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**Working Paper**

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# A G D I Working Paper

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**Fintechs and the financial inclusion gender gap in Sub-Saharan African countries**

**Aurelien K. Yeyouomo**
CEREG, University of Yaoundé 2, Soa, Cameroon
E-mail: aurelien_kamdem@yahoo.fr

**Simplice A. Asongu**
African Governance and Development Institute,
P.O. Box 8413, Yaoundé, Cameroon
E-mails: asongusimplice@yahoo.com,
asongus@afridev.org

**Peter Agyemang-Mintah**
College of Business, Zayed University, Abu Dhabi,
P.O. Box 144534, Abu Dhabi, United Arab Emirate, UAE
E-mail: z10875@zu.ac.ae

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Research Department

# Fintechs and the financial inclusion gender gap in Sub-Saharan African countries

**Aurelien K. Yeyouomo, Simplice A. Asongu & Peter Agyemang-Mintah**

## Abstract

This study addresses the issue of financial innovation in developing countries, focusing specifically on the role fintechs have in closing the gender gap of financial inclusion in Sub-Saharan Africa (SSA) over the period 2011-2017. The empirical evidence is based on the multilevel tobit regression model fitted to panel data. The results of this study show that fintechs reduce the financial inclusion gender gap by mitigating the gender gap in access to and use of financial services. Furthermore, they cast doubt on the ability of fintechs development to bridge this gap on its own, and hint on the joint importance of targeted policy initiatives aimed at directly closing the gender gap to this end. These findings have important economic policy implications and provide evidence of improved economic conditions for women in terms of financial inclusion leading to a narrowing of the gender gap.

Keywords: Fintechs development, financial inclusion gender gap, Tobit, SSA.

## 1. Introduction

The importance of gender financial inclusion in sustainable development is no longer to be demonstrated (Adegbite and Machethe, 2020). Indeed, gender financial inclusion contributes to poverty reduction by improving women's income; family well-being and contributing to a significant increase in household savings levels (Swamy, 2014). Similarly, gender financial inclusion promotes entrepreneurship, agriculture, and inclusive economic development (Meunier et al., 2017; Cabeza-García et al., 2019; Atakli and Agbenyo, 2020). Despite the recognition of the contributions of gender financial inclusion in economic and sustainable development, the gender gap in financial inclusion still persists in developing countries, including sub-Saharan Africa (SSA) (Demirgüç-Kunt et al., 2018). More importantly, Demirgüç-Kunt et al. (2013) demonstrated that, in the case of developing countries, women are more often excluded in the use of financial services and this gap is justified by inequalities in terms of income, education and employment. Moreover, Kumar and Pathak (2022) show that being a woman implies lower levels of financial inclusion.

Yet policies that address the 'financial inclusion gender gap' positively influence women's inclusion by smoothing consumption, increasing savings and investment, facilitating new business opportunities and therefore lead to economic development (Trivelli et al., 2018). However, closing this gender gap in financial inclusion appears to be one of the key objectives of the 21$^{st}$ century (Adegbite and Machethe, 2020). This is even more valid for SSA which, apart from achieving sustainable development objectives, is facing post-Covid 19 recovery. Besides, failure to take gender inequality into account in the design of policies responses to Covid 19 will rather lead to the worsening of inequalities within economies (Zimmerman et al., 2020).

Thus, both at the individual and global levels, persistence of the search for solutions in reducing this gap in terms of financial inclusion justifies the renewed interest in the literature (Khera, 2018; