A G D I Working Paper

WP/22/002

Enhancing ICT for Female Economic Participation in Sub-Saharan Africa

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2022 African Governance and Development Institute WP/22/002

Research Department

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January 2022

Abstract

This study investigates how enhancing information and communication technology (ICT) affects female economic participation in sub-Saharan African nations. Three female economic participation indicators are used, namely female labor force participation, female unemployment and female employment rates. The engaged ICT variables are: fixed broadband subscriptions, mobile phone penetration and internet penetration. The Generalized Method of Moments is used for the empirical analysis. The following main findings are established: First, there is a (i) negative net effect in the relevance of fixed broadband subscriptions in female labour force participation and female unemployment and; (ii) positive net effects from the importance of fixed broadband subscriptions on the female employment rate. Secondly, an extended analysis is used to establish thresholds at which the undesirable net negative effect on female labour force participation can be avoided. From the corresponding findings, a fixed broadband subscription rate of 9.187 per 100 people is necessary to completely dampen the established net negative effect. Hence, the established threshold is the critical mass necessary for the enhancement of fixed broadband subscriptions to induce an overall positive net effect on the female labour force participation rate.

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

1. Introduction

The premise of information and communication technology (hence ICT) in the engagement of the female gender for economic development in sub-Saharan Africa (SSA) is inspired by four main factors in the scholarly and policy-making circles, notably, the: (i) policy syndrome of inequality in SSA in the light of Sustainable Development Goals (SDGs)[1]; (ii) low participation of the female gender in formal economic activities in the sub-region; (iii) importance of ICT in addressing the challenge of exclusive development in post-2015 development agenda and (iv) gaps in the literature. The four main points are expanded in the following passages.

First, a fundamental policy concern in the post-2015 sustainable development agenda is to reduce extreme poverty to a level below 3% of the world's population by 2030. Some positions in the attendant literature maintain that the goal of eradicating extreme poverty in Africa can be feasibly achieved if average economic growth rates witnessed by the continent during the period 2000 to 2010 are maintained (Ravallion, 2013; Bicaba, Brixiova & Ncube, 2017). While another strand of the literature posits that extreme poverty levels are likely to decline in the future (Yoshida, Uematsu & Sobrado, 2014; Chandy, Ledlie & Penciakova, 2013), Africa's situation is quite distinct, given that close to half of countries in the SSA region failed to achieve the Millennium Development Goal (MDG) extreme poverty target, in spite that the sub-region experienced more than two decades of resurgence in economic growth (Tchamyou, 2019, 2020; Asongu & Odhiambo, 2019)[2].

Two resulting perspectives from the underlying narrative merit more critical discussion. On the one hand, inequality and extreme poverty have been rising because the fruits of economic growth experienced over the past two decades did not trickle to the poorest factions of the population (Ncube, Anyanwu & Hausken, 2014;Asongu & le Roux, 2019; Asongu & Kodila-Tedika, 2017). On the other hand, assuming that economic growth rates experienced between 2000 and 2010 are maintained through 2030, it may yet be difficult to reduce extreme poverty across SSA unless the policy syndrome of inequality is addressed.

[1]The conception and definition of policy syndrome is complex and multifaceted. For instance, it is considered by Fosu (2013) to represent factors that are detrimental to economic growth, namely: "administered redistribution", "state breakdown", "state controls", and "suboptimal inter temporal resource allocation". Asongu (2017) qualifies the phenomenon as a gap in the knowledge economy between countries. Within the framework of this study, the concept of policy syndrome is in accordance with a recent stream of inclusive development literature which considered a policy syndrome to represent both inequality and growth that is not inclusive (Asongu & Nwachukwu, 2017a; Tchamyou, 2019a, 2019b; Tchamyou, Erreygers & Cassimon, 2019; Asongu & Odhiambo, 2019).

[2]In accordance with Fosu (2015), the nexus between poverty, inequality and economic growth are connected in the view that increasing inequality mitigates the negative responsiveness of poverty to economic growth.

This inference is clearly articulated by Bicaba *et al*. (2017): "*This paper examines its feasibility for Sub-Saharan Africa (SSA), the world's poorest but growing region. It finds that under plausible assumptions, extreme poverty will not be eradicated in SSA by 2030, but it can be reduced to low levels through high growth and income redistribution towards the poor segments of the society*" (p. 93). This verbatim narrative also extends to North Africa (Ncube *et al*., 2014). The underlying concern of extreme poverty is even more apparent when the female gender is excluded from formal economic activities. This is the focus of this study on enhancing ICT for formal female economic participation is consistent with SDG5b, on the empowerment of women through ICT. The empowerment of women in the context of this study is within the framework of promoting female formal economic participation[3].

Second, consistent with Efobi, Tanankem and Asongu (2018), women's participation in the labour market in SSA is very low. The authors maintain that the women in the sub-region are instead accommodated in the informal economic sector through activities such as petty trading, small holding farming and unpaid domestic activities (Ellis, Blackden, Cutura, MacCulloch & Seebens, 2007; Tandon & Wegerif, 2013; FAO, 2011; Wekwete, 2014; Efobi, Tanankem & Asongu, 2018). The scholarly perspective is consistent with the views from the World Bank (2015) and the International Labour Organization (2013) that compared to men, women are more involved in the informal economic sector. Hence, the focus of the present study is on the formal economic participation of women, not economic participation of women. This is essentially because women are already substantially involved in the informal economic sector.

Unfavorable welfare externalities are undoubtedly linked to the low participation of women because, relative to other regions of the world, the sub-region reflects the highest female poverty rate (Hazel, 2010). As recently argued by Efobi *et al*. (2018), policies that are tailored to enhance the participation of the female gender in economic activities can generate a dual externality in terms of reducing poverty, notably by: improving the structural distribution of labour and increasing women's welfare. A mechanism by which gender inequality can be reduced is the ICT channel owing to its high penetration potential in Africa.

