets: Based on the former (5) equation, the transformation is:

$$\Delta lny_{i,t} *= \beta_o + \beta_1 lny_{i,t-1} + \beta_2 lns_{k_{i,t}} - \beta_3 ln(n+\delta+g)_{i,t} + \beta_4 lnInternet\_Access_{i,t_{i,t}} +$$

$$\beta_5 lnIndividual_{i,t} + \beta_6 lnFixed\_Internet_{i,t} + \beta_7 lnMobile_{i,t} + \beta_8 lnAvailability_{i,t} + \varepsilon_{i,t} \quad (6)$$

In order of appearance, the dependent variable is the first log of GDP per capita of country [i] for the period [t] at a constant (2011) price, the lagged form of the dependent variable ($y_{i.t-1}$), the logs (ln) of investment ratio in physical capital ($s_k$), the employment growth (n+δ+g), Internet access in education (Internet Access) and the level of individual users of Internet (Individual), the fixed broadband Internet (Fixed Internet) penetration, the mobile broadband subscriptions (Mobile) and the latest available technologies (Availability).

## 3. Results of ICTs and long-run productivity growth relations

Table 2 describes the descriptive (Mean and Standard Deviation, Minimum, Maximum, Skewness and Kurtosis) and stationarity statistics of the examined variables are reported by observations. The sample consists of a strongly balanced panel of 23 emerging economies from 2007 to 2016. The Levin–Lin–Chu test also applied to a subset of panel data for the emerging countries to examine whether the series contains a unit root (Levin et al., 2002). Each of them is significant at all the usual testing levels. Therefore, the null hypothesis can be rejected and conclude that the series is stationary. The results of the correlation analysis can be found in the Appendix.

Table 2. Descriptive and stationarity statistics of the examined variables in the case of emerging countries

| Variable | Mean | SD | Min. | Max. | Skewness | Kurtosis | L-L-C test |
|---|---|---|---|---|---|---|---|
| GDP per capita growth | 10.61 | 0.74 | 9.18 | 12.15 | 0.21 | 2.23 | -13.85*** |
| GCF (%) | 24.91 | 6.81 | 13.39 | 47.68 | 1.45 | 5.36 | -8.73*** |
| (n+δ+g) | 8.3E+07 | 1.7E+08 | 2.9E+06 | 7.5E+08 | 3.09 | 11.52 | -8.77*** |
| Access to the Internet (%) | 4.05 | 0.75 | 1.55 | 5.72 | -0.24 | 3.21 | -14.65*** |
| Individual users (%) | 34.84 | 19.81 | 0.26 | 76.13 | 0.11 | 1.91 | -43.43*** |
| Fixed Internet broadband | 1.34 | 1.43 | -4.07 | 3.42 | -1.16 | 4.41 | -16.33*** |
| Mobile broadband | 3.15 | 1.32 | -1.94 | 4.94 | -1.59 | 8.79 | -17.63*** |
| Availability | 4.686 | 0.606 | 3.147 | 6.049 | 0.027 | 2.43 | -7.81*** |

Source: *authors' estimations based on (World Economic Forum, 2019) and* (The World Bank, 2019). *Note: *** p< .01, ** p< .05, * p< .1. L-L-C denotes Levin–Lin–Chu test.*

Tables 3 and 4 provide the corresponding results of dynamic regression estimations. In both cases, the two-step GMM estimator should be preferred in order to handle the proposition of biased standard errors (Windmeijer, 2005) and assess the validity of comparisons. In the bottom sections of these tables, the significant Wald-test indicates the accurate choice of dynamic approaches. In each model (1 to 10), the Sargan tests also demonstrate the results of over-identifying restrictions. The lack of autocorrelation is also performed by the first AR(1), and second-order AR(2) Arellano tests. These consistent results are validated as all estimators are free from serial correlation and robust under the altered comparisons (IMF, FTSE).

Although the influence of the lagged output per capita is not robust in all of the examined cases, these results denoted the existence of long-run economic growth convergence among the examined emerging countries. As would be expected according to the neoclassical economic growth theories, an increase in the investment ratio has a positive effect on productivity growth in both cases, and employment growth attainment ($n+\delta+g$) is negatively related to productivity growth. However, the coefficients of access to the Internet is small and ranging from 0.025 to 0.153,in both groups of emerging markets, it might positively influence productivity growth. Hence, if there is a one-unit increase in the quantity of education by enhanced access to the Internet, it will promote productivity development. Moreover, there is no relation between the ratio of Internet users and productivity growth. The absence of significance only means that more individual users, ceteris paribus, does not indicate productivity growth in this approach.

