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in Sub-Saharan Africa**

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Abstract

This study assesses how business/financial sustainability in the perspective of financial stability moderates information technology to influence female economic participation in 49 countries in Sub-Saharan Africa for the period 2008-2018. The empirical evidence is based on Tobit regressions that enabled the study to account for the censored nature of the outcome variables. The following important findings are established. First, ICT dynamics (mobile phone penetration, internet penetration and fixed broadband subscriptions) are consistently moderated by business sustainability to positively affect female employment in the industry. Second, business sustainability scores need to exceed certain thresholds before moderating fixed broadband subscriptions to induce favorable overall effects on female employment, female labour force participation and female unemployment rates. These thresholds are 18.742 and 19.505 Z-scores for positive effects on female employment and female labour force participation, respectively and a Z-score of 17.300 for a negative impact on female unemployment. The thresholds which should be exceeded are within policy reach, make economic sense and are policy relevant. The study contributes to the extant literature by providing actionable thresholds of business sustainability that can be employed by policy makers in order for information technology to positively influence female economic inclusion in Sub-Saharan Africa.

Keywords: information technology; business sustainability, gender inclusion

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

1. Introduction

This study focuses on assessing how business sustainability within the remit of financial stability moderates information technology to promote female economic participation in the formal economic sector. The study builds on existing empirical evidence that information

technology promotes female economic participation and inclusive development (Cushman and McLean, 2008; Tchamyou *et al.*, 2019; Asongu and Odhiambo, 2020; Lechman and Popowska, 2020) by arguing that such a nexus is contingent on dimensions of stability such as business/financial sustainability in the perspective of financial stability². Arguments for the focus of the study are threefold, namely, (i) the low representation of women in the formal economic sector of Sub-Saharan Africa (SSA) countries compared to the rest of the world; (ii) the potential for ICT penetration and complementary factors such as financial sustainability in the of light gaps in the attendant female economic participation literature and (iii) the relevance of the study in the achievement of inequality and poverty related targets in sustainable development goals (SDGs). These three motivational elements are expanded in the same chronological order.

First, consistent with contemporary policy and scholarly literature (Woldemichael, 2020; Asongu *et al.*, 2020), about 90% of women in SSA are employed in the informal economic sector and hence, policies that encourage women to be more involved with the formal economic sector are worthwhile, especially as they pertain to addressing constraints confronting these women, *inter alia*, lack of access to finance, less education and low skills, limited opportunities from information technology and political instability³. The narrative has motivated a growing stream of literature focusing on measures through which progress in gender equality in labour markets can be accelerated by decreasing gender discrimination in social mobility and economic opportunities (Moras, 2017; Morsy, 2020; Uduji and Okolo-Obasi, 2018, 2019, 2020). This present study focuses on linkages between business sustainability, information technology and female economic participation because of an apparent and persist gap in the literature. Accordingly, while financial development has been found to be an important factor in promoting gender inclusion, the relevance of financial development has not been framed within the context of financial instability, information technology and gender inclusion as framed in the present study. Moreover, it is also relevant to articulate that financial stability is fundamental because it provides a stable environment for financial inclusion that is necessary for the achievement of most SDGs (i.e. including SDG5 focused on gender economic empowerment) (UNCD, 2022).

² Business sustainability, financial sustainability and financial stability are used interchangeably throughout the study.

³For robustness purposes, these factors are involved in the conditioning information set or control variables of the present study.

Second, the contemporary literature has not focused on the problem statement being envisaged in this study because the attendant literature has largely been oriented towards, *inter alia*: the imperative of involving more girls in educational faculties of science (Elu, 2018); the connection between financial development and female economic participation (Nanziri, 2020; Morsy, 2020; Mannah-Blankson, 2018; Bayraktar and Fofack, 2018); nexuses between the importance of corporate social responsibility and information technologies in the participation of women in the agricultural sector (Udujiand Okolo-Obasi, 2018, 2019, 2020) and the importance of financial access and information technology in formal gender economic involvement (Bongomin *et al.*, 2018; Efobi *et al.*, 2018). The closest study in the literature to the present study is Efobi *et al.* (2018) which has established that information technology promotes female economic participation. In what follows, we discuss how the present study is distinct from the underlying study.