Third, the high penetration potential of ICT in Africa has recently motivated a growing stream of literature on the relevance of ICT in socio-economic development outcomes (Tchamyou, 2017; Abor, Amidu & Issahaku, 2018; Minkoua Nzie, Bidogeza & Ngum, 2018;

[3]'Formal female economic participation', 'formal gender economic inclusion', 'gender economic inclusion' and 'female economic participation' and are used interchangeably throughout the study.

Isszhaku, Abu & Nkegbe, 2018; Gosavi, 2018). The underlying motivation is prompted by the fact that compared to other regions of the world in which the penetration of ICT has reached levels of saturation; there is still a great room for its penetration in SSA (Asongu, 2013; Penard, Poussing, Yebe & Ella, 2012; Afutu-Kotey, Gough & Owusu, 2017; Asongu & Boateng, 2018; Efobi *et al*., 2018; Gosavi, 2018; Humbani& Wiese, 2018; Asongu & Odhiambo, 2019a). The study focuses on how enhancing ICT affects female formal economic participation because of an apparent gap in the scholarly literature.

Fourth, to the best of our knowledge, the recent inclusive development literature in Africa has been oriented towards, *inter alia*: linkages between income inequality and foreign investment (Kaulihowa & Adjasi, 2018); nexuses between income, consumption and the wealth of the poorest elements of society in SSA (De Magalhães & Santaeulàlia-Llopis, 2018); connections between inequality and corruption (Sulemana & Kpienbaareh, 2018); gender inclusion (Bayraktar & Fofack, 2018; Mannah-Blankson, 2018;Elu, 2018); the reinvention of development assistance for inclusive and sustainable and human developments (Page & Söderbom, 2015;Jones & Tarp, 2015; Asongu, 2016) and nexuses between education, finance, sharing of information and inequality in Africa (Tchamyou, 2019, 2020; Meniago & Asongu, 2018).

Two main studies are closest to the present inquiry in the literature, notably: Efobi *et al*. (2018) and Asongu and Odhiambo (2019). Efobi *et al*. (2018) have investigated how ICT affects the formal participation of the female gender in 48 countries in Africa using data for the period 1990-2014 and employing the following as estimation strategies: Ordinary Least Squares, Fixed Effects and the Generalized Method of Moments (GMM) regressions. The findings reveal that ICT enhances female economic participation in the following order of increasing relevance in ICT dynamics: mobile phone penetration, internet penetration and fixed broadband subscriptions. Asongu and Odhiambo (2019) have investigated how enhancing ICT affects income inequality in 48 African countries using data for the period 2004-2014. The authors use three inequality indicators, namely, the: Gini coefficient, Atkinson index and Palma ratio. Using the GMM estimation approach, the authors conclude that increasing the penetration of the internet and fixed broadband subscriptions have an overall negative effect on the Atkinson index and the Gini coefficient, while enhancing mobile phone penetration and internet penetration have a negative effect on the Palma ratio.

The positioning of this study is similar to both studies in that three main ICT dynamics are employed, namely: mobile phone penetration, internet penetration and fixed broadband

subscriptions. However, the main distinguishing feature is that Asongu and Odhiambo (2019) is extended within the inclusive development context of Efobi *et al*. (2018). Moreover, in order to increase room for policy implications, this study provides specific policy ICT thresholds there are relevant in promoting female economic participation. Contrary to the two underlying studies, this study argues that policy makers are not sufficiently informed on the dynamics ofnexuses between ICT indicators and inclusive development. In essence, providing specific actionable ICT policy thresholds is more policy-relevant than informing policy makers that ICT affects inclusive development in a negative or positive direction. The positioning of the study also departs from the extant literature on the nexus which has focused on, *inter alia*: availability, accessibility and use of ICT by women in schools (Olatokun, 2007; Dlodlo, 2009), the effect of childcare on the economic empowerment of women (Clark, Kabiru, Laszlo & Muthuri, 2019)and the participation of women in technology to drive economic development (Webb & Buskens, 2014; Powell & Chang, 2016).

The theoretical framework supporting the nexus between ICT and inclusive female participation in the formal economic sector is broadly in accordance with the neoclassical models of knowledge creation and knowledge diffusion for economic development (Kwan & Chiu, 2015). In line with the relevant literature, these neoclassical underpinnings maintain that information technology is a relevant means to socio-economic development in less technically-advanced economies (Abramowitz, 1986; Bernard & Jones, 1996). The theoretical framework broadly accords with the fact that ICT improves the wellbeing of citizens and the socio-economic development of nations (Uduji & Okolo-Obasi, 2018a, 2018b; Bongomin, Ntayi, Munene & Malinga, 2018; Muthinja& Chipeta, 2018). The underlying theoretical underpinning is consistent with the context of this study which is focusing on SDG 5b, especially as it pertains to enhancing the use of ICT to promote the formal economic participation of women.

The expectation that ICT can be enhanced to boost formal female economic participation is in line with facts outlined in support of the relevance of ICT in socio-economic prosperity, *inter alia* ICT: (i) it provides opportunities that limit the physical displacement of citizens because they are endowed with the possibilities of engaging activities from a distance (Ureta, 2008; Shaikh & Karjaluoto, 2015; Efobi *et al*., 2018). (ii) ICT improves the possession of timely and relevant information that is imperative for the economic development of projects because it avails users with affordable access to development inputs, mitigates existing barriers to economic activities and expands possibility

frontiers (Smith, Spence, & Rashid, 2011). (iii) The engaged positive feedbacks on human and economic developments are more apparent among poorer factions of the population, including women who were previously limited from engaging in informal and formal market and economic activities (Asongu, 2015). In a nutshell, the highlighted stream of studies broadly accords with the stance that the rewards from ICT are more apparent in poor households compared to those of their rich counterparts.

Given that the context of this study is partly motivated by SDGs, it is worthwhile to articulate how inclusive human development (i.e. gender inclusion) and the concept of sustainable development are connected. This study borrows from Amavilah, Asongu and Andrés (2017) in positing that for inclusive development to be sustainable, it must be sustained and for sustained development to be sustainable, it should be inclusive. The positioning of the study also steers clear of a contemporary stream of sustainable development literature which has been particularly oriented towards assessing, *inter alia*: nexuses between environmental pollution and inclusive development (Asongu & Odhiambo, 2019b), connections between economic development and the sustainability of the environment within the framework of conflicts (Fisher & Rucki, 2017); linkages between normative beliefs and individual attitudes related to environmental welfare (Wang & Lin, 2017); the relative relevance of environmental sustainability from comparative fundamental characteristics (Asongu, 2018a) and the importance of planning in sustainable outcomes of economic development (Saifulina & Carballo-Penela, 2017).