Table 3. Results of regressions (Equation 6) in the case of emerging (IMF) countries

| Dependent variable: productivity growth ($lny_{i,t}$) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Country Group | | | | IMF | | | |
| Independent | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
| constant | -0.677 | -0.689 | -0.876 | -0.826 | -0.648 | -0.422 | -0.657 |
| | (-19.98)*** | (-11.62)*** | (-12.06)*** | (-6.92)*** | (-7.01)*** | (-3.98)*** | (-8.13)*** |
| $ln(y)_{i,t-1}$ | -0.212 | -0.255 | -0.284 | -0.265 | -0.261 | -0.534 | -0.243 |
| | (-38.08)*** | (-7.07)*** | (-8.65)*** | (-5.85)*** | (-5.78)*** | (-3.03)*** | (-5.42)*** |
| $ln(sk)_{i,t}$ | 0.218 | 0.231 | 0.194 | 0.183 | 0.222 | 0.162 | 0.192 |
| | (21.91)*** | (12.57)*** | (10.02)*** | (7.08)*** | (7.71)*** | (4.47)*** | (6.77)*** |
| $ln(n+g+\delta)_{i,t}$ | -0.586 | -0.525 | -0.575 | -0.574 | -0.552 | -0.826 | -0.609 |
| | (-10.99)*** | (-5.71)*** | (-7.23)*** | (-5.28)*** | (-5.42)*** | (-2.90)*** | (-5.57)*** |
| $ln(Internet\_Access)_{i,t}$ | 0.036 | 0.021 | 0.025 | 0.031 | | | |
| | (2.22)** | (0.83) | (1.61)* | (1.11) | | | |
| $ln(Individual)_{i,t}$ | | -0.003 | | 0.006 | | | |
| | | (-0.75) | | (0.25) | | | |
| $ln(Availability)_{i,t}$ | | | 0.182 | 0.165 | | | |
| | | | (4.99)* | (2.95)* | | | |
| $ln(Fixed\_Internet)_{i,t}$ | | | | | 0.002 | | |
| | | | | | (1.14) | | |
| $ln(Mobile)_{i,t}$ | | | | | | -0.002 | |
| | | | | | | (-2.91)*** | |
| $ln(Internet\_Access)^* ln(Availability)_{i,t}$ | | | | | | | 0.051 |
| | | | | | | | (2.71)*** |
| Number of Observations | 159 | 159 | 159 | 159 | 159 | 88 | 159 |
| Number of Countries | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Number of Instruments | 22 | 18 | 18 | 13 | 11 | 8 | 11 |
| Wald test | 1646.2*** | 375.7*** | 409.28*** | 184.08*** | 161.74*** | 55.85*** | 160.58*** |
| AR(1) test | -1.207 | -1.031 | -0.303 | -1.395 | -0.858 | -0.135 | -1.381 |
| AR(2) test | -1.928 | -2.083 | -1.583 | -2.001 | -2.182 | -0.85 | -1.955 |
| Sargan test | 18.827 | 14.758 | 15.411 | 11.862 | 11.478 | 4.436 | 13.072 |

Source: *authors' estimations based on (World Economic Forum, 2019) and* (The World Bank, 2019). *Note: *** p< .01, ** p< .05, * p< .1*

The study is also finding that every unit increase in fixed broadband penetration increases GDP per household. On the other hand, an increase in mobile broadband penetration is found to reduce GDP per capita. In a similar empirical case, Wallsten (2011) also concludes that the mobile broadband result could be due to non-productive applications of mobile broadband technology that cannot substitute or complement to existing fixed broadband. The results, as shown in Table 3 and 4, indicate that a high degree of positive correlation can be demonstrated between the availability of the latest technologies and productivity. Moreover,

increased access to the Internet in schools and higher technology adoption can also together contribute to better productivity performance. Considering the crucial role of the Internet and the latest technologies, substantial economic improvement can be noticed in the case of emerging markets. In other words, their moderation effects imply that *greater access to the Internet and technological adoption stimulates productivity development in the emerging economies*.

