A G D I Working Paper

WP/19/038

Foreign Direct Investment, Information Technology and Economic Growth Dynamics in Sub-Saharan Africa [1]

Forthcoming: Telecommunications Policy

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[1] This working paper also appears in the Development Bank of Nigeria Working Paper Series.

2019 African Governance and Development Institute WP/19/038

Research Department

Foreign Direct Investment, Information Technology and Economic Growth Dynamics in Sub-Saharan Africa

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January 2019

Abstract

The research assesses how information and communication technology (ICT) modulates the effect of foreign direct investment (FDI) on economic growth dynamics in 25 countries in Sub-Saharan Africa for the period 1980-2014. The employed economic growth dynamics areGross Domestic Product (GDP) growth, real GDP and GDP per capita while ICT is measured by mobile phone penetration and internet penetration. The empirical evidence is based on the Generalised Method of Moments. The study finds that both internet penetration and mobile phone penetration overwhelmingly modulate FDI to induce overall positive net effects on all three economic growth dynamics. Moreover, the positive net effects are consistently more apparent in internet-centric regressions compared to "mobile phone"-oriented specifications. In the light of negative interactive effects, net effects are decomposed to provide thresholds at which ICT policy variables should be complemented with other policy initiatives in order to engender favorable outcomes on economic growth dynamics. Practical and theoretical implications are discussed.

JEL Classification: E23; F21; F30; L96; O55

Keywords: Economic Output; Foreign Investment; Information Technology; Sub-Saharan Africa

1. Introduction

The positioning of this study on the importance of information and communication technology (ICT) in modulating the relevance of foreign direct investment (FDI) in growth dynamics in Sub-Saharan Africa (SSA) is motivated by three main factors in the scholarly literature, namely: (i) the importance of economic growth in economic development; (ii) the relevance of ICT in driving contemporary economic development outcomes and (iii) gaps in contemporary economic development literature. These factors are expanded in turn.

First, economic prosperity is relevant for economic development because it, *inter alia*, provides investment and consumption opportunities, employment, social mobility and a plethora of avenues that increase living standards and boost general wellbeing in society. Growth performances across countries are contingent on a plethora of factors, and FDI and information technology have been documented to be particularly relevant in boosting economic growth in developing countries (Hassan, 2005; Fanta & Makina, 2017;Dunne &Masiyandima, 2017; Boamah, 2017). Compared to FDI, ICT is more contemporary as a driver of economic growth. This is mainly because in most developing countries, while FDI has been an important determinant of economic growth since political independence, the importance of information technology is comparatively more contemporary in driving development outcomes (Veeramacheneni, Vogel & Ekanayake, 2008).

Second, ICT is relevant in the economic prosperity of a country because it helps to boost the country's production capacity in a plethora of economic sectors (Hong, 2016). Moreover, ICT also helps to link the production activities of a country to global value chains, increases competitiveness, reduces poverty and enhances transparency and efficiency in public sector management (Sassi & Goaied, 2013). The importance of ICT in driving economic prosperity also builds on an evolving stream of development literature that is focused on how information technology can be leveraged for positive macroeconomic externalities in Africa (Tchamyou, 2017; Abor, Amidu & Issahaku, 2018; Asongu & Nwachukwu, 2018; Isszhaku, Abu & Nkegbe, 2018; Gosavi, 2018; Minkoua Nzie, Bidogeza & Ngum, 2018; Asongu & Odhiambo, 2019a; Efobi, Tanankem & Asongu, 2018). The merit of information technology in driving comparative development in SSA in relation to other regions of the world builds on the relative importance of ICT in the sub-region compared to other regions. Accordingly, contemporary information technology literature is consistent with the position that there is still substantial room for ICT penetration in SSA compared to other world regions that are experiencing saturation levels in the penetration of ICT (Afutu-Kotey, Gough & Owusu, 2017; Penard, Poussing, Yebe & Ella, 2012; Asongu, 2013a; Asongu &

Boateng, 2018; Gosavi, 2018; Humbani & Wiese, 2018; Asongu & Odhiambo, 2019b). The present research extends the underlying strand of literature by assessing the importance of ICT in modulating the effect of FDI on economic growth dynamics. Such a positioning is also motivated by attendant gaps in FDI- and growth-centric contemporary studies.

Third, the attendant studies from which this research departs can be discussed in two main strands. The first on economic growth has focused on *inter alia*: determinants of FDI in SSA and the Middle East and North Africa (Okafor, Piesse & Webster, 2017); linkages between economic growth and financial development (Assefa & Mollick, 2017;Adam, Musah& Ibrahim, 2017); country-specific cases of dynamics in inflation and economic output (Bonga-Bonga&Simo-Kengne, 2018); nexuses between aid volatility, aid and sector prosperity (Kumi, Muazu & Yeboah, 2017); connections between financial development and volatility in economic growth (Muazu & Alagidede, 2017) and linkages between economic growth volatility and innovation (Yaya & Cabral, 2017). Studies in the second strand pertaining to FDI have been concerned with, *inter alia*: the importance of global sector influence on sectoral portfolios in Africa (Boamah, 2017); FDI and income convergence at the regional level (Dunne & Masiyandima, 2017); the estimation of gaps in outputs and potential economic prosperity (Fedderke & Mengisteab, 2017); linkages between bonds, economic growth, equity and institutional debts (Fanta & Makina, 2017) and the role of value chains in harnessing FDI spillovers on economic growth and total factor productivity in SSA (Meniago & Asongu, 2019).

A common shortcoming in the above studies is that the assessments are mainly based on direct linkages between FDI, economic growth and other macroeconomic outcomes. This research argues that it is not enough to provide policy makers with the determinants of macroeconomic variables which are informed by signs and magnitudes of estimated coefficients. Hence, this study goes further than providing signs and magnitudes of estimated coefficients, to assessing the nexus between FDI and economic growth by employing ICT as a moderating policy variable in the underlying relationship. The choice of ICT as a policy indicator is motivated by its high penetration potential in SSA. Hence, by employing ICT as a moderator of the FDI-growth relationship, policy makers are informed of the relevance of ICT in improving the absorption capacity of FDI in order to boost economic prosperity. Hence, the corresponding research question is the following: how does ICT moderate the effect of FDI on economic growth dynamics in SSA?

The rest of the paper is organized as follows. The theoretical model underpinning nexuses between FDI, ICT and economic growth areclarified in section 2 while the data and methodology are explained in section 3. Section 4 focuses on the empirical results while the research concludes with implications and future research directions.

2. Theoretical model on nexuses between FDI, ICT and economic growth

Borrowing from Hassan (2005) on the theoretical connection between FDI, technology and economic prosperity, there are various mechanisms (e.g. ICT) through which positive externalities linked with FDI can be manifested. (i) According to the *competitive mechanism*, enhanced competition engenders higher productivity, efficiency and more investments in physical and/or human capital. Moreover, growing competition can prompt changes in the industrial sector that warrant enhanced competitiveness and activities that are export-led. (ii) The *training mechanism* engenders higher training activities in management and labour. (iii) According to the *linkages mechanism*, FDI is facilitated by existing levels of technology, and foreign investments are also a means of technology transfer to domestic firms. (iv) According to the *demonstration mechanism*, more advanced firms are imitated by domestic firms in terms of technology usage.

