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## Information Technology and Gender Economic Inclusion in Sub-Saharan Africa

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# Information Technology and Gender Economic Inclusion in Sub-Saharan Africa

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## Abstract

This study investigates how ICT affects gender economic inclusion via gender parity education channels. We examine the issue using data from 49 countries in sub-Saharan Africa for the period 2004-2018 divided into: (i) 42 countries for the period 2004-2014; and (ii) 49 countries for the period 2008-2018. Given the overwhelming evidence of negative net effects in the first sample, an extended analysis is used to establish thresholds of ICT penetration that nullify the established net negative effects. We found that in order to enhance female labor force participation, the following ICT thresholds are worthwhile for the secondary education channel: 165 mobile phone penetration per 100 people, 21.471 internet penetration per 100 people and 3.475 fixed broadband subscriptions per 100 people. For the same outcome of inducing a positive effect on female labor force participation, a 31.966 internet penetration per 100 people threshold, is required for the mechanism of tertiary school education. These computed thresholds have economic meaning and policy relevance because they are within the established ICT policy ranges. In the second sample, a mobile phone penetration threshold of 122.20 per 100 people is needed for the tertiary education channel to positively affect female labor force participation.

*Keywords*: Africa; ICT; Gender; Inclusive development
*JEL Classification*: G20; I10; I32; O40; O55

## 1. Introduction

Although governments, non-governmental organizations (NGOs) and regulators across the globe generally now recognize that fostering gender equality is one of the most effective mechanisms for promoting economic development and poverty alleviation (United Nations, 2015, 2018; Whiting, 2019), yet the loss of human capital attributed to gender inequality in Africa is estimated at 2.5 trillion USD by a recent World Bank report (Nkurunziza, 2018; World Bank, 2018). According to the World Bank, in poor countries women are largely employed in the informal economic sector with self-employment as the most common work type especially within the agriculture area. The report recommends that programs and policies should be put in place in order to promote access of women to employment opportunities in the formal economic sector through, *inter alia*, the enhancement of financial services, education and access to basic infrastructure and other services[1] (Nkurunziza, 2018; World Bank, 2018). Whiting (2019) has documented seven outrageous and surprising statistics about gender-based inequality[2].

Given the persuasive need to achieve the goals outlined in the Sustainable Development Goals (SDGs), information and communication technology (ICT) has emerged as an effective mechanism for achieving such objectives (World Bank, 2016; Sugiawan & Managi, 2019). Despite the pivotal role and effects of new technology adoption and scaling-up (Amankwah-Amoah, 2019; Amankwah-Amoah & Hinson, 2019; You et al., 2019), there remains limited understanding on how best ICT can be harnessed to help deliver gender inclusion.

Against this background, this study seeks to fill the void in the current literature by assessing how ICT modulates the effect of education channels on gender inclusion in the formal economic sector of sub-Saharan Africa (SSA). Our study is further motivated by the importance of gender equality in achieving SDGs in the post-2015 development agenda, as well as the relevance of ICT in contemporary inclusive development outcomes. These

[1] The terms “gender inclusion”, “gender economic participation”, “female labour force participation”, “female employment”, “female economic participation” and “gender economic inclusion” are used interchangeably throughout the study. Inclusive education”, “gender parity education” and “gender inclusive education” are also used interchangeably throughout the study.

[2]The statistics are: (i) “*women are 47% more likely to suffer severe injuries in car crashes because safety features are designed for men*”; (ii) “*33,000 girls become child brides every day*”; (iii) “*women in rural parts of Africa spend 40 billion hours a year collecting water*”; (iv)“*it will take 108 years to close the gender gap”; (v) “only 6 countries give women equal legal work rights as men*”; (vi) “*22% of AI professionals are women - and it could be down to lack of confidence*” and (vii) “*for every female film character, there are 2.24 men*”.

motivational factors are expanded in the same chronology as they are highlighted. First, gender equality is fundamental in the achievement of SDGs not only because it advances women's rights but also because equal economic opportunities for girls and women have positive economic and human welfare ramifications (Robinson, 2015). Moreover, beyond being a human right, gender equality is paramount because no economy can sustainably develop (politically, economically and socially) when about half of its population is being marginalized and/or consigned to the peripheral economy. This concern is even more apparent in SSA because close to half of countries in the sub-region failed to attain the extreme poverty target of the Millennium Development Goals (MDGs) (Tchamyou, 2020a, 2020b; see also Durugbo & Amankwah-Amoah, 2019). The failure to attain this MDG target is partly traceable to inequality (i.e. gender exclusion) in the sub-region, because the response of extreme poverty to economic growth decreases with growing levels of inequality (Asongu & Kodila-Tedika, 2017; Asongu & le Roux, 2019)[3]. It should be recalled that the sub-region has been experiencing more than two decades of resurgence in economic growth (Tchamyou, 2019a, 2019b; Asongu & Odhiambo, 2019a). Moreover, Bicaba, Brixiova and Ncube (2017) have concluded that unless the concern of inequality is addressed, it is not likely for SSA to reduce extreme poverty to a threshold of below 3% by 2030. In contemporary development literature, a policy channel by which inequality can be reduced is ICT.

As clarified in the second sub-section of Section 2, this study contributes to the extant female economic participation literature by: (i) engaging mechanisms through which ICT influences gender inclusion and (ii) establishing actionable ICT policy thresholds that are relevant for the engaged mechanisms to promote gender economic inclusion (GEI). The rest of the study is structured as follows. Section 2 presents the theoretical underpinnings motivating the nexuses between ICT, education and inclusive development within the framework of gender formal economic participation. The data and methodology are discussed in section 3 while section 4 presents and discusses the empirical results. Section 5 concludes with implications and future research directions.

[3] Accordingly, apart from inequality, a multitude of factors can elucidate the low economic participation and inequality in the distribution of the fruits of economic prosperity. In line with Fosu (2013), some of the conditions for the unfavorable economic performance of African countries are: "administered redistribution", "state breakdown", "state controls", and "suboptimal inter temporal resource allocation".

