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The impact of ICTs on self-employment in sub-Saharan Africa: what is the reality in countries that offer few economic opportunities for women?

Fabrice-Gilles NDOMBI AVOUBA

ndombigilles@yahoo.ca

Marien Ngouabi University

Sylvaniste Etsiba

Marien Ngouabi University

Abigail Chari

Stellenbosch University

Raynica Steffie Mboulou

Marien Ngouabi University

Tamisai Chipunza

University of Johannesburg

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Title

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Abstract

This article aims to determine the effects of ICT on women's self-employment in 19 sub-Saharan African (SSA) countries where economic opportunities for women remain limited. Using a balanced panel covering the period from 2014 to 2024 and a PCSE model, the study reveals a consistent negative effect of the three dimensions of ICT, namely mobile telephony, fixed telephony, and internet use, on the share of women engaged in self-employment. This result can be explained by the structural constraints faced by individual women entrepreneurs and by the rise of women's cooperatives, whose development is facilitated by ICT through improved coordination and resource pooling. Robustness analysis using FGLS and MMQR econometric tools confirms the effectiveness of the estimators and highlights differentiated effects across distributional quantiles. This study concludes that in an unfavorable institutional context, digital technology tends to favor the transition to collective forms of organization rather than stimulating individual entrepreneurship. Therefore, public authorities should develop digital skills training programs tailored to the needs of women, especially those engaged in networked activities, to optimize productivity gains.

Keywords: ICT, self-employment, Sub-Saharan Africa, PCSE

JEL classification: L60, J23, O55, C23

1. Introduction

Women's participation in the labor market influences not only the economy but also social dynamics (Ibourk, 2023). Over time, it has become a subject of growing interest to researchers because of its significant impact on the economic development of nations (Halim et al, 2023). Compared to men, women bring different skills and ideas that are economically valuable (Lagarde, 2014). This concept, which promotes women's status in strategic spheres of society, aligns with the vision of the United Nations Women's Agency (UN Women) on the one hand and that of the African Women's Development Fund (AWDF) on the other.

Furthermore, according to the ILO report (2007), women's participation in the workforce has increased over the last two decades. For Gopalan (2024), this progress is one of the outcomes of the ongoing digital evolution worldwide. In this sense, information and communication technologies (ICT) have helped to reduce barriers to entry into the labor market, particularly in terms of access to information through various digital platforms, thus offering individuals in general, and women in particular, the opportunity to expand their professional networks and increase their visibility (Brixi et al, 2023). Similarly, Vaton (2015) and Morley (2017) agree in their reflections that ICT is one of the causes of the feminization of jobs.

In economics, the relationship between ICT and women's labor market participation has given rise to a rich and controversial body of literature. Indeed, on a theoretical level, the ideas put forward by the authors can be summarized under two approaches: the push approach and the crowding-out approach. The first approach is based on the hypothesis that ICTs are a lever for women's participation in the labor market. It includes the theory of Technological Life Cycles (Ruttan, 1959), the theory of disruptive innovation (Christensen, 1997), and the theory of use and gratification (Katz, 1959). The second approach posits that ICT tends to distance women from the labor market. It includes several theories, among which we can cite: the digital gap theory (Dimaggio and Hargittai, 2001) and the theory of technological domestication (Silverstone and Morley, 1992). Similarly, on an empirical level, the results obtained by researchers present a dichotomy. On the one hand, the work of authors such as Uchema et al. (2016) and Ngoua and Simon (2021) shows that ICTs have a positive effect on women's labor market participation in Sub-Saharan Africa (SSA). On the other hand, studies by Sinha, S. (2018) and Asongu et al. (2020) show that ICT negatively influences women's labor market participation in SSA.

Despite their differences, these studies share the common finding that they highlight the direct effects of ICT on women's search for and/or engagement in income-generating activities, while leaving aside the search for indirect effects. This gap has been filled by Asonghu and Odhiambo (2022), Nkounkou Ngoa and Song (2021), and Ndjokou (2024), who each tested the mediating role of the variables "inequality," "governance," "female education," and "financial development" in the relationship between ICT and women's participation in the labor market. It is therefore clear that none of the interaction variables tested to date provides an inclusive account of the business environment. However, as Bourdreaux and Nikolaev (2018) point out, women do not participate in the labor market in the same way depending on whether the environment in which they operate offers them the opportunity to take full advantage of their entrepreneurial and/or managerial skills. Similarly, the World Bank's Women, Business and Law report (2023) notes that in the labor mark , women are more likely to empower themselves and innovate when their rights are protected.

The added value of this work therefore lies in examining the link between ICT and women's participation in the labor market in countries where economic opportunities for women are limited. Such stratification is made possible not by the Doing Business ease of doing business

index, which is a barometer of the overall business climate, but rather by the World Bank's Women in Business and the Law index. This index, which focuses specifically on assessing the economic environment for women, allows us to construct a panel of countries that offer few economic opportunities, such as Congo, Mali, and Botswana, rather than using it as a simple interaction variable in the estimated model.

Furthermore, unlike many studies at the frontier of digital economics and labor economics, we approach women's participation in the labor market through women's self-employment/independent work (street vendors, food stall operators, home-based producers of goods, etc.). This choice is motivated primarily by the fact that commonly used indicators (female activity rate, female employment rate, female sectoral employment, etc.) mask the situation of self-employed women, and secondly by the idea that self-employment is one of the predominant forms of employment for women in Africa, where there is a high rate of informality (Pasali, 2022). Indeed, this form of work is an important source of income for women from low-income households and serves as a safety net for workers without access to stable salaried employment (Loayza & Rigolini, 2011).

Furthermore, this new idea also provides an opportunity to extend the study period in order to take into account, in particular, the changes brought about by COVID-19 on the situation of women. In addition, we take a methodological leap forward in this study by using a Panel Standard Error Correction (PCSE) model to estimate our results, unlike previous studies, which often use classical, dynamic, and error correction panel models. The choice of this model is partly justified by its ability to correct for the problems of heteroscedasticity and contemporaneous autocorrelation posed by the predominance of individuals in the panel of 19 SSA countries. To ensure the robustness of the PCSE results, we use the feasible generalized least squares (FGLS) estimator and the new method-of-moments quantile regression (MMQR) approach.

Furthermore, the value of exploring the effects of ICT on self-employment in countries offering few economic opportunities for women lies in the fact that approximately 230 million jobs and nearly 65% of new hires in SSA will require digital skills by 2030 (World Bank, 2023), while women currently represent only 30% of technology professionals in Africa (UNESCO, 2023). Added to this are the disruptions faced by women entrepreneurs in their use of the internet and fixed/mobile telephony. According to the 2022 UNU-INU report, network outages in Africa are disrupting the labor market to such an extent that the existence of women-led businesses appears threatened by declines in revenue.

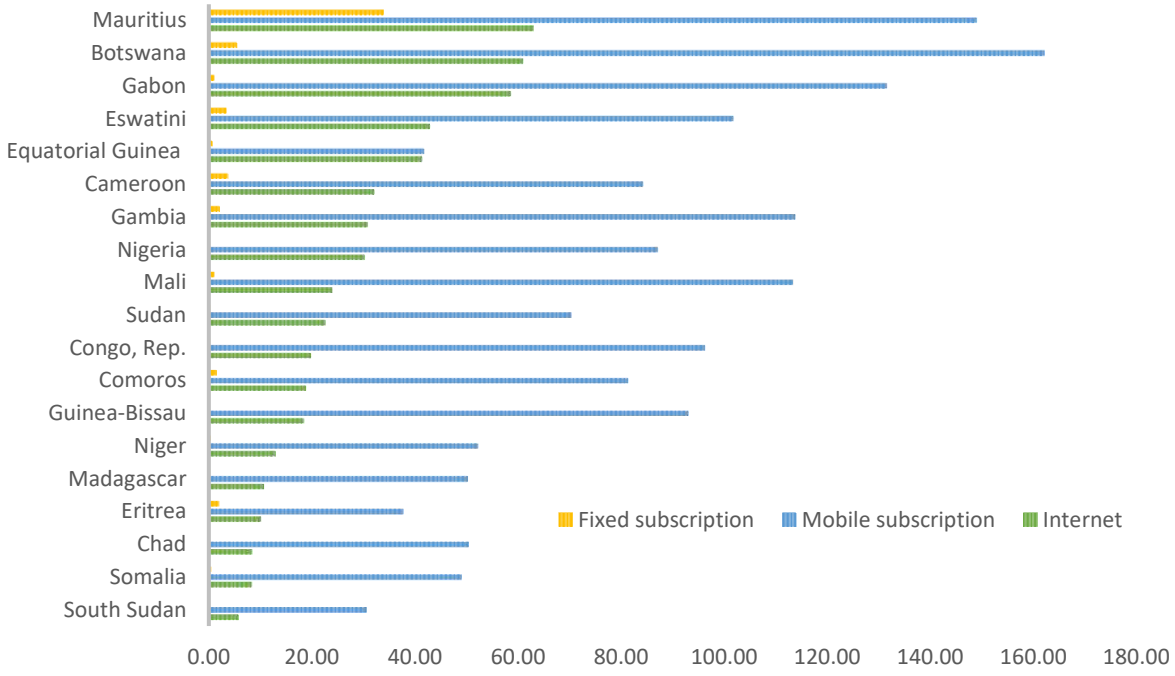
While these findings hold for women's employment overall, it remains to be seen whether they can be confirmed for self-employment. Hence, the following research question: What effects do ICTs have on women's self-employment in SSA countries that offer few economic opportunities for women? The objective of this study is therefore to determine the effects of ICTs on women's self-employment in countries offering few economic opportunities for women. The rest of this article comprises the following sections: (2) Overview of ICT and self-employment, (3) Literature review, (4) Empirical strategy, (5) Empirical evidence, (6) Conclusion and economic policy implications.