In summary, amongst the theoretical mechanisms that facilitate the relevance of FDI in economic growth is the role of information technology which is used in this study as the moderating variable. Hence, existing levels of information technology can influence the absorption capacity of FDI to influence macroeconomic outcomes such as economic growth.

These theoretical insights are consistent with the theoretical models that predict the importance of FDI in economic growth in developing countries (Romer, 1990; Grossman & Helpman, 1991; Barro & Sala-i-Martin, 1998; Borensztein, De Gregorrio & Lee, 1998; Hassan, 2005). In the light of the attendant theoretical underpinnings, let us consider two sectors in a country which differ in terms of productivity levels. Sector 1 which consists of foreign firms producing intermediate goods is characterised by advanced technology while sector 2consists of domestic firms. The number of available intermediary goods drives technological progress. The theoretical framework is consistent with Hassan (2005). The framework from Equation (1) to Equation (9) can be summarized in the following: (i) individuals maximize their utility in the consumption of goods and (ii) when these goods are produced by both domestic and foreign firms (i.e. related to FDI), there are some conditions associated with FDI such as technology that can facilitate the production of goods that would provide more utility to individuals. In the context of the study, overall utility at the aggregate level is appreciated in terms of economic growth dynamics while technology that can improve the absorptive capacity of FDI for the underlying economic growth is mobile phone penetration and internet penetration. The equations are presented and further discussed in what follows.

Preferences: Individuals maximize an intertemporal utility function of the form:

$$U(0) = \int_0^\infty e^{-\rho t} u(c_t) L_t dt \qquad (1)$$

where ρ is the discount rate, c_t is the per capita consumption in period t and L_t is family size. The instantaneous utility function is of the Constant Relative Risk Aversion (CRRA) type:

$$U(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}, \qquad (2)$$

where σ the intertemporal elasticity of substitution between periods. The utility from consuming goods can be further maximized if the goods are produced in a competitive market environment involving FDI andin which,technology plays a role.

Technology: Let Y be consumption goods produced by two sectors, and sold in competitive markets. Hence, the corresponding economic output can be written as:

$$Y = Y_1 + Y_2 \qquad (3)$$

And the production function for each of the sectors can also be written as:

$$Y_1 = A_1 H^{\alpha} k^{1-\alpha} \text{ given that } 0 < \alpha < 1, \qquad (4)$$

where H represents human capital endowmentwhereas K denotes the stock of physical capital and is defined as:

$$K = \sum_{i=1}^{N^{FDI}} x_i Y_1 + Y_2 \qquad (5)$$

where x_i reflects intermediate goods when i indexes a variety of intermediate goods, and N^{FDI} represents the number of intermediate goods varieties by sector 1 (where firms of foreign ownership work). Consistent with Romer (1990), the intermediate goods are involved in the production function in a separate and additive fashion. Moreover, the stock of physical capital is a developing country is captured with N^{FDI} intermediate goods. K in equation (4) can be substituted and considering that in equilibrium the quantity and price of each intermediate good are similar, $\bar{x}$:

$$Y_1 = A_1 H^{\alpha} N^{FDI} \overline{X}^{1-\alpha} \qquad (6)$$

The production function of sector 2 can be written as:

$$Y_2 = A_2 L_2^{\beta} \tag{7}$$

When the following restrictions are involved in the parameters:

$A_1(1-\alpha) > A_2\beta$

It follows that the corresponding efficiency prevailing in sector 2 represents a fraction of that prevailing in sector 1:

$$A_2 = \varepsilon A_1 \tag{8}$$

$\varepsilon < 1$

The fixed cost can be written as:

$$F = f(N^{FDI}) \text{ where, } \frac{\partial F}{\partial N^{FDI}} < 0 \tag{9}$$

The evidence of the underlying negative nexus is characteristic of monopolistic rents for sector 1. Moreover, the existence of F necessitates prevailing growing returns in sector 1 and hence, the availability of extra profits. Conversely, when they are positively related in the form,

$$\frac{\partial F}{\partial N^{FDI}} > 0$$

A convergence hypothesis can be inferred as one of the predictions of the model, since a country characterized by a larger technological gap will grow faster. As it has been observed, FDI is associated with the competition that improves efficiency in overall production processes in the competitive market and by extension the maximization of utility derived by individuals from consuming the produced goods. Moreover, as shall be further substantiated below (i.e. for the context of this research), such competition, aggregate productivity and maximization of overall utility can be further facilitated by other moderating factors of production such as information technology.

In the light of the theoretical underpinnings, information and communication technology can be an effective moderator of the importance of FDI in facilitating economic growth. Within the neoclassical framework, as documented by Solow (1956), the incidence of FDI on economic growth is contingent on diminishing returns in physical capital. Within the framework of the New Theory of Economic Growth, FDI can influence both the level of economic growth and output per capita in the domestic economy because, *inter alia*, it: facilitates usage and exploitation of material at the local level, is associated with advanced management techniques, eases access to novel ICT, finances current account deficits, stimulates investments in research and development as well as boosts the stocks of human and physical capital.

Within the specific context of this research, information technology in terms of mobile phone penetration and internet penetration are factors that facilitate the absorptive capacity of FDI for economic growth outcomes. The main reason ICT can modulate the effect of FDI on economic growth is because, in this era of knowledge-based economies, ICT represents a factor of production because it facilitates, *interalia*: the acquisition of raw materials needed for the production process, communication between various departments of production and the management of production. Hence, the importance of ICT in the enhancement of productivity, as well as the efficient allocation of resources for production pertaining to domestic investment (Isszhaku et al., 2018; Gosavi, 2018; Minkoua Nzie et al., 2018) can be extended to foreign investment (Maryam& Jehan, 2018). In summary, this study argues that the documented ICT as a driver of economic growth (Vu, 2011, 2019) is feasible via the FDI channel in the perspective that ICT can increase the absorptive capacity of FDI for economic growth outcomes.While in developed countries, there is a very high degree of substitution between internet penetration and mobile phone penetration, the difference between mobile penetration and internet penetration is high because access to the internet is still low compared to access to the mobile phone. Hence, in the light of the differing penetration potential, it is intuitive to build on the premise that the moderating capacities of the ICT variables are different and hence, it is logical to expect both to influence the effect of FDI on economic growth dynamics differently[2].

[2] The fact that the research anticipates ICT to facilitate the absorptive capacity of FDI for macroeconomic outcomes such as economic growth is intuitive. Accordingly, FDI in any sector of the economy (primary, secondary or tertiary) depends on domestic technology for the efficiency in corresponding operations linked to human and physical capital. This intuition is very sound. Whether such an intuition is confirmed in the empirical analysis from net impacts and conditional effects is another matter because empirical results are not always consistent with theoretical underpinnings. In fact, applied econometrics is meant to either reject or accept intuition and/or theoretical postulations.