## 2. Theoretical and empirical literature

### 2.1 Theoretical highlights

This section discusses the theoretical underpinnings of the nexuses being assessed. The theoretical underpinnings consolidating the relationship between information technology, education and gender inclusion in the formal economic sector is in line with theoretical foundations of knowledge creation and knowledge diffusion for socio-economic development (Kwan & Chiu, 2015; Warren, Jaafar & Sulaiman, 2016; Barnett, Park & Chung, 2016; Lee & Joshi, 2016; Krishnan, Ahmed & AlSudiary; 2016; Billon, Lera-Lopez & Marco, 2017; Khan & Dongping, 2017; Kang & Kaplan, 2019; Lashitew, van Tulder & Liasse, 2019). It is worth noting that both ICT and education are vital for the creation and diffusion of knowledge which is indispensable for contemporary economic and human developments. According to the associated studies in this theoretical strand, neoclassical models support the view that ICT is particularly crucial for social, economic and political progress in countries at initial stages of industrialization (Abramowitz, 1986; Amankwah-Amoah, 2019; Bernard & Jones, 1996; Asongu, Nwachukwu & Aziz, 2018). Recent inclusive human development literature which has built on these theoretical insights to establish the importance of ICT in inclusive socio-economic outcomes and human wellbeing include Muthinja and Chipeta (2018); Bongomin *et al*. (2018); Uduji and Okolo-Obasi (2018a, 2018b) and Asongu, le Roux, Nwachukwu and Pyke (2019). By facilitating inclusive development via ICT adoption, countries are more likely to foster gender empowerment, bridge the development gap between rural and urban areas that often disproportionately affect women advancement (Asongu & le Roux, 2017) as well as provide opportunities for aspiring entrepreneurs in developing economies (Amankwah-Amoah, 2015, 2016a). Indeed, ICT adoption in tandem with data analytics has potential to lead to improved firm and government decisions (Amankwah-Amoah, 2019; Sheng et al., 2018, 2019).

Both the theoretical and empirical literature are consistent with the perspective that ICT provides opportunities of inclusive development by, *inter alia*: (i) Creating avenues that reduce the need for physical movement of people because they are endowed with avenues of engaging formal economic activities from a distance (Ureta, 2008; Shaikh & Karjaluoto, 2015; Efobi, Tanankem & Asongu, 2018). (ii) Information technology avails modern communication tools with the advantage of having relevant and timely information (that is crucial for the implementation of projects at various stages) fundamentally because users are provided with access to affordable developmental inputs and networks that expand their frontiers of possibility (Smith, Spence & Rashid, 2011). (iii) According to Asongu (2015), the inclusive opportunities from ICT are more apparent among poor factions of the population compared to their wealthier counterparts. These poorer factions include women who are largely consigned to informal economic activities.

### 2.2 Positioning of the paper within the context of extant literature

This study extends Efobi *et al*.'s (2018) work on how ICT enhances female economic participation in SSA from two main perspectives, notably, by: (i) engaging channels via which ICT affects gender inclusion and (ii) providing actionable ICT policy thresholds that are conducive for the engaged channels to enhance GEI.

These critical elements are expanded in the following ways. First, the education channel is considered in the light of observation by Asongu and Nwachukwu (2018) that education interacts with information technology to improve inclusive human development. This research departs from Asongu and Nwachukwu (2018) in that: (i) it focuses on ICT thresholds instead of education thresholds; (ii) uses gender inclusion as an outcome variable instead of the inequality-adjusted human development index; (iii) it employs the generalized method of moments (GMM) as opposed to fixed effects regressions; (iv) it involves all three levels of inclusive education (i.e. primary, secondary and tertiary) instead of focusing exclusively on non-inclusive primary education and (v) it does not articulate comparative emphasize because of specificities in the adopted estimation technique[4]. Beyond the above clarification, it is reasonable to adopt "gender parity education" as a channel by which ICT affects gender inclusion because contemporary educational facilities are tailored to use ICT as an instrument of education.

Second, contrary to Efobi et al. (2018) who have simply provided the signs and magnitudes of the effects of ICT on female economic participation, this research provides actionable policy thresholds that can be used by policy makers to induce positive targets on gender inclusion by means of the gender parity education mechanisms. In essence, this research argues that simply providing linkages between ICT and macroeconomic variables is not enough: studies should go a step further by articulating specific thresholds of policy

[4] Accordingly, a condition for the employment of GMM is that N>T (i.e. number of agents or countries > number of periods in each agent or country). Hence, by decomposing the sample into sub-samples of fundamental comparative characteristics (e.g. income level, legal origins, *inter alia*), N is reduced to decrease the feasibility of the GMM technique.

instruments (i.e. ICT policy thresholds) that are relevant for policy channels (e.g. the education mechanisms) to affect macroeconomic outcomes (e.g. GEI) in the specific direction. Hence, the research question that this study aims to answer is the following: how does ICT affect GEI through gender parity education channels? We also contribute to research on sustainable development (Fujii & Managi, 2019; Sugiawan & Managi, 2019) and GEI (see Swamy, 2014) by offering deep analysis of how ICT affects GEI through gender parity education channels.

### 2.3 Schematic model and hypotheses

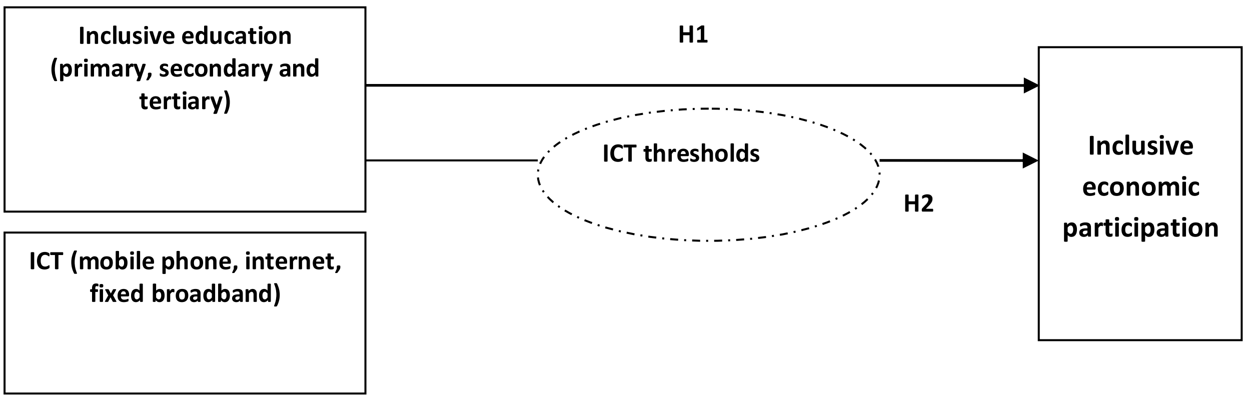
In the light of the motivation covered in the introduction, notably, on the need to assess ICT thresholds that affect the nexus between inclusive education and inclusive economic participation, Figure 1 below illustrates the theoretical framework and testable hypotheses.