Efobi *et al.* (2018) have examined how information technology influences female economic employment in 48 countries in Africa for the period 1990-2014 and concluded that information technology penetration improves opportunities for women in the formal economic sector. However, the present study argues that it is not enough to establish a direct nexus between information technology and female formal employment because in the real world, the relationship is contingent on a number of factors (i.e. political stability, government effectiveness, absence of corruption, rule of law, regulatory quality, *inter alia*), which include financial/business sustainability. The relevance of financial/business sustainability in contributing to the extant literature and policy framework of achieving SDGs has been clarified in a preceding paragraph. Hence, this study departs from the underlying study in terms of its focus on how the nexus between information technology and employment of females in the formal economic sector depends on business financial sustainability which is conceived as financial stability or the likelihood that a bank might survive and not go bankrupt. Accordingly, given that employment in the formal economic sector largely depends on the ability of corporations or business to mobilize credit from banks for investment purposes, for the attendant investment to engender formal economic activities that entail the employment of females, financial stability is worthwhile. The intuition is consistent with the narrative that investors prefer engaging with economic environments that are characterized by some degree of certainty in terms of economic outlook (Kelsey and le Roux, 2017, 2018). Beyond the consideration of focus, the present study also departs Efobi *et al.* (2018) in terms of: (i) scope (48 African countries versus 49 countries in SSA); (ii) periodicity (1990-2014 versus 2008-2018) and (iii) estimation approach or data analysis (Fixed effects and ordinary least squares

regressions versus Tobit estimations). Moreover, the present study also departs from Asongu *et al.* (2021) by providing financial stability thresholds instead of ICT thresholds that are needed for the promotion of gender economic inclusion on the one hand and on the other, in terms of sample and methodology.

Third, the study is also relevant to policy makers in the perspective that it aims to assess how female economic participation can be promoted by means of financial stability and information technology: in the light of policy (United Nations, 2013) and scholarly (Osinubi and Asongu, 2021) discourses on the importance gender-inclusive and sustainable development in the era of globalization. To put this in more perspective, the policy importance of focusing on SSA stems from the fact that compared to other developing countries, the concern of gender economic exclusion in SSA is more apparent (Hazel, 2010; Osabuohien *et al.*, 2019). The position is supported by the World Bank (2018) which has reported that approximately 160 trillion USD in global GDP is lost due to gender economic gap and the corresponding negative externalities are most apparent in poor developing countries such as those in SSA. The dynamics of exclusive development which substantially contributed to most countries in the continent not achieving inclusive development targets surrounding the Millennium Development Goals (MDGs) have also been documented to be critical in the achievement of SDGs (Tchamyou, 2019, 2020).

The rest of the study is organized as follows. The intuition and related literature are provided in Section 2. The data and methodology are discussed in Section 3 while Section 4 provides the empirical results and corresponding discussion. Section 5 concludes with implications and future research directions.

2. Intuition and related literature

The intuition for the nexuses between information technology, financial sustainability and formal economic inclusion is simple to follow. While the positive role of information technology on female economic empowerment has already been established (Efobi *et al.*, 2018), financial instability limits opportunities for the efficient mobilization and allocation of resources for productive investments as by extension, employment avenues (World Bank, 2020). Accordingly, financial stability is essential for economic activities (which engender employment) because in the formal economy, most transactions are done via the financial system. In summary, in periods of financial instability, financial institutions are unwilling to invest in economic activities and/or projects which entail employment opportunities for the females as well as males. Moreover, given that most women are engaged in informal

enterprises, financial instability also limits opportunities for a transition to formal enterprises owing to the lack funding opportunities for the formal financial system (Woldemichael, 2020). It is worthwhile to further clarify that the investment of governments in ICT for various macroeconomic outcomes (which include gender economic inclusion) is contingent on financial stability. This is why thresholds of financial stability at which ICT positively influences gender economic inclusion are provided in the study.

In the light of above premise for assessing the linkage between information technology, financial instability and economic participation, this study also contributes to the growing strand of literature which argues that applied economics based on sound intuition is a worthwhile scientific activity because it contributes to theory-building (Costantini and Lupi, 2005; Narayan *et al.*, 2011; Asongu *et al.*, 2018). Hence, the study is consistent with an argument in the corresponding literature that the purpose of applied economics is not exclusively to either reject or accept theories (i.e. deductive research), not least because applied economics that is based on sound intuition could be used for theory-building (i.e. inductive research). In essence, this study can be considered as deductive research given that the underlying factors have been defined and investigated in the extant literature. The highlighted literature in the introduction is expanded in what follows.

In the nexus between information technology and education, Elu (2018) has engaged the representation of females in SSA within the framework of in Science, Technology, Engineering, and Mathematics (STEM). The author has used data from World Development Indicators of the World Bank to evaluate the shares of females in two main disciplines of STEM. Using a descriptive analysis, the research offers insights into the extent of gender inequality in STEM is the sub-region which can inform the effectiveness of gender-oriented policy interventions in the region designed to promote the female gender in STEM.