2. Overview of ICT and women's self-employment in SSA

The evolution of ICT in SSA can be analyzed in three main phases. The first, relating to *the adoption of ICT by the population,* covers the period from 1999 to 2012. During this period, Africa had nearly 650 million mobile subscriptions. The second phase, focused on *the rise of digital technology,* covers the period from 2013 to 2019. Between these two dates, the penetration rate stood at around 43%, marking a turning point in mobile phone use. Finally, the

third and last phase, described as *continuity,* is symbolized by an internet user rate of over 40% in 2022. This percentage is partly justified by the widespread use of ICTs by economic actors since the onset of COVID-19. For example, to circumvent the barriers imposed by lockdown during the health crisis, many economic actors in SSA countries, such as Congo, have adopted teleworking to ensure the continuity of public and private services. Furthermore, as shown in Figure 1 below:

Graph 1: distribution of countries by ICT usage (%)



Source: Authors based on World Bank data

The current period is characterized by the fact that in almost all of the countries in our study, the percentage of people using the internet is at least 20%, and that Mauritius, Botswana, and Gabon seem to be in a more favorable position, as nearly half of their populations have access to this technology. In these countries, spending on digital infrastructure is around USD 7 billion, according to the 2024 Xalam Analytics report. However, these statistics hide gender disparities. Women are 37% less likely than men to use mobile internet (Africa's Pulse, 2024).

Self-employed women play a crucial role in African economies and face countless challenges. Several key facts can be attributed to their presence in the world of work. These include:

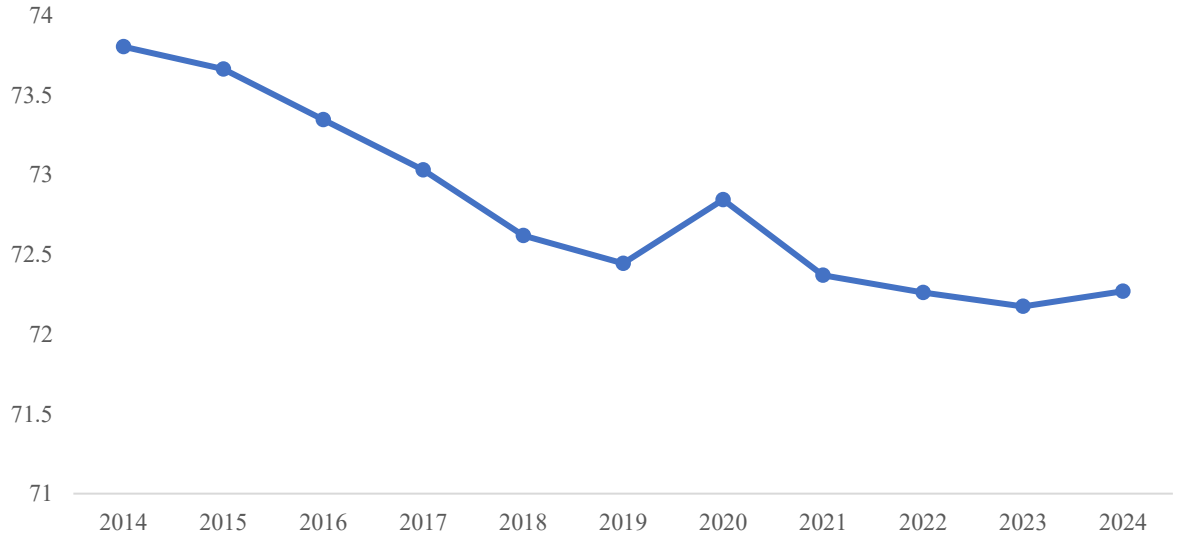
Due to their predominance in the informal sector, this sector accounts for more than 70% of total employment in developing economies and contributes to about one-third of these countries' GDP (IMF, 2021). Women remain concentrated in the "invisible" sectors of informal work, such as domestic work and assistance in small family businesses. These jobs are generally precarious, characterized by low, irregular, or non-existent pay, limited or non-existent access to social security or social protection, and limited capacity to organize to ensure compliance with international labor standards and human rights. According to the ILO (2018), approximately 80% of women in SSA are engaged in activities that are not subject to state control. More than half of this category of economic agents are self-employed. Examples include street vendors, subsistence farmers, and artisans.

Support initiatives for women entrepreneurs and limited access to finance: the African Development Bank, through the African Women's Finance Initiative (AFAWA), aims to unlock up to $5 billion in financing by 2026 for businesses owned or run by women. Despite this initiative, African women entrepreneurs still face problems accessing finance. Only 20% of them have access to formal credit, limiting their ability to perform better. In addition, 37% of women have a bank account, compared to 48% of men (IMF, 2020). Furthermore, it is widely accepted that in African societies, cultural norms and domestic responsibilities very often limit women's ability to seek and hold jobs. As a result, they are forced to balance their work with often disproportionate family responsibilities, which deprives the economy of a real source of positive externalities.

In terms of women's economic contribution, self-employed women make a significant contribution to their countries' GDP. For example, in West Africa, women entrepreneurs generate substantial income from activities such as food processing, sewing, and small-scale trade. In one of its recent reports, the AfDB (2021) highlights that women entrepreneurs are key drivers of economic growth, particularly in rural areas, and therefore contribute to food security. In this sense, they perform agricultural tasks at three levels, namely crop planting, processing, and marketing of products. Similarly, the empowerment of women in this area contributes to the fight against poverty, given that in SSA, agriculture accounts for 32% of GDP and 65% of jobs. In other words, this sector, which women continue to enter given the generosity of the land and its profitability, offers these actors the opportunity to lead a desirable life and thus be protected from poverty.

Figure 2 below shows the trend in self-employment among women in SSA from 2014 to 2024. It highlights three phases: the first shows a gradual decline in the proportion of self-employed women from 2014 to 2019, the second shows an increase in this proportion from 2019 to 2020, and the third shows a continuous decline until 2023.

Graph 2: *Change in the number of self-employed workers (%)*



Source: *Authors based on World Bank data*

In the first phase, in 2014, approximately 74% of women in our sample were self-employed. This proportion gradually declined to 72.50% in 2019. This decrease can be attributed to several structural and economic factors, such as increasing urbanization, the economic transition to salaried jobs in the formal sectors, public policies aimed at formalizing employment and integrating more workers into regulated frameworks, and changes in economic models, with

increased diversification of sources of employment (Abaté, 2017; Kadandji, 2021, and ILO, 2021). The second phase can be explained by several factors, including the development of microenterprises, initiatives to support women's entrepreneurship through microcredit, such as the African Development Bank's African Women in Business initiative (AFAWA), which aims to improve the viability and sustainability of women-led small and medium-sized enterprises (SMEs) while facilitating their access to finance, and the African Women in Business (AWIB) initiative of the same bank, which develops financing instruments and mechanisms specifically for women-led SMEs. Training and diversification of women's self-employed activities from traditional sectors (agriculture, informal trade) to more modern sectors (services, technology) (Mbaye and Gueye, 2018 and AfDB, 2021). The third phase reveals a destruction of self-employed jobs, certainly to the benefit of other types of jobs or collective activities.

3. Literature review

This subsection aims to explain the relationship between our key concepts through economic theories and empirical work.

3.1. Theoretical review

The link between ICT and women's labor market participation can be clarified using several economic theories. The theories identified are grouped into two approaches: the push approach and the crowding-out approach.

i. Push approach

This approach brings together theories that show the predominant role of ICT in women's self-employment. It is composed of the theories of Technological Life Cycles (Ruttan, 1959), Disruptive Innovation (Christensen, 1997), and Uses and Gratifications (Katz, 1959).

's Theory of Technological Life Cycles (Ruttan, 1959): initiated by Ruttan (1959) in his article "Technological Change and Economic Development," it explores how technologies spread throughout economies and societies. It is in line with the economics of innovation, continuing the thinking of economists such as Schumpeter (1934). The premise of this theory is that technologies follow a distinct and predictable life cycle. This cycle varies according to the technology's characteristics, its field of application, and the socio-economic and industrial contexts in which it emerges and spreads. Indeed, for Ruttan (1959), understanding the evolution of a technology throughout its life cycle makes it possible to better anticipate its impact on industry, the labor market, and social structures. Technological innovation is not only a consequence of individual decisions; it is shaped by an interaction between supply (researchers, engineers, institutions) and demand (consumers and businesses). This suggests that a successful innovation must not only be technically viable, but also economically attractive and socially compatible with the needs of society.According to this theory, each technology goes through a life cycle characterized by four (4) main phases: the development or innovation phase (the technology is designed, tested, and improved, often in laboratories or specialized companies); the growth phase (the technology is adopted by a growing number of users, generating increased demand and expansion of production capacity); the maturity phase (the technology is widely disseminated and used in a standardized manner, further innovations become rarer, and production costs decrease); and the decline phase (the technology begins to be replaced by newer and more efficient innovations, and its use gradually declines).

Disruptive innovation theory (Christensen, 1997): this theory was proposed by Christensen in his 1997 book entitled "The Innovator’s Dilemma: When New Technologies Cause Great Firms

to Fail." It emerged at a time when established companies in various industrial sectors were facing the emergence of new technologies that were disrupting their traditional business models. In his book, Christensen (1997) studied how dominant companies in the IT and automotive sectors could fail in the face of innovations that initially seemed marginal or uncompetitive but which, over time, ended up destabilizing their markets. His theory is based on the assumption that a small company or new player introduces a technology or product that initially appears to be underperforming or intended for a niche market. This innovation evolves and develops in such a way as to appeal to mass consumers, offering a simpler, more accessible, and often cheaper alternative to existing products. Dominant companies, focused on the needs of their most demanding customers, fail to react in time, allowing disruptive technology to gain ground and overturn the established order. Disruptive innovations generally begin by responding to needs that seem less important or that concern consumers who are not yet customers of large companies. These innovations are often perceived as inferior at first, as they do not meet the performance or sophistication criteria of existing products. However, they have the advantage of being cheaper, more accessible, and often easier to adopt. As the technology improves, it begins to attract mass consumers and disrupt traditional companies that have failed to adapt.

Uses and gratifications theory (Katz, 1959): In their work, Katz, Blumler, and Gurevitch sought to demonstrate that individuals are active in their use of media, seeking specific content to satisfy a variety of needs and motivations. This theory was formulated in the 1959 article "The Uses and Gratifications Approach to Communication Research" with the aim of understanding why and how individuals use the media to satisfy their personal, social, and psychological needs. It states that individuals actively use the media to satisfy their specific needs, and that their motivations and desired gratifications guide their media behavior. Unlike theories that view the audience as passive receivers, this theory argues that media consumers deliberately choose what they consume to meet personal needs (information, entertainment, social comfort, validation, etc.). In addition, Katz and his colleagues emphasize that individuals are influenced by their personal and social contexts, which means that media use is contextualized and individualized. For example, one person might use television for entertainment, another to stay informed, and a third to feel connected to their community. They also argue that media use is dynamic and changing, depending on the individual's evolving needs and social contexts. A key element of the theory is that it recognizes the diversity of users' needs and that media use varies from person to person. Therefore, understanding the motives for media use is essential to understanding its effects on individuals and society as a whole.

ii. Displacement approach

This approach incorporates theories highlighting the adverse effects of ICTs, a factor that hinders women's participation in the labor market. These are the theories of the digital divide (Dimaggio and Hargitti, 2001) and technological domestication (Silverstone and Morley, 1992).

Digital divide theory: introduced by DiMaggio and Hargittai (2001), this theory emerged in a context where the internet and new digital technologies were becoming more widespread in industrialized countries. Particular attention is paid to unequal access to these technologies among different social groups, especially those on the margins of digital societies, such as poor people, women, the elderly, and those living in developing countries**.** This theory is based on the assumption that access to ICTs does not necessarily guarantee equal opportunities for participation in the digital society**.** The "digital divide" is not limited to physical access to technologies, but includes dimensions such as inequality of use, digital skills**,** and the ability to

take advantage of ICTs in everyday life. In other words, individuals may have access to the internet, but may not use it productively or to the same extent as other groups that are better educated or better supported. To refine their analysis of the "digital divide," DiMaggio and Hargittai emphasized that inequality of access was not simply a question of the availability of technologies, but also of their effective use and the digital skills needed to take advantage of them. They thus highlighted the concept of "digital inequalities," a term that refers to differences in the ability to use ICT effectively and equitably according to socioeconomic, cultural, and geographic criteria. Their research revealed that groups such as women, ethnic minorities, disadvantaged youth, and older adults are less likely to make optimal use of digital technologies, even if they have access to them.

Theory of Technological Domestication: Developed by Silverstone and Morley (1992), this theory emerged in a context in which new technologies, particularly mass media such as television, were rapidly spreading into households in Western countries and beyond. These authors were particularly interested in how technologies were integrated into people's daily lives, and how they were appropriated, modified, and used in the domestic setting. The theory of technological domestication posits that technologies do not impose themselves uniformly on society, but are integrated and adapted to the social practices of individuals in specific contexts. Although technologies are often designed with a global vision and a technical purpose in mind, they must undergo a process of domestication, where they are reconfigured according to the cultural, social, and economic values of their users. The term "domestication" referred to in this theory refers to the process by which technologies become integrated into the social practices and structures of a household or society. This process includes how individuals, families, and communities adopt and adapt technologies to their needs, habits, and social contexts, while sometimes negotiating tensions between technology and cultural practices. Silverstone and Morley (1992) also argue that the appropriation of technology is a complex process that depends not only on physical access to technological tools, but also on how individuals and social groups can control and manage these technologies in their daily lives. This process of domestication can be seen as a dynamic exchange between technology and social practices, where technology is both influenced by society and, conversely, changes social behaviors and relationships.

3.2. Empirical review

First, Efobi et al. (2017) examined how technological progress affects gender identity through women's participation across 48 African countries, using panel data from the World Bank over the period 1990 to 2014. The explained variable, i.e., participation, is measured by two indicators: the female labor force and the female participation and employment rates. Technological progress is measured by internet penetration, mobile phone penetration, and fixed broadband subscriptions. In addition, several estimation methods are used: ordinary least squares, fixed effects, and generalized system moments. The results show that technological improvement increases women's participation in a consistent order according to the extent of growth in mobile phone, internet, and fixed broadband penetration.

Next, Ngoua and Simon (2021) studied the effects of ICT on women's participation in the labor market in 48 African countries, using panel data from the World Bank for the period 2001 to 2017. As measures of women's participation, we used participation levels and the female sectoral employment rate. ICTs are approached through mobile phone penetration and internet penetration. The econometric results obtained using the generalized system of moments method and the fixed effects model showed that ICT (mobile phones and the internet) stimulate women's participation in the labor market. They also highlight that the effect of ICT on women's employment is greater in the industrial sector.

Conversely, Sinha, S. (2018) examined how digital technology and globalization have brought about radical change in the world of work, with increasing access to jobs, information, new production hubs, etc. In India, significant progress has been made in digital intervention thanks to the Digital India initiative, Aadhaar (unique identity number), and women are either self-employed (mainly unpaid family workers) or casual workers, working mainly at the lower end of the professional ladder as agricultural workers, small traders, craft workers in manufacturing, etc. In this context, the article explores whether women can take advantage of the opportunities created by digital transformation, whether in commerce, manufacturing, or financial services. The study argues that differences in access, as well as factors such as inequalities in education and vocational training, access to finance, asset ownership, etc., lead to a gender digital divide, limiting the transformational effects of digital technologies. Women are generally employed at the end of value chains or the professional chain, deprived of social security and in a survivalist state, rather than growing. The paper proposes a set of policies to enable women in India to be part of and benefit from the digital dividend.

For its part, Idowu, O. Omodunni (2025) analyzes the effects of women's access to electricity and ICT diffusion on female employment in 16 West African countries from 1990 to 2020. She disaggregates female employment into three sectors: agriculture, industry, and services. The study uses World Bank data and performs static analysis (combined effect) and dynamic analysis using ARDL procedures on panel data (mean group (MG), combined mean group (PMG), and dynamic fixed effect (DFE)). After confirming the stationarity of the variables. The results of the dynamic analysis show that all variables are positive and constitute long-term determinants of female employment in West Africa. The sectoral analysis reveals that women's access to electricity hinders their employment in agriculture, while it promotes it in the services sector. Furthermore, the spread of ICT in West African countries hurts women's employment in the agricultural and industrial sectors, but stimulates it in the service sector. While women's level of education is a negative determinant of their long-term employment in the economic sectors concerned, fertility has a significant negative impact on their short-term employment across all three sectors. It is suggested that West African governments accelerate their efforts to expand women's access to energy through capacity building, partnerships with local actors, and the creation of an environment conducive to female entrepreneurship. This will ensure a smooth energy transition in the region. In addition, the agricultural sector should be formalized to encourage women's employment.

Finally, Armağan Gezici and Ozge Ozay (2025) examine how different types of ICT capital influence women's employment trends in various sectors of activity in the United States (1990-2018), contributing to debates on technological change and labor market inequalities. Using decomposition and regression analyses, they find that technological change has complex and sometimes contradictory effects on female employment. Although the overall share of female employment increased during this period, this growth was mainly due to intersectoral effects rather than intrasectoral changes. It should be noted that at a more granular sectoral level, they observe signs of a decline in female employment within certain sectors, which calls into question the assumption of a uniform impact of technology on employment opportunities. Their results reveal that different types of technologies have varying impacts on women's labor market participation. While communication capital has a positive correlation with the share of female employment, IT capital has a significant negative correlation, particularly in the service sector. A case study of the financial sector illustrates this dynamic, showing how technological change has profoundly reshaped employment patterns, leading to a significant shift of women away from administrative functions over the past two decades. These findings contribute to broader debates on automation and the future of work by demonstrating that the impact of technological change on gender-based labor market outcomes is neither uniform nor

consistently beneficial. As economies increasingly adopt AI and automation, our findings suggest the need for nuanced policy approaches that take into account the differentiated effects of technology across gender and sectors particularly in service industries where female employment is concentrated.

4. Empirical strategy

In this section, we define the variables and data, then present the methodological approach of the study.

4.1.Variables and data

To empirically assess the effects of ICT on women's self-employment in SSA, we constructed a balanced panel of 19 African countries (*Botswana, Cameroon, Comoros, Republic of Congo, Eritrea, Eswatini, Gabon, Equatorial Guinea, Guinea-Bissau, Madagascar, Mali, Mauritius, Niger, Nigeria, Somalia, Sudan, South Sudan, and Chad*) for which the Women's Economic Opportunity Index is less than or equal to 60, covering the period from 2014 to 2024. This period was chosen in particular because of the adoption of several strategies and policies aimed at digital inclusion, such as "Smart Africa." In addition, programs promoting female entrepreneurship, such as the AFAWA initiative, have been implemented.

ICTs represent our variable of interest. They are taken from the World Bank's World Development Indicators (WDI) database and mainly take three forms: fixed telephone subscriptions (Badri, 2017), mobile phone subscriptions (Idowu, 2025), and internet usage (Idowu, 2025). The explained variable is self-employment, i.e., the percentage of women engaged in economic activity on their own account. Its source is identical to that of the ICT variable. The control variables are total fertility rate (Kpnou, 2023), political stability (Hakizimana et al., 2024), religious freedom (Enomoto et al., 2022), GDP per capita (Ahmad et al., 2024), and Quality of education (Ahmad et al., 2024) come from the WDI (World Development Indicators), WGI (Worldwide Governance Indicators), V-DEM (Varieties of Democracy), and IIAG (Ibrahim Index of African Governance) databases, respectively. Consequently, the empirical model linking the explained variable and the five explanatory variables takes the following linear form:

$$\text{self-employment}_{it} = a_0 + a_1 \times \text{ICT}_{it} + a_2 \times \text{total fertility rate}_{it} + a_3 \times \text{political stability}_{it} + a_4 \times \text{religious freedom}_{it} + a_5 \times \text{GDP per capita}_{it} + a_6 \times \text{Quality of education}_{it} + \varepsilon_{it} \quad (1)$$

As the "ICT" variable is approximated by three distinct indicators, as mentioned above, there are two options. The first is to specify an equation with all control variables, including these three indicators. The second is to specify an equation for each indicator. In either case, the objective remains the same, namely to determine the nature and extent of the effect of each ICT measure on women's self-employment. However, to discriminate between these two options, we performed a VIF test. These results are shown in Table 1 below:

Table1 : Eigenvalue test results

Variables	VIF	1/VIF
Political stability	4.69	0.213023
Net user	4.10	0.243962
Mobile subscription	3.45	0.289607
Ln(GDP/h)	3.35	0.298907
Total fertility rate	3.24	0.308359
Quality_Education	3.06	0.326497
Religious freedom	3.02	0.330971
Fixed subscription	1.97	0.507878
Mean VIF	3.36	

Source: Authors, based on data from the study

Indicate that there is multicollinearity between the explanatory variables. This problem can be clearly seen in the correlation coefficients in Table 2. These coefficients show that several variables are interrelated or can be written as a linear combination. Hence the pairs (Mobile_subscription, Landline_subscription), (Mobile_subscription, Internet_user), (Landline_subscription, Internet_user) of interrelated variables, which leads us to break down equation 1 into three equations:

$$\text{self-employment}_{it} = a_0 + a_1 \times \text{mobile phone subscriptions}_{it} + a_2 \times \text{total fertility rate}_{it} + a_3 \times \text{political stability}_{it} + a_4 \times \text{religious freedom}_{it} + a_5 \times \text{GDP per capita}_{it} + a_6 \times \text{Quality of education}_{it} + \varepsilon_{it} \quad (2)$$

$$\text{self-employment}_{it} = a_0 + a_1 \times \text{fixed telephone subscriptions}_{it} + a_2 \times \text{total fertility rate}_{it} + a_3 \times \text{political stability}_{it} + a_4 \times \text{religious freedom}_{it} + a_5 \times \text{GDP per capita}_{it} + a_6 \times \text{Quality of education}_{it} + \varepsilon_{it} \quad (3)$$

$$\text{self-employment}_{it} = a_0 + a_1 \times \text{internet usage}_{it} + a_2 \times \text{total fertility rate}_{it} + a_3 \times \text{political stability}_{it} + a_4 \times \text{religious freedom}_{it} + a_5 \times \text{GDP per capita}_{it} + a_6 \times \text{Quality of education}_{it} + \varepsilon_{it} \quad (4)$$

Many observations can be drawn from examining the descriptive statistics in this table. The first is that self-employed workers account for an average of 72%. This particularly high percentage reflects Africa's progress in terms of entrepreneurial culture. Secondly, the average number of mobile phone subscribers (84%) is far higher than the number of fixed-line subscribers (3%) and internet users (27%). Thirdly, the countries in our sample are characterized by a low degree of religious freedom and poorer quality education. Finally, these countries experience political instability on average and have fertility rates ranging from 1.3 to 7.3%. The last two statistics indicate a certain degree of birth control in this group of countries.