*Hypothesis* 1 (H1): there is a relationship between inclusive education and inclusive economic participation.

*Hypothesis* 2 (H2): ICT modulates the relationship between inclusive education and inclusive economic participation.

The analytical framework is based on interactive regressions and ICT thresholds are established from the interactive regressions to articulate minimum levels of ICT penetration that are required for inclusive education to favorably affect inclusive economic participation.

Figure 1. Theoretical framework and hypotheses



## 3. Data and methodology

### 3.1 Data

The focus of this study is on 42 countries in Sub-Saharan Africa with annual data for the period 2004-2014[5]. The adopted sample of countries and periodicity of investigation are constrained by issues of data availability at the time of the study. The data are sourced from three principal sources, namely: (i) a gender economic participation indicator from the International Labor Organization (i.e. female labor force participation). (ii) The gender parity education and ICT variables are obtained from World Development Indicators of the World Bank (i.e. mobile phone penetration, internet penetration, fixed broadband subscriptions, "primary and secondary school enrolment", secondary school enrolment and tertiary school enrolment). A control variable is also obtained from this source (i.e. remittances). (iii) Another control variable (i.e. political stability) comes from World Governance Indicators of the World Bank.

The adopted variables are in accordance with contemporary African knowledge economy, education, information technology and inclusive development literature, notably: the gender inclusion and ICT variables are consistent with Efobi *et al.* (2018) and Asongu and Odhiambo (2018) while education variables are in line with Tchamyou (2017) and Tchamyou (2020a). The choice of the gender inclusive education indicators is also motivated by the availability of gender inclusive education variables at the time of the study.

As for the control variables, they have also been adopted in recent scholarly literature on inclusive development, notably: Meniago and Asongu (2018) and Tchamyou, Erreygers and Cassimon (2019a). As highlighted above, these variables in the conditioning information set are political stability and remittances. The expected signs are discussed in the following passages.

First, political stability is expected to provide an enabling atmosphere for investment and economic growth that are necessary for employment opportunities, which have positive externalities on gender participation in the formal economic sector. Furthermore, in the absence of political strife, there are more avenues for social mobility and employment. Hence, in the empirical analysis, political stability should have a positive impact on gender inclusion.

[5]The 42 countries include: "Angola, Benin, Botswana, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo Democratic Republic, Congo Republic, Côte d'Ivoire, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome & Principe, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda and Zambia".

In other words, political stability should reduce female unemployment and increase female employment and female labor force participation. Second, Meniago and Asongu (2018) and Tchamyou *et al*. (2019a) have established that remittances promote inequality in Africa because most of those migrating abroad are from wealthier segments of African society who can afford the expensive visa proceeding fees, administrative expenses and cost of living abroad. Consequently, when funds are remitted from abroad to African countries, these funds ultimately widen the income gap between the rich and the poor because such funds end-up in richer households. The arguments on income inequality can be extended to gender inequality as posited and empirical verified by Asongu and Odhiambo (2018).

It is also worthwhile to articulate that the limitation of variables in the conditioning information set to two is to avoid concerns about instrument proliferation, which can bias estimated coefficients. When there are many variables in the conditioning information set, such concerns of instrument proliferation could arise even when the instruments are collapsed in the estimation process. The use of limited variables in the conditioning information set is not uncommon in the empirical literature based on the GMM. Accordingly, there are studies that have employed no control variables (Osabuohien & Efobi, 2013; Asongu & Nwachukwu, 2017) as well as studies that have used two control variables (Bruno, De Bonis & Silvestrini, 2012) as apparent in this research. The definitions and sources of variables are provided in Appendix 1, whereas the summary statistics is disclosed in Appendix 2. Appendix 3 provides the correlation matrix.

## 3.2 Methodology

### *3.2.1 GMM Specification*

The adoption of the GMM as empirical strategy is fundamentally motivated by a recent strand of empirical literature on the advantages of and conditions for employing the attendant estimation approach, notably: Asongu and Nwachukwu (2016a); Tchamyou (2020a, 2019b); Asongu and Odhiambo (2019b) and Tchamyou et al. (2019a). Drawing on the underlying literature, there are four principal motivations underpinning the adoption of the empirical approach. (i) A primal condition requires that the number of agents or countries should be higher than the corresponding number of periods in each agent or country. From the data structure, it is apparent that the N>T condition is fulfilled in the light of the fact that the number of cross sections is 42 while the periods within each country or cross section is 11 (i.e. 2004 to 2014). Second, the adopted gender inclusion indicator exhibits persistence because the correlation between its level and first lag values is higher than 0.800 which has been documented to be the rule of thumb for establishing that a variable is persistent (Tchamyou, 2019b). An exploratory analysis to assess this evidence of persistence reveals that the corresponding correlation is 0.999. Third, in the light of the panel data structure of this study, the estimation approach is tailored to account for cross-country variations in the dataset. Fourth, the research accounts for the concern of endogeneity from two major perspectives, notably, by: (i) controlling for reverse causality through a process of instrumentation and (ii) taking on board time invariant variables in order to control for the unobserved heterogeneity. It is important to note that there are four main causes of endogeneity: variable omission bias, data collection errors, reverse causality and failure to account for the unobserved heterogeneity.

In this research, the adopted GMM strategy is the extension by Roodman (2009a, 2009b) of Arellano and Bover (1995) which has been established to limit the proliferation of instruments, control for endogeneity and account for cross sectional dependence (Asongu & Nwachukwu, 2016b; Boateng *et al.*, 2018; Tchamyou, Asongu & Odhiambo, 2019b).

The following equations in level (1) and first difference (2) summarize the standard *system* GMM estimation procedure.