With respect to the connection between financial development and female economic participation, Nanziri, (2020) employs FinScope survey of 2015 to assess the difference between men and women in access to financial services in Zambia as well as corresponding predictions and ramifications on living standards in households. From the results, it is apparent that formal financial services are used by fewer women when compared to men. Some of the factors that account for the difference include source of income, location and education. Moreover, women that are financially-included and heading households enjoy substantially better quality of life compared to females that are financially-excluded and heading households. However, when financially-included male-headed households are compared with financially-included female-headed households, no significant difference is apparent. Morsy (2020) has

constructed a database combining bank-related variables to examine linkages between banking concentration and ownership structure, the regulatory framework and other socio-economic indicators proxying for female labour participation as well as gender differences in income, access to property and education across countries. The findings show that women are potentially very likely not to be included in financial sector activities, especially in countries where: (i) the presence of foreign banks is less apparent; (ii) a bigger share in the banking systems is owned by State financial institutions; (iii) information sharing offices such as public credit registries and private credit bureaus are less apparent and (iv) there is a substantial educational gap between males and females. Mannah-Blankson (2018) used both quantitative and qualitative data from 499 households in Ghana in order to examine consequences of microfinance access in gender asset gaps. The author engages two main statistical analyses: (i) the first comprising cross-section estimation analytical procedure that assesses the relevance of microfinance in mitigating intra-household inequality in gender wealth and (ii) the second employing the Oaxaca-Blinder decomposition method to assess wealth disparities between male-headed and female-headed households. The findings reveal that more access to microfinance services is linked to lower gaps in gender assets across and within households. The evidence further shows that when financially-constrained households are targeted, especially within the remit of facilitating access of females to credit, there are favorable consequences in terms of gender inequality and poverty reduction. Within this strand, Bayraktar and Fofack (2018) employ an Overlapping Generations Model of economic development for growth and gender in a low-income country and empirical evidence from the model shows that attendant policies in Burkina Faso are growth-enhancing and welfare-inclusive, not least, because such underlying policies reduce gender gaps associated with economic wellbeing as well as consolidate the economic empowerment of women.

Looking the nexuses between the relevance of information technologies and corporate social responsibility within the remit of women in the agricultural sector, Uduji and Okolo-Obasi (2018) have examined the linkage between young rural women's participation in an electronic (e)-wallet program and the usage of modern agricultural inputs. In essence, the study assesses the extent to which young rural women (YRW) participate in the federal government (FGN) e-wallet programme as well as the subsequent effect on the intensity at which modern agricultural inputs in the country are used. The findings show that it is worthwhile for the DGN to discourage gender differences in unequal access to inputs in agriculture and persistent inequality, especially as concerns women's contribution to family wellbeing that is limited by unfavorable conditions for women owning agricultural land. Uduji and Okolo-Obasi (2019)

within this strand have assessed how initiatives in corporate social responsibility by Multinational Oil companies (MOCs) affect rural women. The results show that the GMoU model is not very sensitive to the female gender, not least, because women seldom have immediate access to livestock programme with the exceptions of those via their sons and husbands. Uduji and Okolo-Obasi (2020) complete this strand by assessing whether corporate social responsibility affects women's development of small-scale fisheries. Findings of the study show that fisherwomen are substantially excluded from GMoUs interventions in small-scale fisheries owing to existing cultural and traditional norms.

In the last strand on the importance of financial access and information technology in formal gender economic involvement, Bongomin *et al.* (2018) test the moderating incidence of social network in the nexus between financial inclusion and mobile money innovation to establish that there is a substantial and positive moderating impact of social networks in the nexus between the use mobile money and financial inclusion. The studies of Efobi *et al.* (2018) and Asongu *et al.* (2021) which are closest to the present exposition have been critically engaged in the introduction.

3. Data and methodology

3.1 Data

The study focuses on a panel of 49 countries for the period 2008-2018⁴. The dataset is limited to the sampled countries because in the light of the motivation of this study, SSA (which is the focus of the research) entails 49 countries. The choice of the periodicity is motivated by data availability constraints at the time of the study on the one hand and on the other, the need to leverage on more updated data for findings with more contemporary policy implications. Four main data sources are used for the study, namely, the: (i) International Labour Organization (ILO); (ii) Financial Development and Structure Database (FDSD) of the World Bank; (iii) World Governance Indicators (WGI) of the World Bank and (iv) World Development Indicators of the World Bank. These sources are detailed in Appendix 1 in the light of the corresponding data.