The rest of the study is organised as follows. The data and methodology are discussed in Section 2, while the empirical findings are covered in section 3. The study concludes in section 4 with implications and future research directions.

2. Data and methodology

2.1 Data

This research focuses on 42 countries in SSA using data of annual periodicity for the period 2004-2014[4]. The adopted periodicity and sampled countries which are contingent on data

[4]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".

availability constraints at the time of the study are consistent with a recent strand of literature which is partly motivating this study (Tchamyou, 2019, 2020; Asongu & Odhiambo, 2018, 2019c). The data is obtained from five main sources. First, the female economic participation indicators come from the International Labor Organization, namely: (i) female labor force participation, (ii) female unemployment rate and(iii) female employment rate. Second, the ICT variables are from World Development Indicators of the World Bank, namely: internet penetration, mobile phone penetration and fixed broadband subscriptions. A control variable is also from the same source (i.e. remittances). Third, another control variable is from World Governance Indicators of the World Bank (i.e. political stability). Third, a third control variable is from the Financial Development and Structure Database (FDSD) of the World Bank (i.e. financial stability).

The three adopted outcome variables on female economic participation are consistent with Efobi et al. (2018) which is partly motivating this research. The adopted ICT indicators are also in line with the attendant information technology literature underlying this study, notably: Efobi et al. (2018) and Asongu and Odhiambo (2019). Three control variables are selected in line with a recent strand of inclusive development literature (Anyanwu, 2011; Tchamyou, 2019, 2020; Meniago & Asongu, 2018). These three control variables are: remittances, financial stability and political stability. Elements of the conditioning information set are restricted to three in a bid to limit concerns about the validity of estimated models. Accordingly, it is in the interest of avoiding instrument proliferation that the variables in the conditioning information set are limited to three. It is also worthwhile to emphasise that such a restriction is not uncommon in scholarly literature because there are studies using the GMM approach with no control variable (Osabuohien & Efobi, 2013) or fewer than three control variables (Bruno, De Bonis & Silvestrini, 2012). In the following passages, we discuss the expected signs of the control variables.

First, political stability is anticipated to have a positive sign on the outcome variable because it is associated with a conducive environment for entrepreneurship, business development, investment and economic growth that are favourable for unemployment reduction and social mobility. Second, consistent with recent literature, remittances promote inequality in Africa (Anyanwu, 2011; Meniago & Asongu, 2018) and, by extension, gender exclusion. According to the attendant literature, the positive relationship between remittances and inequality (i.e. including gender exclusion) is motivated by the fact that a great proportion of those moving abroad is from more fractions of society that are wealthy. Hence, money sent back home

from foreign countries averagely consolidate the wealth of the richer fractions of the population in society.

Third, whereas financial stability mitigates uncertainty in the economic outlook and improves investment avenues and the much needed economic growth, the overall impact on inequality is considerably traceable to the manner in which the fruits of output resulting from financial stability are distributed across the population. It is important to note that as Asongu, Nounamo, Njangang and Tadadjeu (2021) have argued, financial stability, which is needed for gender inclusion, is an economic situation change variable.In the appendices, the definitions and sources of variables are disclosed (i.e. in Appendix 1), a summary statistics is provided in Appendix 2 and the correlation matrix is also disclosed in Appendix 3.

2.2 Methodology

2.2.1 GMM: Specification, identification and exclusion restrictions

Following recent literature (Asongu & Odhiambo, 2018; Tchamyou, 2019, 2020), the empirical strategy considered in this research is the GMM technique. Building on the attendant literature, four main requirements are needed for the estimation strategy to be employed. First, the N>T condition is fulfilled because the research is focusing on 42 countries for the period 2004-2014 (i.e. 11 years). Second, the indicators of female economic participation are persistent because the respective correlations between level and first lag values are higher than 0.800 which is the established rule of thumb for evidence of persistence in an indicator (Tchamyou, 2019). Accordingly, the correlation coefficients for the indicators are: 0.999 for the female labour participation rate; 0.982 for the female unemployment rate and 0.998 for the female employment rate. Third, owing to the panel structure of the data being investigated, the GMM strategy accounts for cross-country differences in the estimation processes. Fourth, the issue of endogeneity is taken on board for at least two main reasons: (i) simultaneity is controlled by means of internal instruments and (ii) variables that are time-invariant are employed to take on board the unobserved heterogeneity.

The GMM approach adopted by this research is an improved version of Arellano and Bover (1995) by Roodman (2009a, 2009b). The strategy has been established to produce estimates that are more efficient, owing to the fact that it accounts for instrument proliferation with an instrument collapsing option. Examples of studies that are consistent with this narrative include Boateng *et al*. (2018).

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

$$FE_{i,t} = \sigma_0 + \sigma_1 FE_{i,t-\tau} + \sigma_2 T_{i,t} + \sigma_3 TT_{i,t} + \sum_{h=1}^{3} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

$$\begin{aligned} FE_{i,t} - FE_{i,t-\tau} = {} & \sigma_1 (FE_{i,t-\tau} - FE_{i,t-2\tau}) + \sigma_2 (T_{i,t} - T_{i,t-\tau}) + \sigma_3 (TT_{i,t} - TT_{i,t-\tau}) \\ & + \sum_{h=1}^{3} \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \end{aligned} \quad (2)$$

where, $FE_{i,t}$ is a female economic participation indicator (i.e. female labour force participation, female unemployment rate and female employment rate) of country i in period t, σ_0 is a constant, T constitute an ICT dynamic (mobile phone penetration or internet penetration or fixed broadband subscriptions), TT reflects interactions that are quadratic between ICT indicators ("internet penetration" × "internet penetration" or "fixed broadband subscriptions"× "fixed broadband subscriptions" or "mobile phone penetration" × "mobile phone penetration"), the vector of elements in the conditioning information set is captured by W (entailing political stability, financial stability and remittances), τ is an auto-regression coefficient of one because for this study, a one year lag is appropriate to capture information of the past, the time-specific constant is denoted by ξ_t, the country-specific effect is captured by η_i while the error term $\varepsilon_{i,t}$. It is important to note that, one lag is enough to capture past information because two lags do not reflect persistence. Hence, persistence in the outcome variable which is required for the use of GMM is captured by one lag, not by two lags.