$$FE_{i,t} = \sigma_0 + \sigma_1 FE_{i,t-\tau} + \sigma_2 T_{i,t} + \sigma_3 E_{i,t} + \sigma_4 TE_{i,t} + \sum_{h=1}^{2} \delta_j W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

$$FE_{i,t} - FE_{i,t-\tau} = \sigma_1 (FE_{i,t-\tau} - FE_{i,t-2\tau}) + \sigma_2 (T_{i,t} - T_{i,t-\tau}) + \sigma_3 (E_{i,t} - E_{i,t-\tau}) + \sigma_4 (TE_{i,t} - TE_{i,t-\tau}) + \sum_{h=1}^{2} \delta_j (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \quad (2)$$

where, $FE_{i,t}$ is the female economic participation indicator (i.e. female labor force participation) of country $i$ in period $t$, $\sigma_0$ is a constant, $T$ entails ICT (mobile phone penetration, internet penetration and broadband subscriptions ), $E$ denotes education ("primary and secondary school enrolment", secondary school enrolment and tertiary school enrolment), $TE$ denotes interactions between ICT and education indicators ("mobile phone penetration" × "primary and secondary school enrolment"; "mobile phone penetration" × "secondary school enrolment"; "mobile phone penetration"× "tertiary school enrolment"; "internet penetration" × "primary and secondary school enrolment"; "internet penetration" × "secondary school enrolment"; "internet penetration"× "tertiary school enrolment"; "fixed broadband subscriptions" × "primary and secondary school enrolment"; "fixed broadband subscriptions” × “secondary school enrolment” and “fixed broadband subscriptions”× “tertiary school enrolment”), $W$ is the vector of control variables (political stability and remittances), $\tau$ represents the lagged coefficient which is one within the framework of this study because a year lag is enough to capture past information, $\xi_t$ is the time-specific constant, $\eta_i$ is the country-specific effect and $\varepsilon_{i,t}$ the error term.

### *3.2.2 Identification and exclusion restrictions*

The identification and exclusion restrictions properties in the study are consistent with contemporary literature which has employed the adopted GMM empirical approach (e.g. Asongu & Nwachukwu, 2016c; Tchamyou & Asongu, 2017; Boateng *et al*., 2018; Tchamyou et al., 2019b). The identification process is tailored such that “years” are acknowledged as strictly exogenous indicators whereas the ICT, education and elements of the conditioning information set, are defined as “endogenous explaining” or predetermined variables. Roodman (2009b) supports this identification strategy by arguing that years are likely to be strictly exogenous because it is not feasible for years to become endogenous after a first difference[6].

In the light of the identification process above and the corresponding exclusion restrictions narrative, the assumption of exclusion restriction is assessed with a Difference in Hansen Test (DHT) for the exogeneity of instruments. The null hypothesis of this test is the position that the instruments are strictly exogenous in the perspective that “years” affect gender inclusion (i.e. the outcome variable) exclusively through the endogenous explaining or predetermined variables. Hence, for the assumption of exclusion restriction underpinning the study to be valid, the null hypothesis of the DHT should not be rejected. Such failure to reject the null hypothesis is consistent with less contemporary instrumental variables (IV) methodologies in which, a rejection of the alternative hypothesis of the Sargan/Hansen test reflects a position that the identified strictly exogenous variables do not affect the outcome variable or gender inclusion beyond the proposed predetermined variables (see Beck, Demirgüç-Kunt & Levine, 2003; Asongu & Nwachukwu, 2016d).

[6]Hence, the procedure for treating *ivstyle* (years) is ‘iv (years, eq(diff))’ whereas the *gmmstyle* is employed for predetermined variables.

## 4. Empirical results

### 4.1 Presentation of results

The empirical findings are disclosed in this section in Table 1 which shows the findings on nexuses between ICT, education and formal economic participation. The table is divided into three categories of specifications, pertaining to mobile phone penetration, internet penetration and fixed broadband subscriptions. For each specific ICT dynamic, three sub-specifications pertaining to each of the education variables are apparent, notably: "primary and secondary school enrolment", secondary school enrolment and tertiary school enrolment.

For the estimated models, four information criteria are used to examine the validity of estimated models[7]. In the light of these criteria all specifications are valid. In order to examine the overall effect of ICT in moderating the relevance of education on GEI, net effects are computed in the light of contemporary literature on interactive regressions (Asongu & Odhiambo, 2019c). For example, in the third column of Table 1, the net impact from mobile phone penetration in modulating secondary education to affect female labor force participation is -1.316 ([0.011× 45.330] + [-1.815]). In this computation, the average value of mobile phone penetration is 45.330; the unconditional effect of secondary school education is -1.815, whereas, the conditional impact from the interaction between secondary school education and mobile phone penetration is 0.011.

The following findings can be established from Table 1. First is that ICT (i.e. mobile phone penetration, internet penetration and fixed broadband subscriptions) modulates secondary school education to induce a net negative effect on female labor force participation. Second is that internet penetration modulates tertiary school enrolment for a net negative effect on female labor force participation. Finally, the significant control variables have the expected signs.

[7] "*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 Fisher test for the joint validity of estimated coefficients is also provided*" (Asongu & De Moor, 2017, p.200).