In accordance with contemporary gender economic inclusion literature (Efobi *et al.*, 2018; Asongu and Odhiambo, 2020), four main female economic participation variables are employed, namely: the female employment rate in the industry, the female labour force

⁴ The 49 SSA countries are the 55 existing African countries excluding: (i) North African countries which are geographically not in SSA (Algeria, Egypt, Libya, Morocco and Tunisia) and (ii) South Sudan for which only very limited data are available.

participation rate, the female employment rate and the female unemployment rate. Consistent with contemporary information technology literature (Naicker and Van Der Merwe, 2018; Tchamyou *et al.*, 2019; Shehata and Montash, 2019), three main proxies for ICT are employed, namely: mobile phone penetration, internet penetration and fixed broadband subscriptions. Financial instability which is understood as the likelihood to go bankrupt is measured with the Z-score, in accordance with contemporary financial development literature (Meniago and Asongu, 2018; Anning and Adusei, 2022). Moreover, the employment of financial Z-score to proxy for financial/business sustainability is well documented in the literature (Krishna, 2005; Kannadhasan, 2007).

Six control variables, which are informed by contemporary gender inclusive development literature (Wacker *et al.*, 2017; Osinubi and Asongu, 2020), are used to control for variable omission bias, namely: inequality, GDP growth, political stability, inclusive education, trade openness and financial access. (i) Inequality is expected to increased female economic participation as recently documented by Asongu and Odhiambo (2019a). (ii) While GDP growth is anticipated to improve the participation of women in the formal economic sector, Wacker *et al.* (2020) have established the contrary. Hence, the effect can be contingent on existing levels of inequality and by extension, equity in employment opportunities associated with the attendant economic growth. (iii) Political stability should logically provide enabling conditions for the promotion of women rights, investment avenues and employment opportunities which involve the participation of women in the formal economic sector. (iv) Gender inclusive education, financial access and trade openness are also anticipated to promote gender economic inclusion (Steinberg and Nakane, 2012; Osinubi and Asongu, 2020).

The definitions and sources of variables are provided in Appendix 1 while the summary statistics is disclosed in Appendix 2. Appendix 3 captures the corresponding correlation matrix.

3.2 Methodology

As argued in contemporary literature, it is relevant for an estimation technique to be in accordance with the behavior of the corresponding data (Sadik-Zada, 2019; Sadik-Zada *et al.*, 2018). In line with the motivation of the study, the Tobit regressions empirical strategy is employed. This choice of the estimation technique is also consistent with the attendant literature documenting that the underlying technique is worthwhile when the outcome variable is defined within a specific interval (Asongu *et al.*, 2020; Ajide *et al.*, 2019). Hence, the choice of the empirical strategy is tailored to align with the distribution of the outcome variables of female economic participation. Accordingly, the attendant argument is that the Tobit estimation

technique is a good fit when maximum and minimum values are situated within a specified range (Kumbhakar and Lovell, 2000; Koetter and Vins, 2008; Ariss, 2010; Coccoresse and Pellecchia, 2010).

It is important to establish how the requirements for the application of the estimation are consistent with the data defined and summarized in the appendices. In essence, as apparent in Appendix 2, the considered four outcome variables fall within an interval of 0% and 100%. It follows that the attendant dependent variables by definition, construction and conception are censored from 0 to 100. Given the censored nature of the data, an Ordinary Least Squares (OLS) approach is unlikely to lead to the establishment of consistent estimates in light of the premise that an OLS approach is by design not meant to address concerns related to the outcomes variables with distribution values of 0% and 100% and hence the conditional probability of limited observations (Amemiya, 1984). It follows that a double censored Tobit approach is considered for the research in order to reflect the censoring of female economic participation proxies at extreme points of the attendant distributions.

Consistent with Tobin (1958) and Carson and Sun (2007), Equations (1) and Equation (2) reflect the standard procedure for estimating a Tobit model.

$$y_{i,t}^* = \alpha_0 + \beta X_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where $y_{i,t}^*$ is a latent response variable, $X_{i,t}$ is an observed $1 \times k$ vector of explanatory variables and $\varepsilon_{i,t} \approx$ i.i.d. $N(0, \sigma^2)$ and is independent of $X_{i,t}$. As opposed to observing $y_{i,t}^*$, we observe $y_{i,t}$:

$$y_{i,t} = \begin{cases} y_{i,t}^*, & \text{if } y_{i,t}^* > \gamma \\ 0, & \text{if } y_{i,t}^* \leq \gamma, \end{cases} \quad (2)$$

where γ is a non-stochastic constant. It follows that, the value of $y_{i,t}^*$ is missing when it is less than or equal to γ .