3. Data and methodology

3.1 Data

The study focuses on a panel of twenty-five nations in SSA with data spanning from 1980 to 2014[3]. Contingencies in data availability motivate the choice of geographical and temporal scopes of the research. The structure of the data is reorganised to be consistent with the empirical strategy that is adopted for the study, namely: the Generalised Method of Moments (GMM). Accordingly, given that the N>T condition is required for the application of this estimation strategy, non-overlapping intervals or data averages are computed. Seven five-year and five seven-year averages are computed for the purpose of the research. Unfortunately, a preliminary or exploratory analysis suggests that only the latter non-overlapping intervals can be appropriately used to estimate models that pass post-estimation diagnostic tests. Hence the intervals retained are: 1980-1986; 1987-1993; 1994-2000; 2001-2007; 2008-2014. Moreover, in the light of the theoretical underpinnings clarified in the previous section, the notion of convergence can be more taken on board through the process of employing non-overlapping intervals because according to Islam (1995), doing so reduces business cycles disturbances that can last substantially.

Three economic growth dynamics come from the World Development Indicators (WDI) of the World Bank. They are: Gross Domestic Product (GDP) growth, real GDP and GDP per capita. The research normalises the last-two economic growth dynamics with logarithms in order to ensure that the mean values of variables are comparable. For instance, in empirical research, robust findings are unlikely to be established if tens of units are compared with millions of units.

The United Nations Conference on Trade and Development (UNCTAD) database is the source of the Foreign Direct Investment (FDI) indicator which is computed as FDI inflows as a percentage of GDP. In the light of the motivation and theoretical underpinnings of the study, in order to increase the policy appeal of the research, two ICT policy variables are employed, namely: mobile phone penetration and internet penetration.

In accordance with contemporary economic development literature, four elements are selected for the conditioning information set (Elu & Price, 2010;Anyanwu, 2011; Barro, 2003; Sahoo *et al.*, 2010; Fosu, 2015; Asongu, 2015; Nyasha & Odhiambo, 2015a, 2015b; Elu & Price, 2017; Meniago & Asongu, 2018; Kreuser & Newman, 2018 ; Maryam & Jehan, 2018).

[3]The countries, selected on data availability are: Benin; Botswana; Burkina Faso; Burundi; Cameroon; Central African Republic; Cote d'Ivoire; Gabon; Kenya; Lesotho; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Senegal; Sierra Leone; South Africa; Sudan; Swaziland; Tanzania; Togo and Zimbabwe.

These include: population, inflation, government expenditure and education. Consistent with the theoretical underpinnings discussed in the previous section, the adopted control variables in the conditioning information set are also motivated by factors that are essential for FDI to boost economic development. The anticipated signs of variables in the conditioning information set are discussed in what follows.

First, whereas low and stable inflation is conducive for economic prosperity, high inflation translates an economic environment that is characterised by uncertainty and by extension limited investment activities and economic operations. This expectation is consistent with the narrative that inflation breeds ambiguity and/or uncertainty and investors have been documented to prefer economic environments that are less ambiguous (Kelsey & le Roux, 2017, 2018). Second, population growth is positively associated with output and economic activity (Becker, Laeser & Murphy, 1999; Heady & Hodge, 2009). Third, government expenditure is anticipated to boost economic activity, productivity and economic output because from intuition such expenditure is primarily designed to reach macroeconomic objectives of *inter alia*: investment, employment and economic growth. Fourth, consistent with the theoretical underpinnings and recent SSA-centric research (Ssozi & Asongu, 2016a), education or human capital is needed to boost economic productivity. “Gender parity primary and secondary education”is used for two main reasons. On the one hand, gender inclusiveness is important for enhanced economic activity (Asongu & Odhiambo, 2018). On the other, relative to the highest level of education, lower educational levels have been documented to be more relevant in driving socio-economic outcomes and economic development when countries are at initial stages of industrialisation (Petrakis & Stamatakis, 2002; Asiedu, 2014; Tchamyou, 2019a)[4].

Appendix 1 provides the definitions and sources of variables whereas the summary statistics and correlation matrix are respectively disclosed in Appendix 2 and Appendix 3. The summary statistics inform the research that the variables under consideration are comparable from the perspective of mean values. Moreover, the attendant variations from the standard deviations also inform the study that reasonable estimated linkages can be obtained from the regressions. The objective of the correlation matrix is to control for potential issues of multicollinearity which could substantially bias estimated coefficients.

[4]The adopted education proxy is primary and secondary (gross), gender parity index (GPI).

3.2 Methodology

3.2.1 Specification

The choice of this estimation approach is informed by three fundamental motivations that are consistent with contemporary GMM-centric literature (Tchamyou, 2019b; Tchamyou, Erreygers & Cassimon, 2019). (i) Owing to the restructuring of the dataset by means of non-overlapping intervals, the N>T condition needed for the employment of the estimation approach is met because the number of cross sections (i.e. 25 countries) is higher than the corresponding number of time periods in each cross section (i.e. 5). (ii) Cross-country differences are considered in the estimation owing to the panel nature of the dataset. (iii) The concern about endogeneity is tackled from two main angles. On the one hand, the issue of reverse causality or simultaneity is addressed using internal instruments. On the other, time invariant omitted variables are employed to control for the unobserved heterogeneity.

The following level (10) and first difference (11) equations summarize the system GMM estimation procedure for assessing the importance of information technology in moderating the impact of FDI on economic growth dynamics (i.e. GDP growth, real GDP and GDP per capita).

$$EG_{i,t} = \sigma_0 + \sigma_1 EG_{i,t-\tau} + \sigma_2 FDI_{i,t} + \sigma_3 IT_{i,t} + \sigma_4 Inter_{i,t} + \sum_{h=1}^{4} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (10)$$

$$\begin{aligned} EG_{i,t} - EG_{i,t-\tau} &= \sigma_1 (EG_{i,t-\tau} - EG_{i,t-2\tau}) + \sigma_2 (FDI_{i,t} - FDI_{i,t-\tau}) + \sigma_3 (IT_{i,t} - IT_{i,t-\tau}) \\ &+ \sigma_4 (Inter_{i,t} - Inter_{i,t-\tau}) + \sum_{h=1}^{4} \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} + \varepsilon_{i,t-\tau}) \end{aligned}, \quad (11)$$

where $EG_{i,t}$ is an economic growth variable of country i in period t; FDI is foreign direct investment; IT represents information technology (i.e. mobile phone penetration or internet penetration); $Inter$ is theinteraction between FDI and information technology; σ_0 is a constant; τ is the degree of auto-regression which is one or seven-year lag because such sufficiently captures past information; W is the vector of control variables (*population, inflation, government expenditure* and *education),* η_i is the country-specific effect, ξ_t is the time-specific constant and $\varepsilon_{i,t}$ the error term. Equations (10) and (11) are replicated for the threeoutcomes variables, notably: GDP growth, real GDP, andGDP per capita.