2.2.2Identification and exclusion restrictions

Borrowing from recent literature, this research devotes space to clarifying identification and exclusion restriction properties that are indispensable for a robust GMM specification (Boateng *et al*., 2018; Tchamyou *et al*., 2019; Tchamyou & Asongu, 2017). In the light of the attendant literature, "years" are acknowledged to be strictly exogenous variables, whereas the ICT mechanisms and other variables in the conditioning information set are acknowledged as predetermined or endogenous explaining variables. The strategy of identification is partly motivated by Roodman (2009b), who has argued that it is not likely for "years" to be endogenous after a first difference[5].

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

The information criterion used by this research to assess the validity of the exclusion restrictions assumption is the Difference in Hansen Test (DHT). According to this test, the null hypothesis is the stance that; the strictly exogenous variables affect indicators of economic participation exclusively via the identified endogenous explaining mechanisms. This approach to validating exclusion restrictions conforms with the mainstream instrumental variable (IV) strategy in which when the null hypothesis is rejected, it implies that the considered instruments elicit the dependent variable beyond the exogenousconstituents of the predetermined variables (see Beck, Demirgüç-Kunt & Levine, 2003).

3. Empirical results

3.1 Presentation of results

In this section, Table 1 presents results on the nexuses between ICT dynamics and the female labour participation rate, Table 2 focuses on the linkages between ICT and the female unemployment rate, while Table 3 is concerned with connections between information technology and female employment rate. Each table is divided into three main categories which respectively represent each ICT dynamic. In each ICT category, two specifications are apparent: one without a conditioning information set (or control variables) and the other with a conditioning information set. For all specifications in the tables, four information criteria are employed to assess the validity of the GMM model with forward orthogonal deviations[6]. Based on these criteria, the models are overwhelmingly valid, with the exception of the fourth models of Tables 1-2, in which the null hypothesis of the Hansen test is rejected. It is important to articulate that the Hansen test of preferred to the Sargan test because it is robust, though it is also weakened by the proliferation of instruments. Accordingly, the Sargan test is not robust and not weakened by the proliferation of instruments. A strategy with which to address the underlying conflict is to prefer the Hansen test and then avoid the proliferation of instruments by ensuring that the number of instruments is less than the number of cross sections in every specification.

[6] "*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).

In order to examine the overall impact of increasing information technology on female economic participation, net impacts are computed in accordance with recent ICT literature (Asongu & Odhiambo, 2019). For instance, in the last column of Table 1, the net effect on the female labour force participation rate from increasing fixed broadband subscriptions is -0.273(2×[0.016× 0.643] + [-0.294]). In this computation, the mean value of broadband subscriptions is 0.643, the marginal effect of fixed broadband subscriptions is 0.016, the leading 2 is from the quadratic derivation, while the unconditional effect of fixed broadband subscriptions is -0.294.

The following findings can be established from Tables 1-3. There is a: (i) negative net effect in the relevance of fixed broadband subscriptions in female labour force participation; and female unemployment and (ii) positive net effect from the importance of fixed broadband subscriptions on the female employment rate.It is important to articulate that in the last two columns of Table 2, our best estimators are from the specification with the conditioning information set because it is more realistic. Accordingly, in the real world, ICT and female employment do not interact in isolation because their interactions are contingent on other socio-economic and institutional indicators which are captured by a conditioning information set (or control variables). Most of the significant control variables have the expected signs.

Table 1: ICT and female labor force participation rate

	Dependent variable: the female labor force participation rate (FLFpart)					
	Mobile phone penetration		**Internet penetration**		**Broadband subscription**	
FLFpart (-1)	**0.936*** **	**0.939*** **	**0.956*** **	**0.960*** **	**0.926*** **	**0.957*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile (Mob)	-0.003	**-0.010** **	---	---	---	---
	(0.666)	**(0.028)**				
Mob×Mob	0.00001	0.00001	---	---	---	---
	(0.465)	(0.341)				
Internet	---	---	-0.027	**-0.031***	---	---
			(0.104)	**(0.097)**		
Internet ×Internet	---	---	0.0003	0.0004	---	---
			(0.181)	(0.127)		
Broadband(BroadB)	---	---	---	---	**-0.519*** **	**-0.294*** **
					(0.000)	**(0.000)**
BroadB×BroadB	---	---	---	----	**0.031*** **	**0.016*** **
					(0.000)	**(0.000)**
Political Stability	---	0.140	---	**0.422*** **	---	0.139
		(0.334)		**(0.003)**		(0.187)
Remittances	---	**-0.052*** **	---	**-0.037** **	---	**-0.055*** **
		(0.000)		**(0.049)**		**(0.000)**
Financial Stability	---	**-0.033*** **	---	-0.003	---	**-0.024** **
		(0.004)		(0.820)		**(0.013)**
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	na	na	na	-0.479	-0.273
AR(1)	(0.077)	(0.035)	(0.080)	(0.059)	(0.131)	(0.067)
AR(2)	**(0.183)**	**(0.337)**	**(0.166)**	**(0.170)**	**(0.194)**	**(0.647)**
Sargan OIR	(0.084)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	**(0.352)**	**(0.388)**	(0.097)	**(0.805)**	**(0.202)**	**(0.544)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	---	**(0.390)**	---	**(0.272)**	---	**(0.278)**
Dif(null, H=exogenous)	**(0.638)**	**(0.375)**	**(0.265)**	**(0.905)**	**(0.632)**	**(0.629)**
(b) IV (years, eq(diff))						
H excluding group	---	(0.082)	---	(0.370)	---	(0.134)
Dif(null, H=exogenous)	---	(0.827)	---	(0.911)	---	(0.888)
Fisher	**342.44*** **	**3720.29*** **	**1729.77*** **	**8119.54*** **	**2214.95*** **	**3.76e+07*** **
Instruments	20	32	20	32	20	32
Countries	41	38	41	38	40	36
Observations	407	322	402	317	341	277

***,**,*: 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 Fisher 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 not all estimated coefficients needed for the computation of net effects are significant. Constants are involved in all regressions.