Before discussing the empirical results, it is worthwhile to emphasize that the Tobit regressions approach relies on the following assumptions: (i) residuals are acknowledged to be normally distributed and (ii) the dependent variables that are unbounded reflect a linear function of the independent variables of interest (Amemiya, 1984). Two marginal effects are reflected in the predictors: (i) one is the marginal impact of the predictors on the latent, unobserved female economic participation rate and (ii) the other is characteristic of the observed female economic participation rate that is censored. In accordance with contemporary Tobit-centric literature, in reporting of estimated results, only the marginal impacts pertaining to the censored

female economic participation rate are reported because they are reliable in terms of economic interpretation (Lashitew *et al.*, 2019). In accordance with contemporary literature, the independent variable interest and control variables are lagged by one period in order to have some control of the simultaneity aspect of endogeneity (Asongu and Nwachukwu, 2017; Mlachila *et al.*, 2017).

4. Empirical analysis

4.1 Presentation of results

The empirical results are disclosed in this section in Tables 1-2. While Table 1 focuses on linkages between ICT, business sustainability, female employment in the industry and female employment rates, Table 2 is concerned with linkages between ICT, business sustainability, female labour participation and female unemployment rates. Each table is organized into three sets of specification, entailing three specifications for each dependent variable. The three respective specifications per dependent represent each of the ICT dynamics, namely: mobile phone penetration, internet penetration and fixed broadband subscriptions, in this order.

This study is also consistent with contemporary literature on interactive regressions in considering both the unconditional and conditional effects in the understanding of how business sustainability moderates the incidence of ICT on female economic participation. It follows that net effects are computed in order to fully grasp the overall impact of the moderating variables (Preacher *et al.*, 2007; Tchamyoun and Asongu, 2017; Agoba *et al.*, 2020). In this light, for each specification where both the attendant conditional and unconditional effects are significant, net effects are computed. For instance, in the second column of Table 1, the overall impact corresponding to the role of business sustainability in moderating mobile phone penetration for female employment in the industry is 0.070 ($[-0.004 \times 10.865] + [0.114]$). In the corresponding calculation, it is worthwhile to note that the average value of business sustainability is 10.865; the unconditional effect of mobile phone penetration is 0.114 while the conditional impact related to the interaction between the mobile phone penetration and business sustainability is -0.004.

The following findings can be established from Tables 1-2. First, ICT dynamics are consistently moderated by business sustainability to positively affect female employment in the industry. Second, while the net effect from the role of business sustainability in moderating fixed broadband subscriptions to influence female employment is negative, the corresponding conditional effect is positive, which is an indication that if business sustainability is enhanced

beyond a specific threshold, the corresponding net effect would be positive. Third, in Table 2, while business sustainability moderates fixed broadband subscriptions to engender negative and positive net effects on female labor participation and female unemployment respectively, the unfavorable effects are associated with favorable conditional effects. This implies that enhancing business sustainability beyond certain critical thresholds can engender favorable effects in terms of promoting the participation of more women in the formal economic sector. The computation of these thresholds is considered and engaged in the next section.

Third, most of the significant control variables display the expected signs. For instance, political stability and GDP growth are positive for female employment and negative for female unemployment. The incidences of the other control variables on the outcome variables are contingent on two dynamics, notably: (i) the nature of the outcome variable and (ii) the correlation between the attendant control variables and interactive terms. To put this in more perspective, the finding that trade openness (financial access) increases (decreases) female employment in the industry while trade openness (financial access) decreases (increases) female employment is consistent with the intuition that industrial activities are mostly related to trade and the corresponding funding in the industry sector is largely from foreign direct investment and not from domestic financial resources (UNCTAD, 2019; Asongu and Odhiambo, 2019b).

Table 1: ICT, business sustainability and female economic participation (1)