The empirical strategy adopted by this study is an extended version of Arellano and Bover (1995) by Roodman (2009). The motivation for the empirical strategy is that it has been documented to provide betterestimated coefficients when compared with less contemporary GMM-centric estimation strategies (Love & Zicchino, 2006; Boateng, Asongu, Akamavi & Tchamyou, 2018). The procedure adopted by the research is the *two-step* specification, compared to the *one-step* because the former is consistent with heteroscedasticity.

3.2.2 Identification, simultaneity and exclusion restrictions

The identification process consists of defining three sets of variables, notably: the outcome variables, the endogenous explaining variables and the strictly exogenous variables. After this identification process, the procedure of exclusion restrictions entails the validation of the exclusion restriction assumption which is the position that the outcome variables are affected by the strictly exogenous variables exclusively via the identified endogenous explaining variables. This research is consistent with the attendant GMM-centric literature (Tchamyou & Asongu, 2017; Meniago & Asongu, 2018; Tchamyou *et al.*, 2019) by defining: (i) the strictly exogenous variables as years and (ii) the endogenous explaining variables as the main independent variables of interest (i.e. FDI and ICT dynamics) and elements of the conditioning information set (i.e the four control variables). Consistent the previous sections and motivation of the study, the outcome variables are obviously growth dynamics. Roodman (2009) is sympathetic to this identification strategy because according to him, it is not likely for the identified strictly exogenous variables to be endogenous after a first difference.

In the light of this clarification, the GMM is specified such that instrumental variables (iv or *ivstyle*) capture the strictly exogenous variables whereas the endogenous explaining variables are articulated in the *gmm*style. It is relevant to emphasise that the exclusion restriction assumption maintains that the strictly exogenous variables influence the outcome variables primarily through the identified exogenous components of the endogenous explaining variables. Still conforming to the attendant GMM-centric literature, in the findings that are reported in the following section, the Difference in Hansen Test (DHT) for the exogeneity of instruments is employed to examine the validity of the exclusion restrictions assumption. In essence, its null hypothesis should not be rejected in order for the exclusion restriction assumption to hold.

It is important to articulate that contrary to a strand of income convergence literature in which the initial level of income is included in Eqs. (10) and (11) in order to capture the effect of convergence (Barro, 1991, 1997; Forbes, 2000; Giuliano & Ruiz-Arranz, 2009; Vu, 2019), other strands of the literature based on GMM regressions include the lagged dependent variable which is used to capture the convergence effect (Narayan, Mishra & Narayan, 2011; Bruno, De Bonis& Silvestrini, 2012; Asongu, 2013b). Such a convergence effect is apparent when the absolute value of the lagged dependent variable is between 0 and 1 (Prochniak & Witkowski, 2012a, 2012b; Asongu & Andrés, 2019). Moreover, the contemporary notion of convergence is beyond income levels (Asongu, 2014) because the theoretical underpinnings of the convergence literature have been recently extended from income levels to other fields of economic development, *inter alia*: information technology and knowledge economy (Karagiannis, 2007; Asongu, 2017a, 2017b) and financial development (Narayan *et al*., 2011; Bruno *et al*., 2012; Asongu, 2013).

4. Empirical results

4.1. Presentation of results and net effects

The empirical results are disclosed in this section in Tables 1-3. Table 1 focuses on linkages between FDI, ICT and economic growth. Table 2 is concerned with nexuses between FDI, ICT and real GDP while the focus of Table 3 is on connections between FDI, ICT and GDP per capita. Each table is divided into two main sections: the left-hand side reveals findings from "mobile phone"-centric regressions whereas the right-hand side showsresults of the corresponding "internet penetration"-oriented estimations.

The specifications are tailored such that concerns about instrument proliferation are limited after the estimation exercise. For this purpose, only oneelement of the conditioning information set is used once in four of the five specifications. The first specification is without a conditioning information set. It is worthwhile to emphasize that it is not uncommon in the GMM-centric literature for specifications to bevoid of control variables or characterised by limited involvement of control variables. Such is tolerable if the purpose of doing so is to avoid instrument proliferation that invalidates the estimated model. Some examples of corresponding studies that have involved no control variable for the purpose of avoiding instrument proliferation include: Osabuohien and Efobi (2013) and Asongu and Nwachukwu (2017).

Four fundamental criteria are employed to assess whether the estimated models are valid or not[5]. Based on these criteria, the estimated models are overwhelmingly valid with the exceptions of three specifications: one in Table 1 (i.e. in the third column) and two in Table 2

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[5] "*First, the null hypothesis of the second-order Arellano and Bond autocorrelation test (AR (2)) in difference for the absence of autocorrelation in the residuals should not be rejected. Second the Sargan and Hansen over-identification restrictions (OIR) tests should not be significant because their null hypotheses are the positions that instruments are valid or not correlated with the error terms. In essence, while the Sargan OIR test is not robust but not weakened by instruments, the Hansen OIR is robust but weakened by instruments. In order to restrict identification or limit the proliferation of instruments, we have ensured that instruments are lower than the number of cross-sections in most specifications. Third, the Difference in Hansen Test (DHT) for exogeneity of instruments is also employed to assess the validity of results from the Hansen OIR test. Fourth, a Fischer test for the joint validity of estimated coefficients is also provided*" (Asongu & De Moor, 2017, p.200).

(i.e. sixth and eleventh columns). The common feature among the three invalid models is that the null hypothesis of the second order auto-correlation test in difference is rejected.