Table 4. Results of regressions (Equation 6) in the case of emerging (FTSE) countries

| Dependent variable: productivity growth ($lny_{i,t}$) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Country Group | FTSE | | | | | | |
| Independent | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
| constant | -0.436 | -0.399 | -0.601 | -0.559 | -0.295 | -1.112 | -0.426 |
| | (-4.34)*** | (-3.37)*** | (-5.36)*** | (-3.51)*** | (-2.44)** | (-1.92)* | (-4.92)*** |
| $ln(y)_{i,t-1}$ | 0.168 | 0.154 | 0.145 | 0.138 | 0.278 | 0.051 | 0.136 |
| | (1.93)* | (1.76)* | (1.76)* | (1.66)* | (2.49)** | (0.95) | (1.57)* |
| $ln(sk)_{i,t}$ | 0.092 | 0.085 | 0.078 | 0.075 | 0.103 | 0.054 | 0.088 |
| | (2.92)*** | (2.71)*** | (2.51)** | (2.45)** | (2.83)*** | (2.91)*** | (3.27)*** |
| $ln(n+g+\delta)_{i,t}$ | -0.761 | -0.767 | -0.801 | -0.792 | -0.676 | -0.548 | -0.821 |
| | (-5.14)*** | (-5.51)*** | (-5.63)*** | (-6.08)*** | (-4.47)*** | (-3.57)*** | (-5.83)*** |
| $ln(Internet\_Access)_{i,t}$ | 0.146 | 0.153 | 0.134 | 0.141 | | | |
| | (3.39)*** | (3.28)*** | (3.53)*** | (3.27)*** | | | |
| $ln(Individual)_{i,t}$ | | -0.006 | | -0.006 | | | |
| | | (-0.48) | | (-0.40) | | | |
| $ln(Availability)_{i,t}$ | | | 0.141 | 0.128 | | | |
| | | | (2.31)** | (1.87)* | | | |
| $ln(Fixed\_Internet)_{i,t}$ | | | | | 0.ö16 | | |
| | | | | | (1.96)* | | |
| $ln(Mobile)_{i,t}$ | | | | | | -0.003 | |
| | | | | | | -(3.81)*** | |
| ln(Internet_Access)* $ln(Availability)_{i,t}$ | | | | | | | 0.093 |
| | | | | | | | (2.71)*** |
| Number of Observations | 161 | 161 | 161 | 161 | 160 | 88 | 161 |
| Number of Countries | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Number of Instruments | 11 | 12 | 12 | 13 | 11 | 8 | 11 |
| Wald test | 61.89*** | 62.16*** | 81.79*** | 80.91*** | 39.33*** | 49.34*** | 96.51*** |
| AR(1) test | -2.846 | -2.448 | -2.234 | -2.036 | -2.938 | -0.984 | -2.411 |
| AR(2) test | -1.283 | -1.252 | -1.349 | -1.361 | -1.118 | -0.102 | -1.341 |
| Sargan test | 8.933 | 8.822 | 8.491 | 8.395 | 5.385 | 6.331 | 8.941 |

Source: *authors' estimations based on (World Economic Forum, 2019) and* (The World Bank, 2019).
*Note: *** p< .01, ** p< .05, * p< .1*

## Discussions

The present study was designed to determine the effect of ICTs (access to the Internet in schools, individual Internet users, fixed internet and mobile broadband), and the latest available technologies (adoption) stimulated development in the case of emerging markets from 2007 to 2016. The robust dynamic GMM specifications are applied in two alternative country-groups. One came from the IMF and the other from the FTSE approaches, and both resulted in parallel outcomes.

The results of this study indicate the investigation of the extent to which ICTs features, technologies enhance the development of emerging markets. The additional contribution of this study is the examination of various global competitiveness (GCI) pillars concerning economic development with Internet access in schools and technology adoption in the case of

various emerging markets. It is interesting to note that in each case the development of Internet usage (free access and broadband infrastructure) builds a competitive environment, enhances the cooperation of innovators and entrepreneurs and encourages the level of human capital.

Meanwhile, the negative influence of mobile subscriptions on productivity growth could be explained by the lower penetration rate of mobile cellular in developing countries (Albiman & Sulong, 2017). Developing countries with low mobile bandwidth subscriptions and patent application levels may lack sufficient communications infrastructure and technology to support the production process. Although emerging business environments can adopt the latest technologies to increase productive efficiency and prosperity, technological progress in newly-industrialized countries involves acquiring advanced technological capabilities rather than to enhance innovation at the technological frontier. Consequently, the results of this study imply that the development and such applications of ICT shave not resulted in productivity growth over recent decades.