Table 2: ICT and female unemployment rate

	Dependent variable: the female unemployment rate (FU)					
	Mobile phone penetration		**Internet penetration**		**Broadband subscription**	
FU (-1)	**0.974*** **	**0.938*** **	**0.901*** **	**0.908*** **	**0.925*** **	**0.947*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile (Mob)	-0.003	-0.011	---	---	---	---
	(0.641)	(0.278)				
Mob×Mob	0.00002	**0.00006***	---	---	---	---
	(0.421)	**(0.086)**				
Internet	---	---	0.006	0.023	---	---
			(0.701)	(0.337)		
Internet ×Internet	---	---	0.00002	-0.0003	---	---
			(0.885)	(0.499)		
Broadband(BroadB)	---	---	---	---	**0.189*** **	**-0.129*** **
					(0.000)	**(0.000)**
BroadB×BroadB	---	---	---	---	**-0.013*** **	**0.008*** **
					(0.000)	**(0.000)**
Political Stability	---	0.219	---	**0.651*** **	---	**0.267** **
		(0.370)		**(0.000)**		**(0.034)**
Remittances	---	-0.004	---	0.007	---	0.004
		(0.558)		(0.272)		(0.590)
Financial Stability	---	-0.004	---	0.023	---	0.0008
		(0.811)		(0.116)		(0.944)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	na	na	na	0.172	-0.118
AR(1)	**(0.192)**	**(0.197)**	**(0.198)**	**(0.196)**	**(0.193)**	**(0.192)**
AR(2)	**(0.400)**	**(0.208)**	**(0.407)**	**(0.203)**	**(0.168)**	**(0.133)**
Sargan OIR	(0.018)	**(0.301)**	(0.023)	**(0.308)**	(0.064)	**(0.287)**
Hansen OIR	**(0.139)**	**(0.710)**	(0.028)	**(0.429)**	**(0.346)**	**(0.280)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	---	**(0.153)**	---	**(0.157)**	---	**(0.122)**
Dif(null, H=exogenous)	**(0.477)**	**(0.910)**	**(0.034)**	**(0.616)**	**(0.423)**	**(0.462)**
(b) IV (years, eq(diff))						
H excluding group	---	**(0.520)**	---	**(0.464)**	---	**(0.279)**
Dif(null, H=exogenous)	---	**(0.691)**	---	**(0.379)**	---	**(0.329)**
Fisher	**1411.49*** **	**11962.44*** **	**149.87*** **	**18734.03*** **	**2266.79*** **	**5.92e+07*** **
Instruments	20	32	20	32	20	32
Countries	39	36	39	36	38	34
Observations	387	304	382	299	322	260

***,**,*: 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 Fisher 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 not all estimated coefficients needed for the computation of net effects are significant. Constants are involved in all regressions.

Table 3: ICT and the female employment rate

	Dependent variable: the female employment rate (FE)					
	Mobile phone penetration		**Internet penetration**		**Broadband subscription**	
FE (-1)	**0.994*** **	**0.965*** **	**1.001*** **	**0.968*** **	**0.991*** **	**0.982*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile (Mob)	0.001	0.006	---	---	---	---
	(0.858)	(0.171)				
Mob×Mob	-0.000003	**-0.00004** **	---	---	---	---
	(0.906)	**(0.021)**				
Internet	---	---	0.009	-0.018	---	---
			(0.433)	(0.201)		
Internet ×Internet	---	---	-0.00008	0.0002	---	---
			(0.619)	(0.271)		
Broadband(BroadB)	---	---	---	---	**0.058***	0.014
					(0.055)	(0.713)
BroadB×BroadB	---	---	---	---	**-0.004** **	-0.002
					(0.010)	(0.246)
Political Stability	---	-0.201	---	**-0.318** **	---	-0.042
		(0.121)		**(0.016)**		(0.779)
Remittances	---	**-0.013** **	---	-0.011	---	**-0.019***
		(0.021)		(0.126)		**(0.052)**
Financial Stability	---	-0.001	---	**-0.017***	---	-0.003
		(0.874)		**(0.052)**		(0.724)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	na	na	na	0.052	na
AR(1)	**(0.327)**	**(0.142)**	**(0.148)**	**(0.143)**	**(0.145)**	**(0.138)**
AR(2)	**(0.150)**	**(0.174)**	**(0.321)**	**(0.190)**	**(0.182)**	**(0.129)**
Sargan OIR	**(0.306)**	**(0.389)**	**(0.374)**	**(0.441)**	**(0.382)**	**(0.538)**
Hansen OIR	**(0.640)**	**(0.346)**	**(0.423)**	**(0.259)**	**(0.432)**	**(0.150)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	---	**(0.138)**	---	**(0.215)**	---	**(0.148)**
Dif(null, H=exogenous)	**(0.753)**	**(0.532)**	**(0.439)**	**(0.329)**	**(0.567)**	**(0.230)**
(b) IV (years, eq(diff))						
H excluding group	---	**(0.298)**	---	**(0.085)**	---	**(0.128)**
Dif(null, H=exogenous)	---	**(0.401)**	---	**(0.608)**	---	**(0.287)**
Fisher	**1824.47*** **	**1.20e+06*** **	**13522.66*** **	**16378.21*** **	**8.58e+07*** **	**399708.83*** **
Instruments	20	32	20	32	20	32
Countries	39	36	39	36	38	34
Observations	387	304	382	299	322	260

***,**,*: 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 Fisher 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 not all estimated coefficients needed for the computation of net effects are significant. Constants are involved in all regressions.