Table2 : *Correlation matrix and descriptive statistics*

	Self-employment	**Subscription Mobile**	**Fixed subscription**	**User net**	**Fertility rate**	**Political stability**	**Freedom of religion**	**Ln(GDP)**	**Quality Education**
Self-employment	1								
Mobile subscription	-0.642*	1							
Landline subscription	-0.662*	0.477*	1						
Net_user	-0.659*	0.756*	0.491*	1					
Fertility rate	0.714	-0.553	-0.631	-0.654	1				
Political stability	-0.498	0.576	0.478	0.577	-0.711*	1			
Religious freedom	-0.411	0.681	0.460	0.491	-0.517*	0.723	1		
Ln(GDPh)	-0.661*	0.551*	0.523	0.757	-0.684*	0.629	0.460	1	
Quality_Education	-0.435	0.486	0.537	0.580	-0.574*	0.739	0.486	0.691	1
Average	72.801	84.041	3.027	27,398	4,473	-0.841	1,985	7,311	0.388
Standard Deviation	24.007	39,453	7.488	20.635	1,296	1,021	1,186	1,008	0.171
Max	97,845	179.02	37.3	81.4	7,342	1,095	4	9.334	0.74
Min	11,536	13.485	0	0.99	1.32	-2.729	0	5.354	0.07
Observations	209	209	209	209	209	209	209	209	209
Variables	Self-employed workers	Mobile phone subscription	Landline subscription	Internet users	Fertility rate	Political stability	Religious freedom	GDP per capita	Quality of education
Measures	In	As a % of 100 per capita	As a % of 100 per capita	As a % of 100 per capita	In	scale -2.5 to 2.5	scale 0 to 100	Constant 2015 USD	Scale 0 to 1
Sources	WDI	WDI	WDI	WDI	WDI	WGI	IIAG	WDI	V-DEM

Source: *Authors using STATA 17 software, *significant at the 1% level*

4.2.Methodological approach

The panel comprising 19 countries and 11 years is microeconomic in nature, since the number of individuals exceeds the time frequency (N>T). Under these conditions, we perform four main preliminary tests in order to choose the appropriate estimation method for this type of data, following the example of Freire-Seoane et al (2020). These tests are:

Hausman's test*:* this test allows us to discriminate between a fixed effects model and a random effects model. To do this, two hypotheses are proposed, namely H0: the appropriate model is the random effects model. In other words, there is no correlation between the error term and the independent variables in the panel data model, i.e.$Cov(a_{i,}x_{it}) = 0$; H1: the appropriate model is the fixed effects model. That is, the correlation between the error term and the independent variables in the model is statistically significant, i.e.$Cov(a_i x_{it}) \neq 0$.

Heteroscedasticity: under the null hypothesis of homoscedasticity, this test developed by Green (2003) allows us to verify whether the variance of the error for each individual in the panel is identical, in order to use the ordinary least squares (OLS) covariance matrix to make statistical inferences. Similarly, it requires a fixed effects model whose residuals can be used in a modified Wald test to test for the presence of heteroscedasticity.

Serial correlation in errors: proposed by Wooldridge (2002), this test shows that in the absence of error autocorrelation, introducing the mean of the explained variable and its lagged value into the model is sufficient to asymptotically filter out the effects of the unobservable common component when *N* tends to infinity. Thus, it corresponds to a Dickey Fuller model augmented in the interindividual dimension whose testable hypotheses are H_0: the residuals are not linked by a reproduction process, and H_1: the residuals are linked by a reproduction process.

Cross-sectional dependence: Pesaran (2003) proposes a unique test that takes into account possible dependencies between individuals. He does not test the unit root on transformed variables taken as deviations from deterministic components. Instead, he chooses to retain the raw series by augmenting the Dickey-Fuller model with the introduction of individual means of the explained variable and first differences. From this point of view, Pesaran's (2003) approach is very similar to the Dynamic Least Squares (DOLS) logic of Stock and Watson (1993). Consequently, the hypotheses of this test are H0: absence of cross-sectional dependence, H1: presence of cross-sectional dependence.

The application of these tests, including the homogeneity of slopes test, yielded the results shown in Table 3 below.

Table3 : Results of pre-estimation tests of the PCSE model

Tests	**(2)**		**(3)**		**(4)**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Homogeneity	1.307	0.191	1.030	0.303	1.260	0.208
Heteroscedasticity	24750*	0.000	23372*	0.000	25295*	0.00
Hausman	24.86*	0.00	18.18*	0.005	24.48 *	0.00
Error autocorrelation	6.280**	0.022	7.436**	0.013	5.959**	0.013
Cross-sectional dependency	19.646	0.353	16.498	0.557	15.809	0.605

Source*: Authors, using Stata software, *significant at the 1% level** significant at the 5% level.*

This table shows that our sample is homogeneous. In other words, the countries covered by our study have similar characteristics. It also shows that our data are affected by heteroscedasticity and autocorrelation biases. The combined existence of these two problems of violation of the assumptions of the Ordinary Least Squares (OLS) method leads us to opt for the PCSE (Panel-Corrected Standard Errors) estimator developed by Beck and Katz (1995) in order to obtain effective coefficients.

Note that this is an estimator that pools information between clusters to estimate error variances. It is a vector with T elements, which can be grouped in the form of a T × N matrix where the residuals$\hat{e}_i$ are columns, i.e. E =$[\hat{e}_1\ \hat{e}_2 \ldots.\ \hat{e}_{N-1}\ \hat{e}_N]$. Similarly, the corrected variance/covariance matrix of the panel of$\hat{b}$ is as follows: PCSEV Ar$(\hat{b})$ =$(X'X)^{-1}\ X'^{(\hat{\Omega})}X(X'X)^{-1}$. Furthermore, it corresponds to a "sandwich estimator" of the order of the Huber-White robust estimator, with the only difference being the use of the "Kronecker product for the calculation of. Also, the variance of the error for each individual is estimated as the Mean Squared Error (MSE) of their residuals. It is therefore a robust estimation technique based on the principle that the intercorrelation between individuals is the same throughout the study period (Johnson, 2004).

5. Empirical evidence

This section is devoted, on the one hand, to the results of the econometric evaluation of the relationship studied by the PCSE and, on the other hand, to the analysis of the robustness of the results of this evaluation.

5.1.Econometric results

i. Presentation of results

Estimates of female self-employment using three ICT indicators, taken separately to avoid correlation bias, are shown in Table 4 below. Overall, it reveals that the coefficients associated with the Wald statistic are significant, as their p-values are below the 5% threshold. As a result, we can say that in each of these models, there is at least one explanatory variable that lends itself to both econometric and economic commentary. In addition, the results we obtained after applying the OLS in the three models are of good quality. This is because the three coefficients of determination have values above 90%, which means that in these models, the combination of our five candidate variables explains the phenomenon of self-employment to an extent of approximately 90%. Specifically, the predictive powers are 90.70% for model 2, 92.10% for model 3, and 91.10% for model 4. Furthermore, the intraclass correlation (rho), which indicates the extent to which the variance in our results can be explained by differences between countries, is over 90%.

With regard to the explanatory variables, it should be noted that in model 2, three are significant at the 1% threshold. These are "mobile phone subscription," "fertility rate," and "GDP/hour." In model 3, there are also three significant variables at the same threshold, namely "fixed telephone subscription," "fertility rate," and "GDP/hour." In model 4, only the "fertility rate" remains significant at this threshold. The other variables, and especially the variable of interest, "internet usage," do not have this characteristic. Furthermore, the negative sign of the variables "fixed telephone subscription" and "mobile telephone subscription" leads us to conclude that ICT reduces self-employment among women at in countries where there are few economic opportunities for women. We can now move on to the interpretation and discussion of the results of the study.