## Conclusions

The results are consistent with previous literature (Karaçor et al., 2018), (Kliestik et al., 2018), etc. on the paradigm that the quality of education, stemming from Internet access in schools, and features of goodwill, etc., promote the emerging market development. The same results defined at the level of higher education, particularly in analysis of economic consequences of student migration caused by the quality of education (Mishchuk et al., 2019). Meanwhile, the individual usage of the Internet has no significant correlation with productivity growth, in the long run, enhancing the scepticism of Maurseth (2018). The findings also suggest that the positive effect of the latest technological adoptions is robust in the case of emerging markets (Meyer & Meyer, 2016), and the role of the transfer and diffusion of new technologies (Postelnicu & Dabija, 2015).

Finally, several important limitations need to be considered. First, the results have demonstrated only one aspect of the relation between ICTs, innovative capacity, and emerging market development and each of the regression models typically suffer from common method bias generally decreases when additional independent variables are not included in a regression equation.

This study also offers some useful policy implications. Emerging economies have to focus on support for the adoption of new industrial technologies and on making their economies attractive for sustainable economic growth per capita in the long run (Meyer & Meyer, 2017). Indeed, the authorities of emerging countries should also increase investments in ICTs infrastructure as it is more cost-effective and beneficial than fixed-line telephones. Authorities are also required to upgrade and expand existing infrastructure to accelerate Internet usage and broadband adoption (Qiang et al., 2009). In order to improve efficiency in public administration, the diffusion of ICTs should be stimulated not only in the private sector through policy interventions, i.e. tax reduction, subsidies, promoting E-commerce solutions, and developing public-private partnerships (Bahrini & Qaffas, 2019), (Oláh et al., 2018), (Bilan et al., 2019). Bringing these vital elements together enables decision-makers to frame policies based on parallel confluences.

Moreover, the authors believe that a better understanding of additional ICTs features (i.e. 5G mobile broadband, bandwidth, Internet of things, etc.) related to productivity is a vital element in the success of government policies to enhance productivity performance, and not only in the case of emerging markets. Further research analysis in this cross-country approach could be worth undertaking.

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## Appendix

Table A1. Correlation matrix of examined variables in the case of emerging (IMF) countries

| | Productivity growth | GCF | (n+δ+g) | Access | Individual | Fixed Internet | Mobile broadband | Availability |
|---|---|---|---|---|---|---|---|---|
| **Productivity growth** | 1 | | | | | | | |
| **GCF** | 0.56*** | 1 | | | | | | |
| **(n+δ+g)** | -0.06 | 0.01 | 1 | | | | | |
| **Access** | 0.09 | 0.15** | -0.11 | 1 | | | | |
| **Individual** | -0.21*** | -0.16** | -0.07 | 0.69*** | 1 | | | |
| **Fixed Internet** | -0.14** | -0.09 | -0.18*** | 0.58*** | 0.85*** | 1 | | |
| **Mobile broadband** | -0.16* | 0.01 | -0.13 | 0.4ö*** | 0.66*** | 0.61*** | 1 | |
| **Availability** | 0.11 | -0.03 | 0.28*** | 0.36*** | 0.22*** | 0.11* | 0.03 | 1 |

Source: *authors' estimations based on (World Economic Forum, 2019) and* (The World Bank, 2019).
*Note: *** p< .01, ** p< .05, * p< .1*

Table A2. Correlation matrix of examined variables in the case of emerging (FTSE) countries

| | Productivity growth | GCF | (n+δ+g) | Access | Individual | Fixed Internet | Mobile broadband | Availability |
|---|---|---|---|---|---|---|---|---|
| **Productivity growth** | 1 | | | | | | | |
| **GCF** | 0.41*** | 1 | | | | | | |
| **(n+δ+g)** | -0.41*** | 0.11 | 1 | | | | | |
| **Access** | 0.02 | 0.35*** | 0.19 | 1 | | | | |
| **Individual** | -0.28*** | -0.13* | 0.11 | 0.53*** | 1 | | | |
| **Fixed Internet** | -0.12* | -0.01 | -0.07 | 0.52*** | 0.82*** | 1 | | |
| **Mobile broadband** | -0.32*** | 0.06 | -0.01 | 0.4ö*** | 0.66*** | 0.49*** | 1 | |
| **Availability** | -0.24*** | 0.02 | 0.33*** | 0.51*** | 0.37*** | 0.29*** | 0.19* | 1 |

Source: *authors' estimations based on* (World Economic Forum, 2019) *and* (The World Bank, 2019).
*Note: *** p< .01, ** p< .05, * p< .1*