	Dependent variable: female economic participation					
	Female Employment in the Industry			Female Employment		
	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
Business Sustainability (Z-score)(-1)	0.263 (0.110)	0.238** (0.030)	-0.061 (0.601)	-0.078 (0.827)	-1.033*** (0.000)	-1.395*** (0.000)
Mobile Phone Penetration (Mobile)(-1)	0.114*** (0.004)	---	---	-0.080 (0.248)	---	---
Internet Penetration (Internet)(-1)	---	0.400*** (0.000)	---	---	-0.537** (0.016)	---
Fixed Broadband (Broadband)(-1)	---	---	1.601** (0.023)	---	---	-6.841*** (0.001)
Z-score(-1)× Mobile(-1)	-0.004* (0.054)	---	---	-0.012*** (0.009)	---	---
Z-score(-1)× Internet(-1)	---	-0.022*** (0.000)	---	---	0.009 (0.458)	---
Z-score(-1)× Broadband(-1)	---	---	-0.107** (0.017)	---	---	0.365*** (0.006)
Inequality (Gini)(-1)	-0.034 (0.678)	-0.004 (0.954)	-0.116 (0.174)	0.299 (0.163)	0.218 (0.370)	-0.224 (0.375)
GDP growth (-1)	-0.162 (0.424)	-0.217 (0.284)	-0.468*** (0.008)	0.479** (0.041)	0.650** (0.013)	1.226*** (0.002)
Political Stability(-1)	2.157*** (0.000)	2.931*** (0.000)	3.086*** (0.000)	5.782*** (0.000)	2.780 (0.112)	3.262 (0.202)
Inclusive Education(-1)	1.694 (0.787)	2.905 (0.658)	10.985 (0.108)	-11.311 (0.348)	-14.473 (0.251)	-21.006 (0.132)
Trade Openness(-1)	0.040** (0.027)	0.036* (0.058)	0.038** (0.047)	-0.101*** (0.000)	-0.084** (0.010)	-0.086*** (0.002)
Financial Access(-1)	-0.009*** (0.000)	-0.006*** (0.001)	-0.008*** (0.000)	0.016** (0.010)	0.008 (0.259)	0.007 (0.303)
Net Effects of ICT	0.070	0.160	0.438	na	na	-2.875
Observations	165	163	152	165	163	152

***, **, *: significance levels at 1%, 5% and 10% respectively. dy/dx: average marginal effects. na: not applicable because at least one estimated coefficient needed for the computation of the net effects and thresholds is not significant. The average value of business sustainability is 10.865.

Table 2: ICT, business sustainability and female economic participation (2)

	Dependent variable: female economic participation					
	Female Labour Force Participation			Female Unemployment		
	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
Business Sustainability (Z-score)(-1)	-0.059 (0.856)	-1.022*** (0.000)	-1.444*** (0.000)	-0.015 (0.915)	0.141* (0.095)	0.099 (0.376)
Mobile Phone Penetration (Mobile)(-1)	-0.043 (0.462)	---	---	0.048 (0.145)	---	---
Internet Penetration (Internet)(-1)	---	-0.423** (0.026)	---	---	0.227** (0.041)	---
Fixed Broadband (Broadband)(-1)	---	---	-5.715*** (0.001)	---	---	2.461*** (0.000)
Z-score(-1)× Mobile(-1)	-0.013*** (0.002)	---	---	0.001 (0.563)	---	---
Z-score(-1)× Internet(-1)	---	0.004 (0.730)	---	---	-0.007 (0.209)	---
Z-score(-1)× Broadband(-1)	---	---	0.293** (0.013)	---	---	-0.142*** (0.009)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Net Effects of ICT	na	na	-2.531	na	na	0.918
Observations	141	163	152	165	163	152

***, **, *: significance levels at 1%, 5% and 10% respectively. dy/dx: average marginal effects. na: not applicable because at least one estimated coefficient needed for the computation of the net effects and thresholds is not significant. The average value of business sustainability is 10.865.

4.2 Extension for thresholds of business sustainability

As previously clarified, while favorable net effects have been established from relationships between mobile phone penetration, internet penetration, business sustainability and the involvement of more women in the formal economic sector, this has not been the case from the dynamic of fixed broadband subscriptions. This is essentially because net effects from three of the four female economic inclusion dynamics are not favorable, namely, female employment and female labour force participation where the net impacts are negative and female unemployment which is associated with a positive net impact. Fortunately, associated conditional effects are favorable and reflect an indication that business sustainability should be promoted beyond some critical limits for the anticipated favorable effects.

Consistent with a growing strand of literature on the importance of establishing thresholds for policy making purposes (Tchamyu, 2019), the following business sustainability thresholds are apparent: (i) a business sustainability score that exceeds 18.742 (16.841/0.365) for business sustainability to moderate fixed broadband subscriptions for an overall positive net effect on female employment; (ii) a score of above 19.505(5.715/0.293) for business sustainability to moderate fixed broadband subscriptions for an overall positive net effect on female labour force participation and (iii) a score that rises beyond 17.330 (2.461/0.142) for business sustainability to moderate fixed broadband subscriptions for an negative incidence on female unemployment. It follows that the computed thresholds are critical masses beyond which business/financial sustainability in the perspective of financial stability (i.e. Z-score) effectively complements fixed broadband subscriptions in order to promote formal female economic participation in the sampled countries.