3.2 Extension with policy thresholds

While the findings from Table 2 and Table 3 have shown expected net negative and positive effects, respectively, on unemployment and employment, the results from Table 1 are unfavorable because there are net negative effects on the female labour participation rate from the enhancement of fixed broadband subscriptions. Hence, the analysis in Table 1is extended by computing thresholds for favorable effects on the outcome variable. The computation of these thresholds is feasible because the marginal effects are positive. These positive marginal effects further imply that with increasing marginal returns from fixed broadband subscriptions, at specific critical masses of fixed broadband subscriptions, the enhancement of fixed broadband subscriptions completely nullify the negative net effect.

In the light of the above, in the last column of Table 1, the fixed broadband threshold is 9.187 (0.294/ [2×0.016]) subscriptions per 100 people. Hence, at a fixed broadband critical mass of 9.187 subscriptions per 100 people, the net effect on the female labour force participation is 0 (2×[-0.294 × 9.187] + [0.016]). Hence, above a threshold of 9.187, there is a positive net effect on the female labour force participation rate. In the same vein, in the penultimate column of Table 1, the corresponding positive threshold is 8.370 (0.519/ [2×0.031]). Our better positive threshold is 9.187 (compared to 8.370) because it is the specification that involves a conditioning information set. The established threshold makes economic sense and has policy relevance because it is within the policy range (i.e. minimum to maximum values) disclosed in the summary statistics. Hence, the established threshold in this study is the critical mass necessary for the enhancement of fixed broadband subscriptions to induce an overall positive net effect on the female labour force participation rate.

The conception and definition of threshold is consistent with the attendant threshold literature, notably: critical masses upon which increasing environmental pollution can compromise human development that is inclusive (Asongu, 2018b); baseline conditions for favorable impacts (Cummins, 2000); thresholds for desirable impacts (Roller & Waverman, 2001; Batuo, 2015) and information sharing critical masses for the mitigation of market power in the promotion of access to finance (Asongu, le Roux, Tchamyou, 2019c).

3.3 More countries with contemporary data

In order to examine how the findings established in the previous section withstand empirical scrutiny, more countries in SSA with more contemporary data are used, notably: 49 countries

with data for the period 2008-2018[7]. Hence, this section in terms of data structure is distinct from the previous section which uses data for the period 2004-2014 from 42 countries. An 11-year periodicity is chosen as in the previous sample to limit concerns of instrument proliferation. The corresponding findings are presented in Tables 4-6. However, net effects and attendant thresholds cannot be computed from the estimations because at least one estimated coefficient essential for the estimation of such net effects and/or thresholds is not significant. Hence, while these findings are reported to avoid publication bias, our best estimators are from the findings in Tables 1-3. The corresponding summary statistics and corresponding matrix are in Appendix 4 and Appendix 5, respectively.

4. Concluding implications and future research directions

This study investigates how enhancing information and communication technology (ICT) affects female economic participation in sub-Saharan African nations. Three female economic participation indicators are used, namely female labor force participation, female unemployment andfemale employment rates. The engaged ICT variablesare: fixed broadband subscriptions, mobile phone penetration and internet penetration. The Generalized Method of Moments is used for the empirical analysis. The following main findings are established: There is a (i) negative net effect in the relevance of fixed broadband subscriptions in female labour force participation and female unemployment and; (ii) positive net effects from the importance of fixed broadband subscriptions on the female employment rate.

An extended analysis is used to establish at which thresholds the undesirable net negative effect on female labour force participation can be avoided. From the corresponding findings, a fixed broadband subscription rate of 9.187 per 100 people is necessary to completely dampen the established net negative effect. Hence, policy makers in sampled countries should target fixed broadband subscriptions above this threshold in order for fixed broadband subscriptions to have an overall positive effect on the female labour force participation rate. The established threshold makes economic sense and has policy relevance because it is within the policy range (i.e., minimum to maximum values) disclosed in the summary statistics. Hence, the established threshold in this study is the critical mass necessary for the enhancement of fixed broadband subscriptions to induce an overall positive net effect on the female labour force participation rate.

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

The fact that compared mobile phone penetration and internet penetration, the findings are most significant from fixed broadband subscriptions, is consistent with Efobi et al. (2018). The unexpected findings in some of the specifications can be explained by building on the arguments of Carr (2003) that the influence of infrastructural technologies is more apparent at the macroeconomic level compared to the microeconomic level. Some of the insignificant findings could also be attributed tothe fact that the sampled countries are heterogeneous and, by extension, country-specific factors influence the impact of ICT on the outcome variables. Such country-specific effects can be taken on board in future studies, because the GMM technique is not designed to control for country-specific factorsas such country-specific factors arecorrelated with the lagged dependent variables which engender sources of endogeneity. Moreover, distinguishing countries in terms of cultural and religious factors, as suggested, will reduce the number of countries per subsample and, by extension, will result in feasible conditionsfor employing the GMM technique. Future studies can also improve the established findings by assessing other mechanisms by which gender inclusion in the formal economic sector can be enhanced.

Some of the insignificant findings could also be traceable to the fact that the sampled countries are heterogeneous and, by extension, country-specific factors influence the role of ICT on the outcome variables. Such country-specific effects can be taken on board in future studies because the GMM technique is not designed to control for country-specific factors because such country-specific factors are correlated with the lagged dependent variables which engender sources of endogeneity. Moreover, distinguishing countries by cultural and religious factors as suggested will reducethe number of countries per sub-sample and, by extension, feasible conditions for employing the GMM technique. Future studies can also improve the established findings by assessing other mechanisms by which gender inclusion in the formal economic sector can be enhanced.