Table 4: *Results of PCSE estimates*

Variables	(2)	(3)	(4)
	PCSE		
Mobile subscription	-0.057 *		
	(0.008)		
Landline subscribers		-0.802 *	
		(0.000)	
Net_user			-0.003
			(0.935)
Total fertility rate	7.510*	6.413*	7.813*
	(0.000)	(0.000)	(0.000)
Political stability	0.194	-0.035	-0.033
	(0.820)	(0.960)	(0.965)
Freedom of religion	0.299	0.185	-0.126
	(0.708)	(0.771)	(0.859)
Ln (GDP/h)	-0.002*	-0.002*	-0.002*
	(0.000)	(0.000)	(0.000)
Quality of education	3.729	3.346	1.241
	(0.489)	(0.472)	(0.797)
Constant	49,282*	50,367*	44,558*
	(0.000)	(0.000)	(0.000)
R2	0.907	0.921	0.911
Wald chi2(6)	249.35	261.00	197.19
Probabilities	0.00	0.00	0.00
Rho	0.913	0.944	0.937

Source: Authors using STATA software
significant at the 1% thresholdsignificant at the 5% threshold, () p-value*

ii. Interpretations and discussions of results

Equations 2, 3, and 4, or the models for estimation purposes specified in subsection 4.1, are presented in the form of a level-level model. As a result, the coefficients " a_1 " of the variable "mobile_subscription" and "a_1" of the variable "fixed_subscription" can be interpreted as the marginal effects of mobile phone and fixed-line telephone use. It therefore corresponds to the variation in "a_1" and "a_1" percent of self-employment due to a one percent variation in mobile subscriptions on the one hand and landline subscriptions on the other. In our case, a_1= -0.057 and a1= -0.802, which means that when mobile phone subscriptions increase by one percent, the number of women in self-employment decreases by 5.7%. Similarly, a one percent increase in landline subscriptions results in an 80% decrease in self-employment. The common meaning of these two results suggests a favorable attitude towards cooperatives at the expense of individual initiatives, which would seem more risky in a context where it is difficult for women to do business. Thus, the digital gap theory, developed in particular by DiMaggio and Hargittai (2001), is particularly relevant in explaining these dynamic inter hips. According to this perspective, increased access to technology does not automatically reduce social and gender inequalities; on the contrary, it can sometimes reinforce them, especially when skills, economic resources, or freedom of movement are unevenly distributed among groups. In this context, the rise of ICTs can mainly benefit individuals who are already privileged—generally men, city

dwellers, and educated people while undermining women who work independently in highly competitive and low-capital sectors (Hilbert, 2022).

Furthermore, the theory of technological domestication, proposed by Silverstone and Morley (1992), offers additional insight. It emphasizes that the use of technology is never neutral: it is embedded in social structures. Indeed, in contexts where movement is restricted and entrepreneurial opportunities for individuals are severely limited, information and communication technologies (ICT) may be integrated into domestic life rather than used as tools for economic empowerment. Thus, technological advancement does not necessarily translate into an increase in self-employment for women, but rather a redefinition of working patterns (Hafkin, 2020). This can lead women to form collective organizations or to turn to salaried or semi-collective jobs that are better structured. Similarly, based on Amartya Sen's capabilities approach (1999), it is clear that access to ICTs only truly expands individual freedoms when social, institutional, and economic conditions allow women to transform this resource into real opportunities. Otherwise, these technologies may remain tools whose benefits are captured by other groups, without improving women's economic autonomy in the short term.

In terms of empirical analysis, the findings of this article are consistent with a trend in the literature that highlights the ambivalent, even negative, effects of ICTs on female employment. Several recent studies argue that digital transformation does not always promote female entrepreneurship and may even reduce women's presence in certain sectors of the labor market. Indeed, research conducted by Sinha (2018) has revealed that the technological structuring of markets tends to intensify competition and reinforce pre-existing inequalities between men and women, particularly in informal, low-capital-intensive activities. Research conducted by Asongu et al (2020) in Africa also reveals that the use of information and communication technologies (ICT) can actually reduce women's participation, especially when these technologies open the door to more skilled jobs that are often inaccessible to them.

Other studies corroborate this idea by emphasizing that the impact of ICT varies greatly across sectors. In particular, Idowu (2025) demonstrated that digitization leads to job losses for women in agriculture and industry, while creating opportunities in certain services. This highlights the complex and non-linear nature of technological impact. The findings of the article analyzed support this view. Rather than showing that women are leaving the labor market en masse, they suggest a reorganization within the informal sector, where self-employment, often precarious and low-paid, is declining in favor of more collective or better-structured forms of activity. Quantile regression analyses, which reveal that the negative effect of the internet is more pronounced in countries where the proportion of self-employed women is already high, reinforce this interpretation. Therefore, the introduction of ICTs does not eliminate female activity, but changes its dynamics, increasing competitive pressure on the most vulnerable workers.

In terms of context, the negative effect of ICTs on female self-employment in SSA can be explained in part by two main channels: the rise of women's cooperatives and the process of creative destruction.

The first channel can be explained by the gradual transformation of women's forms of economic organization, in particular the rise of cooperatives and productive groups as a strategy for collective resilience. Faced with marginalization in an increasingly digitized and competitive economic landscape, women are responding by formalizing and pooling their activities. Forming cooperatives or associations of women entrepreneurs is not simply a trend, but an economic necessity. In this regard, the AfDB (2022) estimates that women-led cooperatives and

savings and credit groups (tontines) increased by more than 30% in West Africa between 2015 and 2021. This is reinforced by Haines' (2022) analysis of women entrepreneurs in Kenya, which showed that access to smartphones has enabled groups of women artisans to pool their resources to create joint accounts on platforms such as Jumia and Shopify, thereby reducing their transaction costs by nearly 25%.

Similarly, the FAO (2020) and UN Women (2023) show that more than 34% of rural women in the region are now members of a cooperative or economic activity association, compared to around 22% in 2010. This movement is not marginal, as Bernard and Spielman (2009) documented in Ethiopia that women's participation in collective economic groups increased by 40% in a decade, changing the very nature of their productive activity. In several West African countries, Agarwal (2018) has shown that these structures offer access to markets, credit, and information, outsourcing some of the activities that were previously carried out individually. In this context, ICTs play a catalytic role. The adoption of digital tools facilitates the pooling of tasks (accounting, procurement, marketing) within cooperatives, which automatically reduces the need for a multitude of individual micro-enterprises. GSMA (2022) points out that 45% of women's cooperatives in Kenya now use WhatsApp Business or M-Pesa to manage their collective sales. Digital technology therefore improves the efficiency of collective work but, at the same time, reduces the incentive to maintain strictly individual activities. This structural shift can be reflected in the data by a statistical decline in the proportion of women in self-employment, even though their total economic participation is increasing in other forms of organization.

Thus, individually, they may have remained self-employed and precarious saleswomen, but collectively, they form a small or medium-sized digital enterprise (SME). Consequently, the statistical decline in self-employment partly reflects a transition to more structured forms of employment, where the status of lone self-employed entrepreneur is replaced by that of salaried member or partner within a collective entity. This transition, while positive for economic resilience, is often recorded in surveys as a departure from self-employment, without necessarily capturing the new nature of the collective activity.

The second contextual channel refers to the process of creation-destruction induced by the rapid spread of digital technologies. Schumpeterian theory manifests itself here in the rapid destruction of low-productivity informal jobs and the slower and more demanding creation of digital opportunities. This concept, according to which the introduction of new technologies destroys the least productive activities before creating new ones, was put forward by Aghion and Howitt (1992). In sub-Saharan Africa, this phenomenon is particularly intense because a large proportion of self-employed women's jobs are concentrated in low-productivity sectors, namely small informal businesses, domestic catering, street vending, and artisanal agro-processing. According to the World Bank (2024), 76% of self-employed women still operate in low value-added segments.

The GSMA (2020) report on the platform economy in Africa provides an eloquent statistic: while e-commerce and mobility platforms created around 1.5 million income opportunities in 2019, more than 70% of these gig workers were men. At the same time, a study by Dyer (2022) on the impact of market digitalization in Senegal showed that the simple increase in the use of mobile money for transactions led to an 11% decline in the number of small independent food vendors in Dakar's markets, who faced competition from more structured players capable of advertising online and managing deliveries. The jobs destroyed, often micro-retail businesses run by women, are lost immediately and on a massive scale. Conversely, the new jobs created by digital technology (community manager, data analyst, software developer) require a level of skill and start-up capital that excludes a large part of the female workforce, as confirmed by the

World Bank report (2021) indicating that women are 25% less likely than men to use the Internet for complex work-related tasks. This structural and gender gap explains why the net effect of ICTs on female self-employment may be negative in the medium term, with job destruction outpacing job creation in accessible job segments.