It is worthwhile to illustrate the above thresholds with an example focusing on the associated net effects. For instance, in the last column of Table 1, given that the computed threshold is 18.742, when the attendant threshold is reached, the corresponding net effect becomes zero or 0.000 ($[0.365 \times 18.742] + [-6.841]$). Hence, a score above 18.742 leads to an overall positive net effect on female employment. In the same vein, in the last column of Table 2, since the computed threshold is 17.330, when such a threshold is reached, the overall effect on the female unemployment is zero or 0.000 ($[-0.142 \times 17.330] + [2.461]$). In other words, since the corresponding conditional effect is negative, above the 17.300 critical mass of business sustainability, the overall effect on female unemployment is negative. This computation of thresholds is consistent with contemporary threshold literature, notably: human development thresholds for inclusive mobile banking (Asongu and Odhiambo, 2018); critical masses upon which increasing environmental pollution can hamper inclusive human

development (Asongu, 2018); critical points for favorable effects (Roller and Waverman, 2001; Batuo, 2015) and information sharing thresholds for the reduction of market power in order to promote financial access (Asongu, le Roux and Tchamyou, 2019).

5. Discussion, conclusion and future research directions

5.1 Discussion

In accordance with the attendant threshold literature (Tchamyou, 2019), in order for the computed critical masses to make economic sense and by extension, have policy relevance, they should be within the statistical range of the policy or moderating variable. In the light of information provided in Appendix 2, the computed thresholds make economic sense and have policy relevance because they are within the statistical minimum and maximum range of business sustainability or the Z-score (i.e. 2.176 to 44.412). The corresponding policy perspectives are substantiated in what follows.

First of all, as already clarified, the provided policy thresholds make economic sense and are policy worthwhile because they are situated within the statistical range of business sustainability disclosed in the summary statistics. As to the concern of whether the attendant policy critical masses can be easily implemented by policy makers in the sampled countries, such implementation is feasible because the attendant thresholds do not substantially deviate from the mean or average value of business sustainability (i.e. 10.865) relative to the range of business sustainability (i.e. 2.176 to 44.412). In other words, had the policy thresholds been closer to the maximum value of the range instead of the mean, formulating policies to reach the suggested policy thresholds would have been difficult.

Second, it is also important to clarify that, compared to mobile phone penetration and internet penetration, the need for business sustainability to reach some critical levels in order to be moderated by fixed broadband subscriptions to promote female economic participation may be traceable to the fact that the penetration level of fixed broadband subscription in the sampled countries is low compared to the penetration of the mobile phone and internet. Hence, beyond working to enhance business sustainability to the suggested levels in the sampled countries, policy makers should also work towards improving the levels of fixed broadband subscriptions in the sampled countries.

The main limitation of this study or threat to the study's validity is that the prescribed policy thresholds should be within country-specific remits before the corresponding policy thresholds are valid and policy-relevant. For instance, while averages of the policy variables are employed when computing ICT net effects, owing to country-specificities, such averages

may be more relevant to some countries compared to others. For instance, in implementing the prescribed policy thresholds, countries should first assess whether prescribed policy thresholds are within country-specific policy ranges (i.e. between country-specific minimum and maximum values of the policy variables).

Another limitation worth mentioning is that, Z-scores used to proxy for financial stability have a number of shortcomings. For instance, Z-scores as founded on accounting information substantially rely on the corresponding auditing and accounting framework. Accordingly, financial institutions have the capacity to influence the data reported and provide a picture that is overly positive of their financial situation. Moreover, Z-scores also just assess individual financial institutions while overlooking how instability (or stability) in one institution can influence another institution, hence, providing a picture that is not complete of the risks that nexuses between financial institutions entail.

5.2 Conclusion

This study assesses how business/financial sustainability in the perspective of financial stability moderates information technology to influence female economic participation in 49 countries in Sub-Saharan Africa for the period 2008-2018. The empirical evidence is based on Tobit regressions. The following findings are established. First, ICT dynamics (mobile phone penetration, internet penetration and fixed broadband subscriptions) are consistently moderated by business sustainability to positively affect female employment in the industry. Second, business sustainability scores need to exceed certain thresholds before moderating fixed broadband subscriptions to induce favorable overall effects on female employment, female labour force participation and female unemployment rates. These thresholds are 18.742 and 19.505 Z-scores for positive effects on female employment and female labour force participation, respectively and a Z-score of 17.300 for a negative impact on female unemployment. The thresholds which should be exceeded are within policy reach, make economic sense and are policy relevant.

Future studies can focus on assessing how the established findings are affected by the Covid-19 pandemic which has disrupted the labour market. Accordingly, women have substantially borne the brunt of the corresponding economic disruption. Hence, as the relevant data become available, it will be worthwhile to assess how the engaged channels (ICT and business sustainability) have contributed to stemming the tide of female unemployment owing to the Covid-19 pandemic.