Table 1: FDI, ICT and GDP growth

	Dependent variable: GDP growth									
	The mobile phone penetration channel (Mobile)					The internet channel (Internet)				
GDP growth (-1)	0.048	0.042	-0.012	0.020	0.041	**0.119***	0.016	0.042	**0.117*****	**0.096****
	(0.577)	(0.468)	(0.837)	(0.761)	(0.612)	**(0.051)**	(0.843)	(0.600)	**(0.002)**	**(0.041)**
FDI	**0.334***	**0.319****	**0.356*****	**0.428*****	**0.300***	**0.296*****	**0.293*****	**0.354*****	**0.329*****	**0.346*****
	(0.058)	**(0.031)**	**(0.006)**	**(0.000)**	**(0.053)**	**(0.000)**	**(0.001)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile	0.011	0.031	0.006	0.023	0.002	---	---	---	---	---
	(0.623)	(0.106)	(0.625)	(0.101)	(0.900)					
Internet	---	---	---	---	---	**0.071*****	**0.090***	**0.120*****	**0.112*****	**0.120*****
						(0.005)	**(0.085)**	**(0.001)**	**(0.000)**	**(0.002)**
FDI× Mobile	-0.003	-0.001	**-0.004***	**-0.006*****	-0.003	---	---		---	
	(0.325)	(0.558)	**(0.064)**	**(0.007)**	(0.303)					
FDI× Internet	---	---	---	---	---	**-0.026*****	-0.004	**-0.040*****	**-0.038*****	**-0.048*****
						(0.009)	(0.690)	**(0.000)**	**(0.000)**	**(0.002)**
Population	---	**1.625*****	---	---	---	---	**1.706*****	---	---	
		(0.000)					**(0.000)**			
Inflation	---	---	**-0.002*****	---	---	---	---	**-0.002*****	---	
			(0.000)					**(0.000)**		
Education	---	---	---	0.617	---	---	---	---	-0.593	
				(0.671)					(0.591)	
Gov't Expenditure	---	---	---	---	**0.131*****	---	---	---	---	**0.109****
					(0.004)					**(0.016)**
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	nsa	0.292	0.333	na	0.216	na	0.231	0.212	0.199
AR(1)	(0.071)	(0.069)	(0.084)	**(0.160)**	(0.060)	(0.043)	(0.040)	(0.049)	**(0.113)**	(0.028)
AR(2)	**(0.745)**	(0.090)	**(0.716)**	**(0.227)**	**(0.794)**	**(0.980)**	**(0.061)**	**(0.769)**	**(0.405)**	**(0.810)**
Sargan OIR	**(0.251)**	**(0.365)**	**(0.158)**	(0.089)	**(0.275)**	(0.078)	(0.083)	**(0.330)**	(0.042)	**(0.172)**
Hansen OIR	**(0.155)**	**(0.619)**	**(0.235)**	**(0.299)**	**(0.183)**	**(0.211)**	**(0.131)**	**(0.369)**	**(0.518)**	**(0.145)**
DHT for instruments										
(a)Instruments in levels										
H excluding group	(0.060)	**(0.112)**	**(0.185)**	(0.029)	(0.007)	(0.044)	(0.097)	**(0.136)**	**(0.135)**	(0.012)
Dif(null, H=exogenous)	**(0.299)**	**(0.863)**	**(0.305)**	**(0.755)**	**(0.820)**	**(0.454)**	**(0.237)**	**(0.540)**	**(0.727)**	**(0.632)**
(b) IV (years, eq(diff))										
H excluding group	**(0.277)**	**(0.418)**	**(0.104)**	**(0.317)**	**(0.330)**	**(0.280)**	(0.073)	**(0.351)**	**(0.334)**	**(0.324)**
Dif(null, H=exogenous)	**(0.132)**	**(0.832)**	**(0.869)**	**(0.308)**	**(0.119)**	**(0.207)**	**(0.592)**	**(0.387)**	**(0.793)**	**(0.083)**
Fisher	**410.89*****	**245.39*****	**10165.43*****	**133.91*****	**348.56*****	**31.75*****	**23.14*****	**3337.11*****	**31.20*****	**72.52*****
Instruments	18	22	22	22	22	18	22	22	22	22
Countries	24	24	24	24	24	24	24	24	24	24
Observations	95	95	93	81	93	95	95	93	81	93

***,**,*: significance levels at 1%, 5% and 10% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients and the Wald statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) & AR(2) tests and; b) the validity of the instruments in the Sargan and Hansen OIR tests. Gov't: Government. nsa: not specifically applicable because the estimated model is not valid. na: not applicable because at least one estimated coefficient required for the computation of net effects is not significant. The mean value of mobile phone penetration is 15.806 while the mean value of internet penetration is 3.053. Constants are included in all regressions.

Table 2: FDI, ICT and Real GDP

	Dependent variable: log of Real GDP(lnRGDP)									
	The mobile phone penetration channel (Mobile)					The internet channel (Internet)				
lnRGDP (-1)	**0.671*****	**0.664*****	**0.721*****	**0.793*****	**0.812*****	**0.751*****	**0.788*****	**0.771*****	**0.905*****	**0.887*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
FDI	0.030	**0.037****	0.030	0.016	0.013	**0.047*****	**0.031*****	**0.039*****	**0 .024****	**0.022****
	(0.224)	**(0.041)**	(0.176)	(0.321)	(0.505)	**(0.001)**	**(0.001)**	**(0.000)**	**(0.010)**	**(0.025)**
Mobile	**0.005***	**0.007*****	**0.005****	0.0007	0.001	---	---	---	---	---
	(0.065)	**(0.002)**	**(0.027)**	(0.717)	(0.316)					
Internet	---	---	---	---	---	**0.068*****	**0.051*****	**0.056*****	**0.028*****	**0.036*****
						(0.000)	**(0.000)**	**(0.000)**	**(0.001)**	**(0.000)**
FDI× Mobile	**-0.001****	**-0.001*****	**-0.001*****	**-0.0006***	**-0.0006***	---	---	---	---	---
	(0.023)	**(0.000)**	**(0.005)**	**(0.078)**	**(0.076)**					
FDI× Internet	---	---	---	---	---	**-0.011*****	**-0.007*****	**-0.010*****	**-0.006*****	**-0.007*****
						(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.001)**
Population	---	0.034		---	---	---	**0.096*****	---	---	---
		(0.283)					**(0.000)**			
Inflation	---	---	**-0.0001 *****	---	---	---	---	**-0.0002 *****	---	---
			(0.000)					**(0.000)**		
Education	---	---	---	**0.895*****	---	---	---	---	**0.481****	---
				(0.000)					**(0.011)**	
Gov't Expenditure	---	---	---	---	0.004	---	---	---	---	**0.020****
					(0.465)					**(0.010)**
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	0.021	na	na	nsa	0.013	0.009	0.008	0.005	nsa
AR(1)	**(0.726)**	**(0.898)**	**(0.492)**	**(0.789)**	**(0.902)**	**(0.125)**	**(0.196)**	**(0.377)**	**(0.192)**	(0.086)
AR(2)	**(0.117)**	**(0.160)**	**(0.359)**	**(0.128)**	(0.059)	**(0.130)**	**(0.191)**	**(0.305)**	**(0.148)**	(0.096)
Sargan OIR	(0.005)	(0.000)	(0.007)	(0.094)	(0.034)	(0.009)	(0.001)	(0.008)	(0.022)	(0.053)
Hansen OIR	**(0.123)**	**(0.145)**	**(0.108)**	**(0.172)**	**(0.237)**	**(0.202)**	**(0.196)**	**(0.219)**	**(0.222)**	**(0.147)**
DHT for instruments										
(a)Instruments in levels										
H excluding group	**(0.166)**	**(0.249)**	**(0.207)**	**(0.312)**	**(0.253)**	**(0.239)**	**(0.318)**	**(0.240)**	**(0.451)**	**(0.180)**
Dif(null, H=exogenous)	**(0.150)**	**(0.158)**	**(0.128)**	**(0.167)**	**(0.264)**	**(0.212)**	**(0.191)**	**(0.249)**	**(0.181)**	**(0.191)**
(b) IV (years, eq(diff))										
H excluding group	(0.079)	(0.079)	**(0.167)**	**(0.152)**	**(0.293)**	**(0.195)**	**(0.200)**	**(0.127)**	**(0.137)**	**(0.409)**
Dif(null, H=exogenous)	**(0.421)**	**(0.614)**	**(0.149)**	**(0.354)**	**(0.230)**	**(0.305)**	**(0.298)**	**(0.644)**	**(0.601)**	(0.056)
Fisher	**20560.92 *****	**44367.20 *****	**300.03 *****	**62449.23 *****	**376.60 *****	**100462 *****	**267081 *****	**1.75e+07 *****	**288290 *****	**376285 *****
Instruments	18	22	22	22	22	18	22	22	22	22
Countries	24	24	24	24	24	24	24	24	24	24
Observations	96	96	94	82	94	96	96	94	82	94

***,**,*: significance levels at 1%, 5% and 10% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients and the Wald statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) & AR(2) tests and; b) the validity of the instruments in the Sargan and Hansen OIR tests. Gov't: Government. nsa: not specifically applicable because the estimated model is not valid. na: not applicable because at least one estimated coefficient required for the computation of net effects is not significant. The mean value of mobile phone penetration is 15.806 while the mean value of internet penetration is 3.053. Constants are included in all regressions.