## Table 1: ICT, Education and Female Labor Force Participation (2004-2014)

| | Dependent variable: Female Labor Force Participation(FLFP) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Mobile Phone Penetration** | | | **Internet Penetration** | | | **Fixed BroadBand Subscriptions** | | |
| | PSSE | SSE | TSE | PSSE | SSE | TSE | PSSE | SSE | TSE |
| FLFP(-1) | **0.972*** ** | **0.964*** ** | **0.959*** ** | **0.970*** ** | **0.966*** ** | **0.958*** ** | **0.974*** ** | **0.973*** ** | **0.964*** ** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** |
| Mobile Phone(Mob) | -0.010 | **-0.020*** ** | -0.005 | --- | --- | --- | --- | --- | --- |
| | (0.409) | **(0.003)** | (0.308) | | | | | | |
| Internet | --- | --- | --- | -0.077 | **-0.108** ** | **-0.043*** ** | --- | --- | --- |
| | | | | (0.238) | **(0.031)** | **(0.022)** | | | |
| BroadBand | --- | --- | --- | --- | --- | --- | -0.515 | **-0.494** ** | -0.326 |
| | | | | | | | (0.488) | **(0.016)** | (0.121) |
| Primary (PSSE) | **-4.078*** ** | --- | --- | **-4.767*** ** | --- | --- | **-3.812*** ** | --- | --- |
| | **(0.000)** | | | **(0.000)** | | | **(0.000)** | | |
| Secondary (SSE) | --- | **-1.815*** ** | --- | --- | **-1.868*** ** | --- | --- | **-1.366*** ** | --- |
| | | **(0.003)** | | | **(0.000)** | | | **(0.001)** | |
| Tertiary (TSE) | --- | --- | **-0.670** ** | --- | --- | **-0.959*** ** | --- | --- | -0.188 |
| | | | **(0.022)** | | | **(0.000)** | | | (0.585) |
| Mob ×PSSE | 0.004 | --- | --- | --- | --- | --- | --- | --- | --- |
| | (0.679) | | | | | | | | |
| Mob ×SSE | --- | **0.011** ** | --- | --- | --- | --- | --- | --- | --- |
| | | **(0.026)** | | | | | | | |
| Mob ×TSE | --- | --- | 0.003 | --- | --- | --- | --- | --- | --- |
| | | | (0.270) | | | | | | |
| Internet ×PSSE | --- | --- | --- | 0.061 | --- | --- | --- | --- | --- |
| | | | | (0.327) | | | | | |
| Internet×SSE | --- | --- | --- | --- | **0.087** ** | --- | --- | --- | --- |
| | | | | | **(0.041)** | | | | |
| Internet×TSE | --- | --- | --- | --- | --- | **0.030** ** | --- | --- | --- |
| | | | | | | **(0.011)** | | | |
| BroadBand×PSSE | --- | --- | --- | --- | --- | --- | 0.430 | --- | --- |
| | | | | | | | (0.554) | | |
| BroadBand× SSE | --- | --- | --- | --- | --- | --- | --- | **0.393** ** | --- |
| | | | | | | | | **(0.044)** | |
| BroadBand× TSE | --- | --- | --- | --- | --- | --- | --- | --- | 0.208 |
| | | | | | | | | | (0.207) |
| Political Stability | **0.517*** ** | **0.569*** ** | **0.242*** ** | **0.476*** ** | **0.413*** ** | **0.307*** ** | **0.372*** ** | **0.303*** ** | 0.008 |
| | **(0.000)** | **(0.000)** | **(0.003)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.001)** | (0.885) |
| Remittances | **-0.033*** ** | **-0.027*** ** | **-0.015** | **-0.031*** ** | **-0.025*** ** | **-0.027** ** | **-0.015*** ** | **-0.017*** ** | -0.002 |
| | **(0.000)** | **(0.000)** | **(0.203)** | **(0.000)** | **(0.001)** | **(0.013)** | **(0.000)** | **(0.003)** | (0.856) |
| Time Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Net Effects | na | -1.316 | na | na | -1.200 | -0.728 | na | -1.113 | na |
| Thresholds | na | 165 | na | na | 21.471 | 31.966 | na | 3.475 | na |
| AR(1) | (0.063) | (0.058) | (0.071) | (0.071) | (0.057) | (0.071) | (0.070) | (0.057) | **(0.257)** |
| AR(2) | **(0.217)** | **(0.155)** | **(0.214)** | **(0.240)** | **(0.206)** | **(0.204)** | **(0.748)** | **(0.419)** | **(0.245)** |
| Sargan OIR | (0.000) | (0.033) | (0.010) | (0.000) | (0.000) | (0.025) | (0.000) | (0.000) | (0.000) |
| Hansen OIR | **(0.576)** | **(0.766)** | **(0.794)** | **(0.536)** | **(0.499)** | **(0.637)** | **(0.548)** | **(0.573)** | **(0.724)** |
| DHT for instruments | | | | | | | | | |
| (a)Instruments in levels | | | | | | | | | |
| H excluding group | **(0.590)** | **(0.436)** | **(0.406)** | **(0.151)** | **(0.104)** | **(0.362)** | **(0.320)** | **(0.504)** | **(0.105)** |
| Dif(null, H=exogenous) | **(0.489)** | **(0.781)** | **(0.827)** | **(0.750)** | **(0.783)** | **(0.676)** | **(0.602)** | **(0.524)** | **(0.958)** |
| (b) IV (years, eq(diff)) | | | | | | | | | |
| H excluding group | **(0.301)** | **(0.456)** | **(0.302)** | **(0.528)** | **(0.354)** | **(0.204)** | **(0.317)** | **(0.222)** | **(0.257)** |
| Dif(null, H=exogenous) | **(0.707)** | **(0.810)** | **(0.941)** | **(0.462)** | **(0.553)** | **(0.885)** | **(0.655)** | **(0.795)** | **(0.914)** |
| Fisher | **22936.95*** ** | **4433.62*** ** | **10652.38*** ** | **8352.27*** ** | **434275.41*** ** | **23802.67*** ** | **4.21e+06*** ** | **3.92e+06*** ** | **185586.98*** ** |
| Instruments | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Countries | 36 | 35 | 34 | 36 | 35 | 34 | 35 | 34 | 34 |
| Observations | 253 | 235 | 191 | 249 | 230 | 189 | 226 | 208 | 171 |

***,**,*: 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. 45.330, 7.676 and 0.643 are respectively mean values of mobile phone penetration, internet penetration and fixed broadband subscriptions. na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. Constants are included in the regressions. PSSE: School enrolment, primary and secondary (gross), gender parity index (GPI). SSE: School enrolment, secondary (gross), gender parity index (GPI). TSE: School enrolment, tertiary (gross), gender parity index (GPI).

It is also important to clarify the unfavorable effect of education on the outcome variables. Given that these are interactive regressions, the issue of multicollinearity is overlooked because the constituent variables (ICT, education and interaction between education and ICT) are involved in the specification exercise. Hence, because multicollinearity is overlooked, the estimated coefficients should not be interpreted in isolation but rather by means of net effects and thresholds (Brambor, Clark & Golder, 2006). Accordingly, the constituent estimated coefficients are not interpreted in isolation because when two variables exhibiting high multicollinearity are entered into the same specification, only one emerges from the regression output with the expected sign (Beck *et al*., 2003). The significant control variables have the expected signs.

### 4.2 Extension with policy thresholds

While net effects have been established, where such net effects correspond to asymmetric conditional and unconditional effects, thresholds can be computed to establish at what specific ICT critical masses, ICT interacts with education dynamics to either increase or reduce female participation in the formal economic sector. It is worthwhile to emphasize that, when both the conditional and unconditional effects have the same sign, increasing the conditional or interactive effects does not change the sign of the unconditional effects and/or nullify the established net effects. Hence, thresholds are not computed in all regressions where net effects are apparent. The conception and definition of threshold or critical mass is consistent with contemporary development literature based on interactive regressions (Ashraf & Galor, 2013; Batuo, 2015; Asongu, 2018; Asongu, le Roux & Tchamyou, 2019). Therefore, thresholds can be established from interactive regressions in order to provide evidence of non-linear nexuses.