Table 4: ICT and female labor force participation rate

	Dependent variable: the female labor force participation rate (FLFpart)					
	Mobile phone penetration		**Internet penetration**		**Broadband subscription**	
FLFpart (-1)	**0.918*** **	**0.983*** **	**0.946*** **	**0.977*** **	**0.889*** **	**0.924*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile (Mob)	-0.006	0.007	---	---	---	---
	(0.586)	(0.303)				
Mob×Mob	-3.60e-06	-0.00004	---	---	---	---
	(0.944)	(0.308)				
Internet	---	---	0.010	0.0005	---	---
			(0.561)	(0.962)		
Internet ×Internet	---	---	-0.0003	**-0.0003***	---	---
			(0.117)	**(0.054)**		
Broadband(BroadB)	---	---	---	---	**-0.199*** **	-0.086
					(0.000)	(0.268)
BroadB×BroadB	---	---	---	----	**0.006*** **	0.001
					(0.000)	(0.709)
Political Stability	---	-0.085	---	0.283	---	0.088
		(0.610)		(0.127)		(0.487)
Remittances	---	0.008	---	0.010	---	0.015
		(0.553)		(0.625)		(0.581)
Financial Stability	---	**0.046** **	---	0.021	---	-0.0007
		(0.022)		(0.285)		(0.963)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	na	na	na	-0.187	na
AR(1)	(0.032)	(0.037)	(0.034)	(0.041)	(0.030)	(0.032)
AR(2)	**(0.987)**	**(0.533)**	**(0.674)**	**(0.574)**	**(0.435)**	**(0.572)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)	(0.205)	(0.049)
Hansen OIR	**(0.132)**	**(0.405)**	**(0.178)**	**(0.107)**	**(0.216)**	**(0.812)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	---	**(0.692)**	---	**(0.361)**	---	**(0.376)**
Dif(null, H=exogenous)	**(0.143)**	**(0.304)**	**(0.558)**	**(0.094)**	**(0.268)**	**(0.837)**
(b) IV (years, eq(diff))						
H excluding group	---	(0.027)	---	(0.017)	---	**(0.858)**
Dif(null, H=exogenous)	---	**(0.999)**	---	**(0.680)**	---	**(0.587)**
Fisher	**11651.18*** **	**5517.43*** **	**33117.56*** **	**180120.23*** **	**4.87e+06*** **	**7.71e+06*** **
Instruments	20	31	20	31	20	31
Countries	48	42	48	42	47	41
Observations	472	355	430	354	442	335

***,**,*: 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 Fisher 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, 13.057 and 0.925 are respectively mean values of mobile phone penetration, internet penetration and fixed broadband subscriptions. na: not applicable because not all estimated coefficients needed for the computation of net effects are significant. Constants are involved in all regressions. The positive broadband threshold corresponding to the penultimate column is 16.583.

Table 5: ICT and the female unemployment rate

	Dependent variable: the female unemployment rate (FU)					
	Mobile phone penetration		**Internet penetration**		**Broadband subscription**	
FU (-1)	**0.996*** **	**0.983*** **	**1.005*** **	**0.982*** **	**0.987*** **	**0.969*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile (Mob)	-0.003	0.003	---	---	---	---
	(0.609)	(0.672)				
Mob×Mob	0.00001	4.17e-06	---	---	---	---
	(0.589)	(0.913)				
Internet	---	---	-0.014	-0.010	---	---
			(0.254)	(0.344)		
Internet ×Internet	---	---	0.0001	0.00009	---	---
			(0.264)	(0.493)		
Broadband(BroadB)	---	---	---	---	-0.021	**-0.068***
					(0.112)	**(0.066)**
BroadB×BroadB	---	---	---	---	0.0006	0.001
					(0.358)	(0.196)
Political Stability	---	-0.265	---	-0.141	---	-0.017
		(0.227)		(0.539)		(0.911)
Remittances	---	-0.029	---	**-0.047** **	---	**-0.046** **
		(0.168)		**(0.016)**		**(0.041)**
Financial Stability	---	**0.080*** **	---	**0.082*** **	---	**0.068*** **
		(0.000)		**(0.000)**		**(0.000)**
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	na	na	na	na	na
AR(1)	(0.079)	(0.079)	(0.087)	(0.088)	(0.099)	**(0.110)**
AR(2)	**(0.945)**	**(0.744)**	**(0.850)**	**(0.777)**	**(0.889)**	**(0.754)**
Sargan OIR	(0.002)	**(0.756)**	(0.001)	**(0.235)**	(0.001)	**(0.837)**
Hansen OIR	**(0.227)**	**(0.294)**	**(0.183)**	**(0.358)**	**(0.262)**	**(0.273)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	---	**(0.346)**	---	**(0.505)**	---	(0.060)
Dif(null, H=exogenous)	**(0.294)**	**(0.287)**	**(0.250)**	**(0.302)**	**(0.547)**	**(0.534)**
(b) IV (years, eq(diff))						
H excluding group	---	**(0.632)**	---	**(0.100)**	---	**(0.492)**
Dif(null, H=exogenous)	---	**(0.161)**	---	**(0.757)**	---	**(0.193)**
Fisher	**3074.20*** **	**582.80*** **	**1526.17*** **	**2243.84*** **	**4160.93*** **	**881.70*** **
Instruments	20	31	20	31	20	31
Countries	48	42	48	42	47	42
Observations	472	355	430	354	442	355

***,**,*: 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 Fisher 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, 13.057 and 0.925 are respectively mean values of mobile phone penetration, internet penetration and fixed broadband subscriptions. na: not applicable because not all estimated coefficients needed for the computation of net effects are significant. Constants are involved in all regressions.