However, it is precisely these segments that ICTs are reconfiguring most rapidly. For example, the rise of delivery platforms and digital distribution services has reduced the margins of street vendors in regional capitals: in Lagos, Adewumi (2021) estimates that 28% of them have seen their customer base decline since the massive arrival of informal e-commerce via Instagram and Jumia. Similarly, in the agri-food sector, the introduction of digital intermediation platforms has reduced the role of independent women traders in the supply chain. In Rwanda, Ndiaye et al. (2022) show that nearly 18% of women-owned microenterprises have ceased operations following the digitization of agricultural product distribution. This process of destruction is not immediately offset by the creation of women's businesses using ICT. The digital skills gap documented by ITU (2023), which shows that only 27% of women in the region have basic digital skills, limits the ability of many of them to reposition themselves in more lucrative digital activities. Thus, ICTs are creating new markets, but women who were engaged in traditional activities are not accessing them quickly enough, which explains the observed decline in self-employment.

5.2.Robustness of results

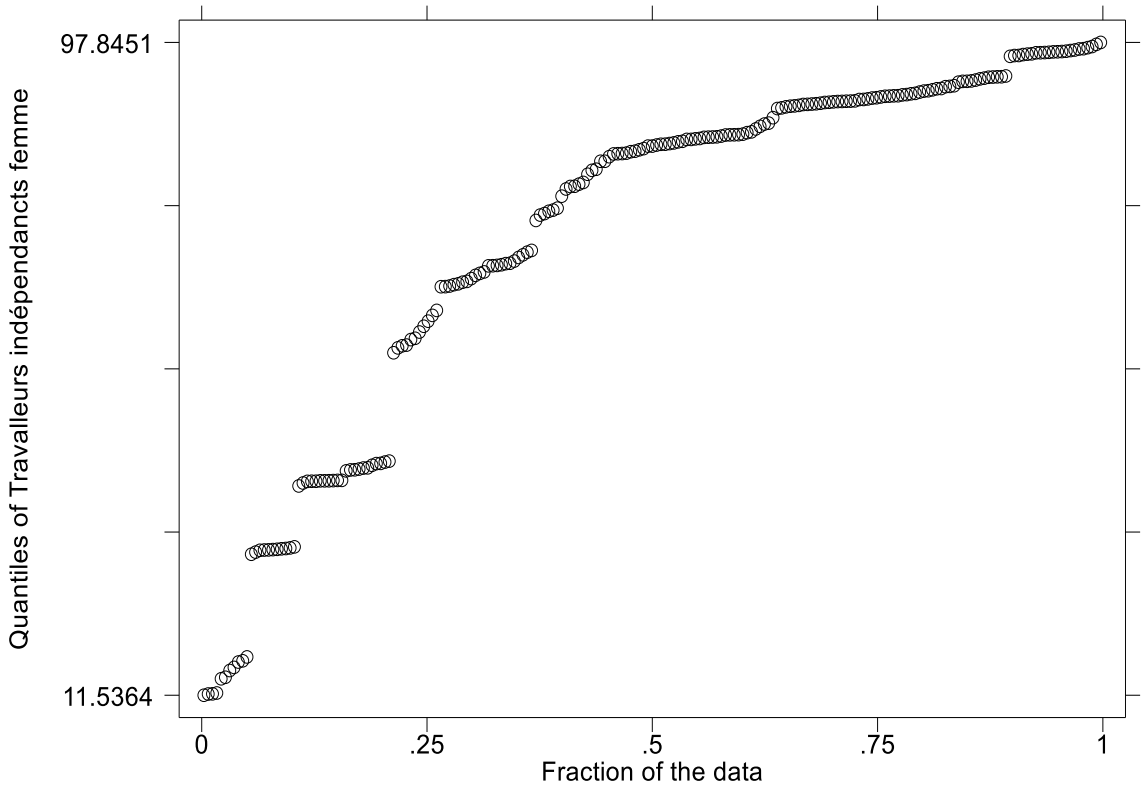
The estimates we obtained after applying the PCSE model are tested using the FGLS (Feasible Generalized Least Squares) model and the new quantile regression approach using the method of moments (MMQR).

i. Why FGLS and MMQR?

The choice of the first econometric tool to perform this test is justified by the fact that it provides unbiased and convergent results. In addition, it can jointly address the problems of autocorrelation and heteroscedasticity (Bai et al., 2021), which is not possible with some conventional panel model . The same applies to ordinary and weighted least squares methods. Indeed, these methods perform poorly when the error term coefficient is not unique and when the explanatory variables follow a typical trajectory over the long term (Lin and Omoju, 2017). In short, FGLS has almost the same characteristics as PCSE. In other words, it is an estimation technique for which the conditions of use are met in the context of this work, and whose results can be compared with those contained in Table 4 above.

As for the second tool, developed by Machado and Santos Silva (2019), we have chosen to use it in order to take into account possible endogeneity issues and to deepen the analysis. Compared to the FGLS, it has the advantage of effectively overcoming problems relating to both the distribution and the presence of fixed effects in panel data. More specifically, it is a technique that captures the effects of ICT on several quantile values of women's self-employment, i.e., the unequal distribution of women engaged in income-generating activities, whether self-employed or not. Indeed, Figure 3 below shows that within our sample, the proportion of self-employed workers changes as we move from one quantile to another. Specifically, the number of self-employed workers is low, medium, and high in quantiles 0.25, 0.50, and 0.75. Hence the interest in exploring the effects of ICT in each quantile to see whether these changes conceal intra-group specificities.

Graph 3: Quantile diagram



Source: Author based on STATA

Based on the work of Machado and Silva (2019), the conditional quantile of a random variable is $Q_{y_{it}}(\delta / \hat{X}_{it})$. Consequently, our diagnosis can be based on equation (5) below:

$Y_{it} = \mu_i + \ddot{X}_{it}\phi + \left(\dot{\Delta}_i + Z'_{it}a\right) U_{it}$ (5) . According to Ike et al (2020), this equation can take the following form:

$$Q_{y_{it}}(\delta / \hat{X}) = (\mu_i + (\dot{\lambda}_i \rho_i \varphi(\dot{\delta})) + X\phi + \ddot{Z}_{it}' a\varphi(\dot{\delta}) \text{ (6).}$$

Ultimately, equations (2), (3), and (4) for estimation purposes take the following MMQR form:

$$Q\text{self-employment}_{it}(\frac{\dot{\delta}_k}{\mu_i}, \hat{X}_{it}) = \mu_i + \phi_{1\delta} \times \text{mobile phone subscriptions}_{it} + \phi_{2\delta} \times \text{total fertility rate}_{it} + \phi_{3\delta} \times \text{political stability}_{it} + \phi_{4\delta} \times \text{religious freedom}_{it} + \phi_{5\delta} \times \text{GDP per capita}_{it} + \phi_{6\delta} \times \text{Quality of education}_{it} + \varepsilon_{it} \text{ (7)}$$

$$Q\text{self-employment}_{it}(\frac{\dot{\delta}_k}{\mu_i}, \hat{X}_{it}) = \mu_i + \phi_{1\delta} \times \text{fixed telephone subscriptions}_{it} + \phi_{2\delta} \times \text{total fertility rate}_{it} + \phi_{3\delta} \times \text{political stability}_{it} + \phi_{4\delta} \times \text{religious freedom}_{it} + \phi_{5\delta} \times \text{GDP per capita}_{it} + \phi_{6\delta} \times \text{Quality of education}_{it} + \varepsilon_{it} \text{ (8)}$$

$$Q\text{self-employment}_{it}(\frac{\dot{\delta}_k}{\mu_i}, \hat{X}_{it}) = \mu_i + \phi_{1\delta} \times \text{internet usage}_{it} + \phi_{2\delta} \times \text{total fertility rate}_{it} + \phi_{3\delta} \times \text{political stability}_{it} + \phi_{4\delta} \times \text{religious freedom}_{it} + \phi_{5\delta} \times \text{GDP per capita}_{it} + \phi_{6\delta} \times \text{Quality of education}_{it} + \varepsilon_{it} \text{ (2)}$$

ii. Estimates using FGLS and MMQR: what are the diagnoses?