The computed thresholds are apparent in four of the nine specifications in Table 1. In the table, the net negative effect and corresponding positive unconditional or interactive effect is an indication that, increasing the interactions between education and ICT to certain ICT thresholds nullifies the established negative net effect. For instance, in the third column of Table 1, a threshold of 165 (1.815/ 0.011) mobile phone penetration per 100 people dampens the negative net effect. Accordingly, at the established threshold, the net effect of mobile phone penetration moderating secondary school enrolment to induce an effect on female labor force participation is 0 ([0.011 × 165] + [-1.815]). Hence, at 165 mobile phone penetration per 100 people, an increase in mobile phone penetration induces a positive net effect on female economic participation. The three other thresholds in Table 1 are: (i) 21.471 internet penetration per 100 people corresponding to the channel of secondary education; (ii) 31.966 internet penetration per 100 threshold corresponding to the mechanism of tertiary school education and (iii) 3.475 fixed broadband subscriptions per 100 people related to the channel of secondary education. These computed thresholds have economic meaning and policy relevance because they are within the policy ranges (i.e. minimum to maximum) of ICT dynamics disclosed in the summary statistics. Policy makers should therefore enhance ICT penetration above the established thresholds in order for ICT to induce positive net effects on gender economic participation through the engaged education channels.

### 4.3 Robustness checks: more countries with contemporary data

To further examine if the findings above would withstand empirical scrutiny, the sample was extended to 49 countries in SSA with a more updated periodicity of 11 years (i.e. 2008-2018)[8]. This section on robustness check departs from the previous section which focuses on 44 countries in the sub-region for the period 2004-2014 (i.e. 11 years). The motivation for taking on board another sample consisting of 11 years was to limit issues of instrument proliferation when post-estimation diagnostics tests are performed. The corresponding correlation matrix and summary statistics are respectively, provided in Appendix 5 and Appendix 4.

In the light of the above, Table 2 is a replication of Table 1 using a more updated dataset. The same criteria of information used to assess the validity of the specifications in Table 1 are also employed for Table 2 and based on the attendant information criteria; all the specifications in Table 2 are valid. Moreover, net effects and corresponding thresholds can only be computed from third specification of the table. The negative net effect is consistent with those established in the previous table and a mobile phone penetration threshold of 122.20 per 100 people is needed for the tertiary education channel to positively affect female labor force participation.

[8] Of the 54 African countries, the North African countries excluded from the SSA sample are: Algeria, Egypt, Libya, Morocco and Tunisia.

## Table 2: ICT, Education and Female Labor Force Participation (2008-2018)

| | Dependent variable: Female Labor Force Participation(FLFP) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mobile Phone Penetration | | | Internet Penetration | | | Fixed BroadBand Subscriptions | | |
| | PSSE | SSE | TSE | PSSE | SSE | TSE | PSSE | SSE | TSE |
| FLFP(-1) | **0.962****** | **0.909****** | **0.964****** | **0.962****** | **0.903****** | **0.957****** | **0.973****** | **0.928****** | **0.974****** |
| | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** | **(0.000)** |
| Mobile Phone(Mob) | 0.058* | 0.021 | -0.007 | --- | --- | --- | --- | --- | --- |
| | (0.074) | (0.136) | (0.163) | | | | | | |
| Internet | --- | --- | --- | 0.055 | -0.038 | **-0.015*** | --- | --- | --- |
| | | | | (0.406) | (0.219) | **(0.099)** | | | |
| BroadBand | --- | --- | --- | --- | --- | --- | **2.945**** | 0.206 | **0.407****** |
| | | | | | | | **(0.015)** | (0.434) | **(0.000)** |
| Primary (PSSE) | -0.749 | --- | --- | **-3.462*** | --- | --- | -1.071 | --- | --- |
| | (0.764) | | | **(0.057)** | | | (0.493) | | |
| Secondary (SSE) | --- | **-1.870****** | --- | --- | **-2.226**** | --- | --- | **-1.366****** | --- |
| | | **(0.006)** | | | **(0.022)** | | | **(0.007)** | |
| Tertiary (TSE) | --- | --- | **-1.222*** | --- | --- | -0.111 | --- | --- | 0.334 |
| | | | **(0.069)** | | | (0.794) | | | (0.200) |
| Mob ×PSSE | **-0.060*** | --- | --- | --- | --- | --- | --- | --- | --- |
| | **(0.080)** | | | | | | | | |
| Mob ×SSE | --- | **-0.024**** | --- | --- | --- | --- | --- | --- | --- |
| | | **(0.048)** | | | | | | | |
| Mob ×TSE | --- | --- | **0.010**** | --- | --- | --- | --- | --- | --- |
| | | | **(0.023)** | | | | | | |
| Internet ×PSSE | --- | --- | --- | -0.065 | --- | --- | --- | --- | --- |
| | | | | (0.310) | | | | | |
| Internet×SSE | --- | --- | --- | --- | 0.009 | --- | --- | --- | --- |
| | | | | | (0.706) | | | | |
| Internet×TSE | --- | --- | --- | --- | --- | 0.008 | --- | --- | --- |
| | | | | | | (0.120) | | | |
| BroadBand×PSSE | --- | --- | --- | --- | --- | --- | **-2.889**** | --- | --- |
| | | | | | | | **(0.013)** | | |
| BroadBand× SSE | --- | --- | --- | --- | --- | --- | --- | -0.259 | --- |
| | | | | | | | | (0.289) | |
| BroadBand× TSE | --- | --- | --- | --- | --- | --- | --- | --- | **-0.323****** |
| | | | | | | | | | **(0.000)** |
| Political Stability | **0.696****** | 0.278 | -0.134 | **0.597****** | **0.548**** | **-0.171**** | **0.531****** | 0.106 | 0.005 |
| | **(0.000)** | (0.106) | (0.159) | **(0.008)** | **(0.032)** | **(0.032)** | **(0.008)** | (0.471) | (0.947) |
| Remittances | **-0.045*** | -0.052 | -0.026 | -0.042 | **-0.077**** | -0.011 | 0.008 | -0.018 | 0.054*** |
| | **(0.086)** | (0.147) | (0.468) | (0.202) | **(0.014)** | (0.782) | (0.693) | (0.229) | (0.000) |
| Time Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Net Effects | na | nsa | -0.558 | na | na | na | na | na | na |
| Thresholds | na | nsa | 122.20 | na | na | na | na | na | na |
| AR(1) | **(0.214)** | **(0.214)** | **(0.155)** | **(0.169)** | **(0.164)** | **(0.164)** | **(0.219)** | **(0.218)** | **(0.205)** |
| AR(2) | **(0.443)** | **(0.669)** | **(0.506)** | **(0.377)** | **(0.467)** | **(0.397)** | **(0.130)** | **(0.227)** | **(0.324)** |
| Sargan OIR | (0.035) | **(0.234)** | **(0.110)** | (0.016) | (0.095) | **(0.132)** | **(0.275)** | (0.024) | **(0.736)** |
| Hansen OIR | **(0.439)** | **(0.535)** | **(0.527)** | **(0.527)** | **(0.608)** | **(0.680)** | **(0.750)** | **(0.730)** | **(0.182)** |
| DHT for instruments | | | | | | | | | |
| (a)Instruments in levels | | | | | | | | | |
| H excluding group | **(0.438)** | **(0.195)** | **(0.378)** | **(0.534)** | **(0.401)** | **(0.288)** | **(0.691)** | **(0.245)** | **(0.477)** |
| Dif(null, H=exogenous) | **(0.408)** | **(0.696)** | **(0.539)** | **(0.460)** | **(0.619)** | **(0.773)** | **(0.649)** | **(0.855)** | **(0.138)** |
| (b) IV (years, eq(diff)) | | | | | | | | | |
| H excluding group | **(0.308)** | **(0.606)** | **(0.309)** | **(0.238)** | **(0.525)** | **(0.333)** | **(0.500)** | **(0.591)** | **(0.428)** |
| Dif(null, H=exogenous) | **(0.518)** | **(0.412)** | **(0.635)** | **(0.718)** | **(0.554)** | **(0.804)** | **(0.758)** | **(0.667)** | **(0.135)** |
| Fisher | **132380.56 ***** | **4651.26 ***** | **15819.83 ***** | **146060.64 ***** | **189151.19 ***** | **582834.22 ***** | **1.33e+06 ***** | **80851.95 ***** | **3.11e+06 ***** |
| Instruments | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Countries | 37 | 37 | 39 | 37 | 37 | 39 | 36 | 36 | 39 |
| Observations | 228 | 233 | 227 | 214 | 219 | 219 | 216 | 221 | 219 |