Table 3: FDI, ICT and GDP per capita

	Dependent variable: log of GDP per capita (lnGDPpc)									
	The mobile phone penetration channel (Mobile)					The internet channel (Internet)				
lnGDPpc(-1)	1.136*** (0.000)	1.068*** (0.000)	1.108*** (0.000)	1.043*** (0.000)	1.045*** (0.000)	1.041*** (0.000)	1.080*** (0.000)	1.061*** (0.000)	0.940*** (0.000)	0.902*** (0.000)
FDI	0.037* (0.070)	0.024* (0.099)	0.004 (0.689)	0.018* (0.067)	0.023 (0.135)	0.012** (0.011)	0.010*** (0.000)	0.021*** (0.000)	0.008** (0.019)	0.015* (0.054)
Mobile	0.001 (0.675)	0.002 (0.250)	-0.002 (0.215)	0.0006 (0.637)	0.00002 (0.991)	---	---	---	---	---
Internet	---	---	---	---	---	0.013*** (0.004)	0.012*** (0.000)	0.023*** (0.000)	0.013*** (0.001)	0.031*** (0.000)
FDI× Mobile	-0.0009** (0.046)	-0.0005* (0.094)	-0.0002 (0.466)	-0.0005* (0.054)	-0.0006* (0.059)	---	---	---	---	---
FDI× Internet	---	---	---	---	---	-0.002* (0.053)	-0.001*** (0.000)	-0.004*** (0.000)	-0.001* (0.078)	-0.005*** (0.000)
Population	---	0.041 (0.199)	---	---	---	---	0.062*** (0.000)	---	---	---
Inflation	---	---	-0.0003*** (0.000)	---	---	---	---	-0.0003*** (0.000)	---	---
Education	---	---	---	0.278 (0.232)	---	---	---	---	0.486** (0.031)	---
Gov't Expenditure	---	---	---	---	0.015** (0.024)	---	---	---	---	0.028*** (0.000)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	0.022	0.016	na	0.010	na	0.005	0.006	0.008	0.004	-0.0002
AR(1)	(0.688)	(0.805)	(0.353)	(0.949)	(0.849)	(0.929)	(0.847)	(0.488)	(0.761)	(0.177)
AR(2)	(0.125)	(0.130)	(0.203)	(0.145)	(0.127)	(0.128)	(0.155)	(0.198)	(0.157)	(0.163)
Sargan OIR	(0.387)	(0.083)	(0.571)	(0.474)	(0.530)	(0.065)	(0.066)	(0.318)	(0.134)	(0.419)
Hansen OIR	(0.316)	(0.286)	(0.256)	(0.427)	(0.391)	(0.311)	(0.349)	(0.213)	(0.444)	(0.251)
DHT for instruments										
(a)Instruments in levels										
H excluding group	(0.270)	(0.266)	(0.401)	(0.302)	(0.297)	(0.292)	(0.442)	(0.656)	(0.408)	(0.298)
Dif(null, H=exogenous)	(0.324)	(0.314)	(0.227)	(0.456)	(0.418)	(0.309)	(0.307)	(0.140)	(0.419)	(0.259)
(b) IV (years, eq(diff))										
H excluding group	(0.275)	(0.140)	(0.406)	(0.418)	(0.406)	(0.115)	(0.172)	(0.124)	(0.456)	(0.160)
Dif(null, H=exogenous)	(0.395)	(0.838)	(0.150)	(0.387)	(0.340)	(0.911)	(0.888)	(0.634)	(0.358)	(0.598)
Fisher	3362.76***	281243***	3.76e+06***	2189.31***	2627.09***	244827***	248016***	1.42e+06***	208005***	559.81***
Instruments	18	22	22	22	22	18	22	22	22	22
Countries	24	24	24	24	24	24	24	24	24	24
Observations	94	94	92	80	92	94	94	92	80	92

***,**,*: significance levels at 1%, 5% and 10% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients and the Wald statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) & AR(2) tests and; b) the validity of the instruments in the Sargan and Hansen OIR tests. Gov't: Government. na: not applicable because at least one estimated coefficient required for the computation of net effects is not significant. The mean value of mobile phone penetration is 15.806 while the mean value of internet penetration is 3.053. Constants are included in all regressions.

Following contemporary literature on interactive regressions (Tchamyou & Asongu, 2017; Agoba, Abor, Osei, & Sa-Aadu, 2019), in order to estimate the importance of ICT in modulating the incidence of FDI on economic growth dynamics, net effects are computed. These net effects constitute the unconditional effects of FDI on economic growth dynamics as well as the conditional effects pertaining to the interaction between FDI and ICT variables. In order to put this computation into greater perspective, an example is considered from Table 1. From the last column of Table 1, the net effect on GDP growth from the relevance of internet penetration in modulating the effect of FDI on GDP growth is 0.199 ([3.053× -0.048] +

[0.346]). In this computation, the average value of internet penetration is 3.053, the unconditional impact of FDI on GDP growth is 0.346 while the conditional impact from the interaction between internet penetration and FDI is -0.048.

The following findings can be established from Tables 1-3. First, both internet penetration and mobile phone penetration overwhelmingly modulate FDI to induce overall positive net effects on all three economic growth dynamics. Moreover, considering the various specifications engaged, positive net effects are consistently more apparent in internet-centric regressions compared to “mobile phone”-oriented specifications. Second, the control variables overwhelmingly have the anticipated signs. Accordingly, whereas inflation negatively affects economic growth dynamics, population, inclusive education and government expenditure engender an opposite effect.

4.2. Net effect decomposition

While the established net effects are consistent with the intuition and theoretical expectations of the study, the conditional effects from interactive estimations between ICT dynamics and FDI are consistently negative. This is an indication that increasing ICT penetration beyond certain thresholds would engender zero net effects on the economic growth dynamics. In order for the established thresholds to make economic sense and have policy relevance, they should be within the statistical range (i.e. minimum to maximum) disclosed in the summary statistics (Asongu & Odhiambo, 2019c). Moreover, in accordance with recent threshold literature, when increasing policy variables beyond critical masses or thresholds engenders undesired macroeconomic effects, it is an indication that the policy variables should be complemented with other policy initiatives in order to facilitate desired or favourable outcomes on the dependent variables (Asongu & Odhiambo, 2019d).