Appendices

Appendix 1: Definitions of Variables

Variables	Signs	Definitions of variables (Measurements)	Sources
Female in Industry	Industry	Employment in industry, female (% of female employment) (modelled ILO estimate)	ILO
Female labour participation	Participate	Labour force participation rate, female (% of the female population ages 15+) (modelled ILO estimate)	ILO
Female employment	Employ	Employment to population ratio, 15+, female (%) (modelled ILO estimate)	ILO
Female Unemployment	Unemploy	Unemployment, female (% of female labor force) (modeled ILO estimate)	ILO
Business Sustainability	Z-Score	Prediction of the likelihood that a bank might survive and not go bankrupt.	FSDS
Mobile Phones	Mobile	Mobile cellular subscriptions (per 100 people)	WDI
Internet	Internet	Internet users (per 100 people)	WDI
Fixed Broad Band	Broadband	Fixed broadband subscriptions (per 100 people)	WDI
Inequality	Gini	“The Gini index is a measurement of the income distribution of a country's residents”.	WDI
Economic growth	GDPg	Gross Domestic Product growth rate (annual %)	WDI
Political stability	PolSta	“ <i>Political stability/no violence (estimate): measured as the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional and violent means, including domestic violence and terrorism</i> ”.	WGI
Inclusive education	Edu	School enrolment, primary and secondary (gross), gender parity index (GPI)	WDI
Trade openness	Trade	Exports plus Imports of Commodities (% of GDP)	WDI
Financial access	Finance	Private domestic credit from deposit banks and other financial institutions (% of GDP)	FSDS

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

Appendix 2: Summary statistics (2008-2018)

	Mean	SD	Minimum	Maximum	Observations
Female in industry	8.547	7.440	0.401	34.603	528
Female labour participation	55.372	17.000	18.143	86.011	528
Female employment	60.197	15.474	20.463	87.118	528
Female unemployment	9.175	8.392	0.218	33.324	528
Business sustainability	10.865	5.686	2.176	44.412	446
Mobile phone penetration	66.389	37.856	2.357	184.298	530
Internet penetration	13.057	11.636	0.250	62.000	485
Fixed broadband subscriptions	0.925	2.748	0.000	21.638	492
Inequality	45.328	6.736	33.000	65.700	325
Economic growth	4.155	4.908	-46.082	20.715	511
Political stability	-0.570	0.910	-3.314	1.200	536
Inclusive education	0.936	0.101	0.630	1.133	298
Trade openness	76.956	42.201	19.100	347.997	498
Financial access	31.501	84.383	0.347	972.204	452

S.D: Standard Deviation.

Appendix 3 : Correlation matrix (uniform sample size: 151)

	Gender Economic Participation					Information Technology				Control Variables				
	Industry	Employ	Participate	Unemploy	Z-Score	Mobile	Internet	Broadband	Gini	GDPg	PolSta	Educ	Trade	Finance
Industry	1.000													
Employ	-0.0424	1.000												
Participate	-0.300	0.973	1.000											
Unemploy	0.527	-0.755	-0.594	1.000										
Z-Score	-0.014	-0.522	-0.601	0.138	1.000									
Mobile	0.356	-0.517	-0.487	0.423	0.190	1.000								
Internet	0.254	-0.447	-0.421	0.375	0.254	0.784	1.000							
Broadband	0.220	-0.310	-0.335	0.102	0.232	0.522	0.693	1.000						
Gini	0.080	0.086	0.213	0.281	-0.241	0.183	0.167	-0.195	1.000					
GDPg	-0.164	0.365	0.333	-0.368	-0.310	-0.237	-0.249	-0.146	-0.012	1.000				
PolSta	0.369	-0.018	0.047	0.098	-0.123	0.343	0.348	0.462	0.339	-0.040	1.000			
Educ	0.301	-0.282	-0.207	0.397	0.182	0.427	0.422	0.296	0.214	-0.176	0.426	1.000		
Trade	0.309	-0.280	-0.212	0.285	0.079	0.105	0.251	0.252	0.027	-0.023	0.268	0.244	1.000	
Finance	-0.0000	-0.067	-0.071	0.035	0.053	0.205	0.157	0.170	-0.040	-0.137	0.116	0.028	0.164	1.000

Industry: female employment in the industry. Employ: female employment. Participate: female labour force participation. Unemployment: female unemployment. Z-score: business sustainability. Mobile: mobile phone penetration. Internet: internet penetration. Broadband: Fixed broadband subscriptions. Gini: Inequality. GDPg: Gross Domestic Product growth. PolSta: Political Stability. Educ: Gender inclusive education. Trade: trade openness. Finance: Financial access.

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