***,**,*: 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. 66.389, 13.027 and 0.925 are respectively mean values of mobile phone penetration, internet penetration and fixed broadband subscriptions. na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. nsa: not specifically applicable because both the unconditional and conditional effects have the same signs. Constants are included in the regressions. PSSE: School enrolment, primary and secondary (gross), gender parity index (GPI). SSE: School enrolment, secondary (gross), gender parity index (GPI). TSE: School enrolment, tertiary (gross), gender parity index (GPI).

## 5. Conclusion, implications, limitations and future research directions

This paper attempted to fill some of the gaps in our understanding on the linkages between information technology and GEI by investigating how ICT affects GEI through gender parity education channels. This study focuses on 49 countries in sub-Saharan Africa for the period 2004-2018 divided into: (i) 42 countries for the period 2004-2014; and (ii) 49 countries for the period 2008-2018. The following main findings are established. First of all, we found that ICT (i.e. mobile phone penetration, internet penetration and fixed broadband subscriptions) modulates secondary school education to induce a net negative effect on female labor force participation while internet penetration moderates tertiary school enrolment for a net negative effect on female labor force participation.

Given the overwhelming evidence of negative net effects in the first sample (i.e. 42 countries for the period 2004-2014), an extended analysis is used to establish thresholds of ICT penetration that nullify the established net negative effects. From the analysis, in order to enhance female labor force participation, the following ICT thresholds are worthwhile for the secondary education channel: 165 mobile phone penetration per 100 people, 21.471 internet penetration per 100 people and 3.475 fixed broadband subscriptions per 100 people. For the same outcome of having a positive effect on female labor force participation, a 31.966 internet penetration per 100 people threshold corresponds to the mechanism of tertiary school education. In the second sample, (i.e. 49 countries for the period 2008-2018), a mobile phone penetration threshold of 122.20 per 100 people is needed for the tertiary education channel to positively affect female labor force participation. These computed thresholds have economic meaning and policy relevance because they are within the policy ranges (i.e. minimum to maximum) of ICT dynamics disclosed in the summary statistics. Taken together, our findings advance empirical research on both sustainable development and GEI.

The study contributes to the existing literature on information technology and inclusive human development (Asongu &Nwachukwu, 2018; Efobi et al., 2018) by extending our understanding of the mechanisms through which ICT influences GEI via gender parity education channels.

### Practical implications

From a practical standpoint, in keeping with the motives of the SDGs, these results imply a need for governments to devote additional resources and policy attention towards gender inclusion activities. Greater financial investments in general education and technology awareness as well as the scaling-up of associated programs are more likely to create conditions that help bridge the gender economic participation gap. In addition, the preceding analysis also implies that policy makers should enhance ICT penetration above the established thresholds in order for ICT to induce positive net effects on gender economic participation through the relevant gender parity education channels. When the findings are further compared and contrasted, it is apparent that inclusive secondary education is the most important channel through which female economic participation is promoted by ICT. This is broadly in accordance with the literature supporting the view that extremely high levels of education are less strongly associated with socio-economic development when countries are at their initial levels of industrialization (Asiedu, 2014; Tchamyou, 2020a).

**Caveats and future research directions**

The established findings should be understood in the light of its main limitations. First of all, in using the GMM application, country-specific effects have not been fully accounted for in order to avoid concerns of endogeneity that originate from the association between the lagged outcome variable and country-specific effects. Hence, such country-specific effects are eliminated to limit concerns of endogeneity.

Second, given the focus on 49 countries in a continent with unique cultures and traditions (see Amankwah-Amoah, 2016b, 2018), future research should seek to broaden the scope of the study by incorporating other developing nations. Future studies could also focus on other mechanisms by which ICT can enhance GEI. Moreover, assessing other policy instruments that can be relevant in moderating gender parity education for more involvement of women in the formal economic sector is worthwhile. It would also be interesting for future research to examine differences in national policies aimed at scaling up technology for women. In spite of the limitations, our study advances our understanding of literature on harnessing technology as means to achieving some of the SDGs.

Another caveat to this study could be the concern of whether the education channel is sufficient enough to capture the non-linearity between ICT and female economic participation. It is important to note that the non-linearity between ICT and female economic participation can be contingent on many factors. While the education channel has been explored in this research, other channels could be explored in future studies. Hence, the fact that education is necessary but not sufficient to capture the non-linearity between ICT and female economic participation is therefore a caveat of this study and hence future studies should explore other complementary mechanisms.

Furthermore, the fact that different ICT dynamics affect various GEI variables through distinct inclusive education channels may motivate the concern of knowing which ICT thresholds will be implemented given the practical difficulty of applying different ICT policies on different education levels. The research therefore acknowledges that the policy ICT thresholds are specific to the engaged gender-inclusive education and gender-inclusive economic participation variables. While it may be difficult to apply different ICT policies for different educational levels from a practical perspective, policy makers can prioritize ICT penetration in certain levels of education contingent on the levels required to stimulate economic inclusion.