The underlying conception and definition of threshold is consistent with the attendant literaure on critical masses for development outcomes, notably: initial conditions for rewarding ramifications (Cummins, 2000); thresholds for favourable outcomes (Roller & Waverman, 2001; Batuo, 2015; Asongu, le Roux, Tchamyou, 2019) and inflexion points at which environmental degradation negatively affects inclusive development (Asongu, 2018).

In the light of the above, in this section, the net effects in the previous section are decomposed to provide thresholds for complementary policies. These critical masses for complementary policies take into account the narrative of decreasing conditional or interactive effects. Accordingly, thresholds are points where the net effects are zero and from where, further increasing ICT engenders negative net effects. Hence, at the established thresholds, ICT has to be complemented with other policy initiatives to modulate FDI for positive effects on economic growth dynamics. This further implies that at the established thresholds, ICT is a necessary but not a sufficient condition for the modulation of FDI to induce positive outcomes on economic growth dynamics.

4.2.1 Decomposing net effects in the nexuses between FDI, ICT and GDP growth

Let y= net effect on GDP growth, x=average mobile phone penetration and z=average internet penetration

Third specification of Table 1: $y = -0.004x + 0.356$ (when x= 15.806, y=0.292)

Negative Threshold: when y=0, x=89(0.356/0.004) per 100 people

Fourth specification of Table 1: $y = -0.006x + 0.428$ (when x= 15.806, y=0.333)

Negative Threshold: when y=0, x=71.333(0.428/0.006) per 100 people

Sixth specification of Table 1: $y = -0.026z + 0.296$ (when z= 3.053, y=0.216)

Negative Threshold: when y=0, z=11.384(0.296/0.026) per 100 people

Eighth specification of Table 1: $y = -0.040z + 0.354$ (when z= 3.053, y=0.231)

Negative Threshold: when y=0, z=8.850(0.354/0.040) per 100 people

Ninth specification of Table 1: $y = -0.038z + 0.329$ (when z= 3.053, y=0.212)

Negative Threshold: when y=0, z=8.657(0.329/0.038) per 100 people

Tenth specification of Table 1: $y = -0.048z + 0.346$ (when z= 3.053, y=0.199)

Negative Threshold: when y=0, z=7.208(0.346/0.048) per 100 people

In the light of the above, for GDP growth, the established thresholds which range from 71.333 to 89 mobile phone penetration per 100 people and from 7.208 to 11.384 internet penetration per 100 people, are within the statistical ranges of the ICT variables disclosed in the summary statistics.

4.2.2 Decomposing net effects in the nexuses between FDI, ICT and Real GDP

Let y= net effect on real GDP, x=average mobile phone penetration and z=average internet penetration

Second specification of Table 2: $y = -0.001x + 0.037$ (when x= 15.806, y=0.021).

Negative Threshold: when y=0, x=37(0.037/0.001) per 100 people

Sixth specification of Table 2: $y = -0.011z + 0.047$ (when z= 3.053, y=0.013)

Negative Threshold: when y=0, z=4.272(0.047/0.011) per 100 people

Seventh specification of Table 2: $y = -0.007z + 0.031$ (when z= 3.053, y=0.009)

Negative Threshold: when y=0, z=4.428(0.031/0.007) per 100 people

Eighth specification of Table 2: $y = -0.010z + 0.039$ (when z= 3.053, y=0.008)

Negative Threshold: when y=0, z=3.900(0.039/0.010) per 100 people

Ninth specification of Table 2: $y = -0.006z + 0.024$ (when z= 3.053, y=0.005)

Negative Threshold: when y=0, z=4.000(0.024/0.006) per 100 people

In the light of the above, for real GDP, the established threshold of 37 mobile phone penetration per 100 people and thresholds from 3.900 to 4.428 internet penetration per 100 people, are within the statistical ranges of the ICT variables disclosed in the summary statistics.

4.2.3 Decomposing net effects in the nexuses between FDI, ICT and GDP per capita

Let y= net effect on GDP per capita, x=average mobile phone penetration and z=average internet penetration

First specification of Table 3: $y = -0.0009x + 0.037$ (when x= 15.806, y=0.022)

Negative Threshold: when y=0, x=41.111(0.037/0.0009) per 100 people

Second specification of Table 3: $y = -0.0005x + 0.024$ (when x= 15.806, y=0.016)

Negative Threshold: when y=0, x=48(0.024/0.0005) per 100 people

Fourth specification of Table 3: $y = -0.0005x + 0.018$(when x= 15.806, y=0.010)

Negative Threshold: when y=0, x=36(0.018/0.0005) per 100 people

Sixth specification of Table 3: $y = -0.002z + 0.012$(when z= 3.053, y=0.005)

Negative Threshold: when y=0, z=6.000(0.012/0.002) per 100 people

Seventh specification of Table 3: $y = -0.001z + 0.010$(when z= 3.053, y=0.006)

Negative Threshold: when y=0, z=10.000(0.010/0.001) per 100 people

Eighth specification of Table 3: $y = -0.004z + 0.021$(when z= 3.053, y=0.008)

Negative Threshold: when y=0, z=5.250(0.021/0.004) per 100 people

Ninth specification of Table 3: $y = -0.001z + 0.008$(when z= 3.053, y=0.004)

Negative Threshold: when y=0, z=8.000(0.008/0.001) per 100 people

Tenth specification of Table 3: $y = -0.005z + 0.015$(when z= 3.053, y=-0.0002)

Negative Threshold: when y=0, z=3.000(0.015/0.005) per 100 people

In the light of the above, for GDP per capita, the established thresholds which range from 36 to 48 mobile phone penetration per 100 people and from 3 to 10 internet penetration per 100 people, are within the statistical ranges of the ICT variables disclosed in the summary statistics.

5. Concluding implications and future research directions

The research assesses how information and communication technology (ICT) modulates the effect of foreign direct investment (FDI) on economic growth dynamics in 25 countries in Sub-Saharan Africa for the period 1980-2014. The employed economic growth dynamics areGross Domestic Product (GDP) growth, real GDP and GDP per capita while ICT is measured by mobile phone penetration and internet penetration. The empirical evidence is based on the Generalised Method of Moments. The study finds that both internet penetration and mobile phone penetration overwhelmingly modulate FDI to induce overall positive net effects on all three economic growth dynamics. Moreover, the positive net effects are consistently more apparent in internet-centric regressions compared to "mobile phone"-oriented specifications.