The results shown in Table 5 below are estimates based on the FGLS and MMQR. With regard to the FGLS, we find that, overall, the results obtained are identical to those produced by the PCSE. Indeed, in model 2, the variable of interest "Mobile_subscription" is significant and has a negative effect on self-employment. In addition, the variables "fertility rate" and "GDP/capita" are significant and have the same sign as those in the PCSE. It is also clear that the effect of "Mobile_subscription" is less pronounced in this new estimate, as its coefficient is 0.03 compared to 0.05 in the PCSE. As for model 3, the finding is almost the same, since the control variables "fertility rate" and "GDP/capita" remain significant at the 1% threshold and retain their negative signs. The same is true for the variable "fixed_subscription," which is also significant at the 1% threshold and has a negative sign. Similarly, its effect also becomes less pronounced, as indicated by its coefficient, which rises to -0.76 from -0.86 previously. In model 4, we observe a slightly different trend, which is justified by the significance of the GDP/capita variable, whereas it was not significant previously. On the other hand, the "Internet use" variable remains insignificant, thus foreshadowing a preference for leisure rather than work online among a number of self-employed workers. This assumption can be partly explained by the COVID-19 period, when it was found that, due to lockdowns, many self-employed workers recorded drastic reductions in their working hours in favor of leisure. Based on all these findings, we can therefore say that the results we obtained after applying the PCSE are robust.

The MMQR also confirms the robustness of the PCSE results. Indeed, whether using model 7 or model 8, the coefficients associated with the variables "Mobile phone subscription" and "Landline subscription" are both significant and negative in the three quantiles (0.25, 0.50, and 0.75). However, this general view masks some specific features. The first is that in model 7, the effect of mobile phone subscription on self-employment is higher with the MMQR than with the PCSE. The second relates to the decrease in the effect of landline subscription on self-employment in model 8 as we move towards the highest quantiles.

In both models, another control variable is also significant. This is "quality of education," whose positive coefficient in the 0.25 and 0.50 quantiles reveals the importance of human capital in the creation of income-generating activities. Thus, the accumulation of this capital in an environment where opportunities for women are few and far between enables women to awaken their creative genius in order to participate in economic activity in general, and in the future of their households in particular. It should be noted that the variables "fertility rate" and "GDP" retain their signs and significance in these two models, particularly at the 0.25 and 0.50 quantiles.

Finally, in model 4, a major finding is the significance of the "Internet use" variable, which was initially insignificant at both the PCSE and FGLS levels. This discovery proves that these two tools, although renowned for correcting heteroscedasticity and autocorrelation biases, are limited in analyses based on statistical distribution splitting. In fact, the MMQR highlights in this case that internet use has a negative effect on self-employment in the 0.25, 0.50, and 0.75 quantiles. This result therefore reinforces the lesson that in countries where women struggle to work individually to support themselves, ICTs tend to steer them towards networks of women entrepreneurs. Thus, we can say that the MMQR provides additional information that confirms the trends shown after applying the PCSE and FGLS.

Table 5: *Results of estimates by the FGLS and quantile regression by the method of moments (MMQR)*

Variables	(2)	(3)	(4)	(7)			(8)			(9)		
	FGLS			MMQR								
				0.25	0.50	0.75	0.25	0.50	0.75	0.25	0.50	0.75
Mobile subscription	-0.039**			-0.282*	-0.251	-0.207*						
	(0.053)			(0.000)	(0.000)	(0.000)						
Fixed subscription		-0.760*					-0.847*	-1.240*	-1.535*			
		(0.000)					(0.000)	(0.000)	(0.000)			
Net user			0.007							-0.310	-0.280*	-0.234
			(0.784)							(0.020)	(0.009)	(0.035)
Total fertility rate	7.391*	6.016*	7.425*	6,953*	8,662*	11,076*	5,247*	6,844*	8,040**	7,226*	9,020*	11.732*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.008)	(0.033)	(0.000)	(0.000)	(0.000)
Political stability	-0.029	-0.192	-0.307	1.466	1.706	2.045	-3.107*	0.559	3.306	0.456	2.471	5.518**
	(0.973)	(0.764)	(0.666)	(0.477)	(0.370)	(0.354)	(0.213)	(0.883)	(0.545)	(0.876)	(0.298)	(0.024)
Freedom of religion	0.129	0.122	-0.145	3.956*	2.921**	1.460	2.191	-0.325	-2.212	0.893	-0.918	-3.658**
	(0.852)	(0.817)	(0.802)	(0.008)	(0.033)	(0.356)	(0.177)	(0.895)	(0.532)	(0.642)	(0.563)	(0.024)
Ln(GDP/h)	-0.002*	-0.002*	-0.002*	-11.122*	-7.678*	-2.815	-17.218*	-7.206**	0.295	-11.629*	-6.713**	0.722
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.168)	(0.000)	(0.056)	(0953.)	(0.000)	(0.016)	(0.793)
Quality of education	2.305	1.891	-0.071	28.895*	18.882**	4.746	60.787*	25,117	-1.608	36,301**	17,467	-11.016
	(0.640)	(0.615)	(0.986)	(0.004)	(0.041)	(0.655)	(0.000)	(2,202)	(0.953)	(0.013)	(0.157)	(0.374)
Constant	48,880*	52,208*	45.688*	119,355*	98,935*	70,106*	137,248*	92,724*	59,365	108,542*	85,761*	51.308**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.173)	(0.000)	(0.000)	(0.012)
Wald chi2(6)	257.38	243.59	213.70									

Source: Authors using STATA software

6. Conclusion and economic policy implications

In SSA, women are playing an increasingly important role in the survival of low-income households. Their active participation in the family economy is undoubtedly the result of inclusive employment policies implemented by the public authorities in these countries, with the support of development partners such as the World Bank. These efforts contribute to reducing inequalities in the labor market and thus to job creation for women in various sectors. However, the sub-sector of self-employment for women does not seem to be experiencing the same dynamism.

In view of this context, we undertook this research to analyze the reasons for this contrast. To this end, we explored the role of ICTs, as they theoretically have the power to create but also to destroy jobs. This study therefore systematically and rigorously explores the effects of information and communication technologies (ICT) on women's self-employment in 19 sub-Saharan African countries offering few economic opportunities. The results obtained using the PCSE and confirmed by the FGLS and MMQR show that the three dimensions of ICT have a negative effect on women's self-employment. Mobile phone subscriptions significantly reduce the percentage of women working for themselves, as do landline subscriptions. The effect of internet use, which is less pronounced in the main model, appears clearly negative in the quantile regressions, confirming the internal consistency of the results. Thus, contrary to some of the literature that associates digital technology with an increase in self-employment thanks to the reduction of barriers to entry and the expansion of entrepreneurial opportunities, our results show that, in countries where economic opportunities for women are limited, the expansion of ICT does not translate into more self-employment, but rather into a shift towards other organizational strategies for women.

This finding can be explained by the specific characteristics of the countries considered. In environments where credit constraints, restrictive social norms, economic insecurity, and domestic responsibilities severely limit women's ability to engage in individual entrepreneurship, women find cooperatives to be a more secure, flexible, and profitable means of conducting income-generating activities. ICTs play a decisive role in this regard, as far from merely promoting individual digital entrepreneurship, they facilitate the structuring, coordination, and productivity of cooperative work. In addition, thanks to mobile phones and the internet, women can organize remote production chains, pool inputs, share information in real time, take training courses, access digital markets, and maintain their activities even when their mobility is limited. Digital technology therefore acts as a catalyst for the women's cooperative economy, rather than a driver of expansion for individual self-employment.

This mechanism can also be observed in relation to risk. In contexts where women are more exposed to economic instability, membership of a cooperative is a risk reduction strategy. ICTs help to strengthen this collective security by facilitating the use of platforms for management, cash flow monitoring, member coordination, and activity planning. Cooperatives also offer joint guarantees that promote access to credit, a crucial element in countries where women face persistent barriers to obtaining individual financing. ICTs thus amplify the advantages of collective organizations by enabling modern, efficient, and transparent management, which enhances their attractiveness compared to traditional self-employment.

The policy implications of this study are profound. First, our results show that promoting ICTs is not enough to stimulate female individual entrepreneurship in countries where the economic environment is not inclusive. ICT will only have a transformative effect if it is accompanied by

policies aimed at strengthening women's economic rights, simplifying access to credit, and creating an environment conducive to individual initiative. Second, public policies should recognize and support women's cooperatives as economic actors in their own right, capable of absorbing economic shocks, generating stable incomes, and modernizing local value chains through digital technology. Finally, it is important to develop digital skills training programs tailored to the needs of women, especially those engaged in networked activities, in order to optimize productivity gains. Finally, this article paves the way for future research on the effects of ICT on women's self-employment by sector of activity.

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