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## Appendices

### Appendix 1: Definitions of Variables

| Variables | | Definitions of variables (Measurements) | Sources |
|---|---|---|---|
| Female Economic Participation | FLFpart | Labor force participation rate, female (% of female population ages 15+) (modeled ILO estimate) | ILO |
| Mobile Phones | Mobile | Mobile cellular subscriptions (per 100 people) | WDI |
| Internet | Internet | Internet users (per 100 people) | WDI |
| Fixed Broad Band | BroadB | Fixed broadband subscriptions (per 100 people) | WDI |
| Primary and Secondary School | PSSE | School enrolment, primary and secondary (gross), gender parity index (GPI) | WDI |
| Secondary School | SSE | School enrolment, secondary (gross), gender parity index (GPI) | WDI |
| Tertiary School | TSE | School enrolment, tertiary (gross), gender parity index (GPI) | WDI |
| Political Stability | PolS | "Political stability/no violence (estimate): measured as the perceptions of the likelihood that the government will be destabilised or overthrown by unconstitutional and violent means, including domestic violence and terrorism" | WGI |
| Remittances | Remit | Remittance inflows to GDP (%) | WDI |

WDI: World Bank Development Indicators of the World Bank. FDSD: Financial Development and Structure Database of the World Bank. WGI: World Governance Indicators of the World. ILO: International Labour Organisation.

### Appendix 2: Summary statistics (2004-2014)

| | Mean | SD | Minimum | Maximum | Obs |
|---|---|---|---|---|---|
| Female Labor Force participation | 62.515 | 15.685 | 30.00 | 88.80 | 451 |
| Mobile Phone Penetration | 45.330 | 37.282 | 0.209 | 171.375 | 558 |
| Internet Penetration | 7.676 | 10.153 | 0.031 | 54.26 | 453 |
| Fixed Broad Band | 0.643 | 1.969 | 0.000 | 14.569 | 369 |
| Primary& Secondary School Enrolment | 0.919 | 0.111 | 0.600 | 1.105 | 307 |
| Secondary School Enrolment | 0.867 | 0.214 | 0.333 | 1.422 | 287 |
| Tertiary School Enrolment | 0.731 | 0.433 | 0.064 | 3.295 | 232 |
| Political Stability | -0.471 | 0.905 | -2.687 | 1.182 | 462 |
| Remittances | 4.313 | 6.817 | 0.00003 | 50.818 | 416 |

S.D: Standard Deviation.

## Appendix 3: Correlation matrix (uniform sample size: 128)

| | ICT Dynamics | | | School Enrolment | | | Control variables | | |
|---|---|---|---|---|---|---|---|---|---|
| FLFpart | Mobile | Internet | BroadB | PSSE | SSE | TSE | PolS | Remit | |
| 1.000 | -0.228 | -0.421 | -0.319 | 0.177 | -0.127 | -0.362 | -0.018 | -0.148 | FLFpart |
| | 1.000 | 0.760 | 0.553 | 0.391 | 0.441 | 0.532 | 0.395 | 0.029 | Mobile |
| | | 1.000 | 0.762 | 0.476 | 0.530 | 0.696 | 0.343 | 0.029 | Internet |
| | | | 1.000 | 0.324 | 0.317 | 0.474 | 0.398 | -0.080 | BroadB |
| | | | | 1.000 | 0.845 | 0.682 | 0.469 | 0.293 | PSSE |
| | | | | | 1.000 | 0.869 | 0.497 | 0.498 | SSE |
| | | | | | | 1.000 | 0.389 | 0.399 | TSE |
| | | | | | | | 1.000 | 0.150 | PolS |
| | | | | | | | | 1000 | Remit |

FLFpart: Female Labour Force participation. Mobile: Mobile Phone Penetration. Internet: Internet Penetration. BroadB: Fixed Broadband Subscriptions. PSSE: Primary and Secondary School Enrollment. SSE: Secondary School Enrolment. TSE: Tertiary School Enrolment. PolS: Political Stability. Remit: Remittances.

## Appendix 4: Summary statistics (2008-2018)

| | Mean | SD | Minimum | Maximum | Obs |
|---|---|---|---|---|---|
| Female Labor Force participation | 60.197 | 15.474 | 20.463 | 87.118 | 528 |
| Mobile Phone Penetration | 66.389 | 37.856 | 2.357 | 174.298 | 530 |
| Internet Penetration | 13.057 | 13.636 | 0.250 | 62.000 | 485 |
| Fixed Broad Band | 0.925 | 2.748 | 0.000 | 21.638 | 492 |
| Primary & Secondary School Enrollment | 0.936 | 0.101 | 0.630 | 1.133 | 298 |
| Secondary School Enrollment | 0.900 | 0.187 | 0.412 | 1.388 | 304 |
| Tertiary School Enrollment | 0.780 | 0.467 | 0.146 | 3.459 | 281 |
| Political Stability | -0.570 | 0.910 | -3.314 | 1.200 | 536 |
| Remittances | 3.856 | 5.041 | 0.0001 | 32.746 | 461 |

S.D: Standard Deviation.

## Appendix 5: Correlation matrix (uniform sample size: 156)

| | | ICT Dynamics | | | School Enrolment | | | Control variables | |
|---|---|---|---|---|---|---|---|---|---|
| | FLFpart | Mobile | Internet | BroadB | PSSE | SSE | TSE | PolS | Remit |
| FLFpart | 1.000 | | | | | | | | |
| Mobile | -0.430 | 1.000 | | | | | | | |
| Internet | -0.513 | 0.830 | 1.000 | | | | | | |
| BroadB | -0.328 | 0.479 | 0.605 | 1.000 | | | | | |
| PSSE | -0.214 | 0.393 | 0.461 | 0.330 | 1.000 | | | | |
| SSE | -0.243 | 0.437 | 0.540 | 0.292 | 0.858 | 1.000 | | | |
| TSE | -0.383 | 0.502 | 0.712 | 0.502 | 0.584 | 0.798 | 1.000 | | |
| PolS | -0.102 | 0.297 | 0.370 | 0.481 | 0.405 | 0.410 | 0.432 | 1.000 | |
| Remit | -0.223 | 0.272 | 0.193 | -0.049 | 0.386 | 0.530 | 0.386 | 0.233 | 1.000 |

FLFpart: Female Labour Force participation. Mobile: Mobile Phone Penetration. Internet: Internet Penetration. BroadB: Fixed Broadband Subscriptions. PSSE: Primary and Seconary School Enrollment. SSE: Secondary School Enrolment. TSE: Tertiary School Enrolment. PolS: Political Stability. Remit: Remittances.