Table 6: ICT and the female employment rate

	Dependent variable: the female employment rate (FE)					
	Mobile phone penetration		**Internet penetration**		**Broadband subscription**	
FE (-1)	**0.929*** **	**0.974*** **	**0.957*** **	**0.963*** **	**0.927*** **	**0.947*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile (Mob)	-0.009	0.008	---	---	---	---
	(0.342)	(0.235)				
Mob×Mob	-3.96e-07	**-0.00007** **	---	---	---	---
	(0.993)	**(0.029)**				
Internet	---	---	0.006	0.008	---	---
			(0.751)	(0.552)		
Internet ×Internet	---	---	-0.0003	**-0.0003** **	---	---
			(0.153)	**(0.018)**		
Broadband(BroadB)	---	---	---	---	-0.143	0.040
					(0.100)	(0.627)
BroadB×BroadB	---	---	---	---	0.004	-0.003
					(0.214)	(0.415)
Political Stability	---	0.013	---	0.065	---	0.055
		(0.946)		(0.689)		(0.685)
Remittances	---	**0.049** **	---	**0.099*** **	---	**0.058* **
		(0.048)		**(0.001)**		**(0.067)**
Financial Stability	---	-0.004	---	**-0.040* **	---	-0.032
		(0.862)		**(0.087)**		(0.133)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects	na	na	na	na	na	na
AR(1)	(0.095)	(0.092)	(0.086)	(0.085)	(0.089)	(0.087)
AR(2)	**(0.921)**	**(0.957)**	**(0.979)**	**(0.954)**	**(0.917)**	**(0.808)**
Sargan OIR	(0.000)	(0.001)	(0.000)	(0.006)	(0.007)	(0.430)
Hansen OIR	(0.093)	**(0.273)**	**(0.300)**	**(0.374)**	**(0.538)**	**(0.728)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	---	**(0.384)**	---	**(0.431)**	---	**(0.274)**
Dif(null, H=exogenous)	(0.098)	**(0.252)**	**(0.532)**	**(0.340)**	**(0.569)**	**(0.800)**
(b) IV (years, eq(diff))						
H excluding group	---	(0.079)	---	**(0.297)**	---	**(0.513)**
Dif(null, H=exogenous)	---	**(0.682)**	---	**(0.443)**	---	**(0.723)**
Fisher	**344.65*** **	**82475.99*** **	**1379.69*** **	**117785.16*** **	**1117.82*** **	**2488.00*** **
Instruments	20	31	20	31	20	31
Countries	48	42	48	42	47	41
Observations	472	355	430	354	442	335

***,**,*: 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 Fisher 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, 13.057 and 0.925 are respectively mean values of mobile phone penetration, internet penetration and fixed broadband subscriptions. na: not applicable because not all estimated coefficients needed for the computation of net effects are significant. Constants are involved in all regressions.

Appendices

Appendix 1:Definitions of Variables

Variables	Signs	Definitions of variables (Measurements)	Sources
Female Economic Participation	FLFpart	Labor force participation rate, female (% of female population ages 15+) (modeled ILO estimate)	ILO
	FU	Unemployment, female (% of female labor force) (modeled ILO estimate)	ILO
	FE	Employment to population ratio, 15+, female (%) (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
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
Financial Stability	Z-score	Prediction of the likelihood that a bank might survive and not go bankrupt.	FDSD

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 LabourOrganisation.

Appendix 2: Summary statistics (2004-2014)

	Mean	SD	Minimum	Maximum	Observations
Female Labor Force participation	62.515	15.685	30.00	88.80	451
Female Unemployment, female	10.831	8.736	0.300	44.800	429
Female Employment	57.201	15.828	23.700	86.400	429
Mobile Phone Penetration	45.330	37.282	0.209	171.375	558
Internet Penetration	7.676	10.153	0.031	56.800	453
Fixed Broad Band	0.643	1.969	0.000	14.569	369
Political Stability	-0.471	0.905	-2.687	1.182	462
Remittances	4.313	6.817	0.00003	50.818	416
Financial Stability	8.713	4.994	-12.024	25.736	404

S.D: Standard Deviation.

Appendix 3: Correlation matrix, 2004-2014(uniform sample size: 294)

Female Participation			ICT variables			Control variables			
FLFpart	FU	FE	Mobile	Internet	BroadB	PolS	Remit	Z-score	
1.000	0.453	0.640	-0.030	0.225	0.103	-0.041	-0.029	-0.209	FLFpart
	1.000	0.463	0.006	0.027	0.066	0.111	-0.090	0.094	FU
		1.000	-0.098	0.030	0.005	-0.197	0.060	-0.104	FE
			1.000	0.668	0.527	0.349	-0.044	0.209	Mobile
				1.000	0.675	0.202	-0.051	0.262	Internet
					1.000	0.354	-0.099	0.239	BroadB
						1.000	0.039	0.094	PolS
							1.000	-0.099	Remit
								1.000	Z-score

FLFpart:Female Labour Force participation. FU: Female Unemployment. FE: Female Employment. Mobile: Mobile Phone Penetration. Internet: Internet Penetration. BroadB: Fixed BroadbandSubscriptions. PolS: Political Stability. Remit: Remittances. Z-score: Financial Stability.

Appendix 4: Summary statistics (2008-2018)

	Mean	SD	Minimum	Maximum	Observations
Female Labor Force participation	60.197	15.474	20.463	87.118	528
Female Unemployment, female	9.175	8.392	0.218	33.324	528
Female Employment	55.372	17.000	18.143	86.011	528
Mobile Phone Penetration	66.389	37.856	2.357	184.298	530
Internet Penetration	13.057	13.636	0.250	62.00	485
Fixed Broad Band	0.925	2.748	0.000	21.638	492
Political Stability	-0.570	0.910	-3.314	1.200	536
Remittances	3.856	5.041	0.0001	32.746	461
Financial Stability	10.865	5.686	2.176	44.412	446

S.D: Standard Deviation.

Appendix 5: Correlation matrix, 2008-2018 (uniformsample size : 366)

	Female Participation			ICT variables			Control variables		
	FLFpart	FU	FE	Mobile	Internet	BroadB	PolS	Remit	Z-score
FLFpart	1.000								
FU	-0.654	1.000							
FE	0.972	-0.804	1.000						
Mobile	-0.458	0.492	-0.514	1.000					
Internet	-0.479	0.446	-0.510	0.726	1.000				
BroadB	-0.290	0.128	-0.272	0.372	0.515	1.000			
PolS	-0.093	0.305	-0.183	0.364	0.265	0.367	1.000		
Remit	-0.049	0.122	-0.091	0.052	0.005	-0.060	0.053	1.000	
Z-score	-0.390	0.097	-0.327	0.081	0.279	0.249	-0.051	-0.112	1.000

FLFpart: Female Labour Force participation. FU: Female Unemployment. FE: Female Employment. Mobile: Mobile phone penetration.Internet: Internet penetration. BroadB: Fixed broad band subscriptions. PolS; Political stability. Remit: Remittances. Z-score: Financial Stability.

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