In the light of negative interactive effects, net effects are decomposed to provide thresholds at which ICT policy variables should be complemented with other policy initiatives in order to engender favorable outcomes on economic growth dynamics. Accordingly, thresholds are points where the net effects are zero and from where, further increasing ICT engenders negative net effects. Hence, at the established thresholds, ICT has to be complemented with other policy initiatives to modulate FDI for positive effects on economic growth dynamics. (i) For GDP growth, the established thresholds range from 71.333 to 89 mobile phone penetration per 100 people and from 7.208 to 11.384 internet penetration per 100 people; (ii) with regard to real GDP, the established threshold is 37 mobile phone penetration per 100 people and from 3.900 to 4.428 internet penetration per 100 people and (iii) for GDP per capita, the established thresholds range from 36 to 48 mobile phone penetration per 100 people and from 3 to 10 internet penetration per 100 people. The established thresholds make economic sense and can be leveraged by policy because they are within the statistical ranges of the ICT variables disclosed in the summary statistics. This further implies that, at the thresholds, ICT is a necessary but not a sufficient condition for the modulation of FDI to induce positive outcomes on economic growth dynamics. Some of the documented complementary policies that facilitate the absorptive capacity of FDI entail, the improvement of human resources, enhanced financial access and institutional development (Nguyen, Duysters, Patterson & Sander, 2009). Other practical and theoretical implications are discussed in what follows.

The first main policy worth mentioning is that ICT is relevant in improving the absorptive capacity of foreign investment and by extension the relevance of foreign investment in driving economic prosperity. Hence, policy makers should consolidate policies that enhance the penetration of ICT in the sub-region. Such policies should entail, *inter alia*: low pricing, universal access schemes and improvements in the infrastructure that are relevant to the smooth functioning of ICT. However, owing to decreasing modulating effects, such policies should be complemented with other initiatives that favor the absorptive capacity of FDI, *inter alia*, improvements in governance (political, economic and institutional) standards, financial development and better human resources.

The second implication pertains to identified elements in the conditioning information set. Accordingly, the study has also established that while inflation negatively affects economic growth dynamics, population, inclusive education and government expenditure engender an opposite effect. It follows that because ICT, FDI and economic growth dynamics do not interact in isolation in the real world, other economic conditions are worthwhile for the favourable relevance of ICT in the positive FDI-growth nexus. From a conceptual standpoint, it is imperative to clarify that a GMM regression with a conditioning information set is consistent with a conditional modelling exercise. Hence, the findings are also interpreted with regard to adopted elements in the conditioning information set. Thus, in order to effectively leverage on the appealing influence of ICT in the FDI-growth nexus, policy makers should also endeavour to implement policies that are favourable to economic and human developments, *inter alia*: stable and low inflation, population growth, government expenditure on productive sectors and inclusive education.

Third, given that this research builds on theoretical elements developed in section 2, it is also worthwhile to articulate the relevance of the findings to the theoretical literature. The choice of three sets of economic growth indicators is meant to also assess conflicting theoretical perspectives in the literature. Accordingly, the Neo-classical Growth Model of Solow (1956) maintains that the effect of FDI on the output growth rate is impeded by diminishing returns in physical capital. Hence, according to the theoretical narrative, FDI can exclusively affect the level of impact on per capita output, but is unlikely to affect the growth rate of output, especially in the long run. Conversely, the New Theory of Economic Growth postulates that FDI affects both output per capita and its growth rate (Hassan, 2005). Our findings are consistent with both theories. On the one hand, they are in line with the New Theory of Economic Growth because FDI positively affects all three growth dynamics when modulated with ICT in the sampled host countries. On the other hand, the results are also broadly in accordance with the Neo-classical Growth Model of Solow because of consistent negative marginal effects from the interaction between FDI and ICT dynamics.

Future studies can improve the established findings by reconsidering the problem statement within country-specific frameworks. This recommendation builds on a caveat in the GMM estimation strategy which, does not involve country-specific effects because these effects are a cause of endogeneity owing to their correlation with the lagged outcome variables. It is also worthwhile to note that smartphones can be better than mobile phones in facilitating the absorptive capacity of FDI for economic growth because smartphones are designed to be connected to the internet. Owing to data availability constraints, only mobile phones are used in this study. Hence, smartphones should be considered in future studies.

Appendices

Appendix 1: Definitions and sources of variables

Variables	Signs	Definitions of variables (Measurements)	Sources
Growth 1	GDPgrowth	GDP growth (annual %)	WDI
Growth 2	lnRGDP	Logarithm of Real GDP: Output-side real GDP at chained PPPs (in mil. 2011US$)	WDI
Growth 3	lnGDPpc	Logarithm of GDP per capita	WDI
Foreign Direct Investment	FDI	Foreign Direct Investment Inflows(% of GDP)	UNCTAD
Mobile Phone Penetration	Mobile phones	Mobile phone subscriptions (per 100 people)	WDI
Internet Penetration	Internet	Internet subscriptions (per 100 people)	WDI
Population	Population	Logarithm of Population (in millions)	WDI
Inflation	Inflation	Consumer Price Index (annual %)	WDI
Education	Education	SEPSGPI: School enrollment, primary and secondary (gross), gender parity index (GPI)	WDI
Government Expenditure	Gov't Expenditure	Governments final consumption expenditure (% of GDP)	WDI

WDI: World Development Indicators. GDP: Gross Domestic Product.UNCTAD: United Nations Conference on Trade and Development.

Appendix 2: Summary statistics

	Mean	SD	Minimum	Maximum	Observations
Gross Domestic Product(GDP) growth	3.569	2.953	-6.154	10.109	124
Real GDP (log)	9.527	1.104	7.670	13.638	120
GDP per capita (log)	7.657	0.838	6.255	9.702	119
Foreign Direct Investment	1.903	2.795	-3.440	22.118	124
Mobile Phone Penetration	15.806	29.054	0.000	142.980	120
Internet Penetration	3.053	6.020	0.000	31.922	98
Population	2.515	0.818	-0.242	4.165	125
Inflation	42.868	347.967	-3.601	3820.096	120
Education	0.854	0.177	0.465	1.341	107
Government Expenditure	16.066	5.358	6.085	36.155	122

S.D: Standard Deviation.

Appendix 3: Correlation matrix (uniform sample size :124)

Growth Dynamics				ICT		Control variables				
GDPg	lnRGDP	lnGDPpc	FDI	Mobile	Internet	Pop	Inflation	Education	Gov. Ex	
1.000	0.177	0.072	0.379	0.166	0.073	0.169	-0.388	0.312	0.215	GDPg
	1.000	0.194	0.044	0.291	0.443	0.764	0.030	0.239	-0.324	lnRGDP
		1.000	-0.020	0.351	0.404	-0.127	-0.039	0.542	0.158	lnGDPpc
			1.000	0.292	0.124	0.035	-0.064	0.180	0.131	FDI
				1.000	0.725	0.062	-0.063	0.364	0.101	Mobile
					1.000	0.290	0.054	0.319	-0.083	Internet
						1.000	-0.009	0.012	-0.369	Pop
							1.000	0.073	-0.045	Inflation
								1.000	0.372	Education
									1.000	Gov. Ex

GDPg: Growth growth. lnRGDP: Logarithm of Real GDP. lnGDPpc: Logarithm of GDP per capita. FDI: Foreign Direct Investment. Mobile: Mobile Phone penetration. Internet: Internet penetration. Pop: population. Gov. Ex: Government Expenditure.

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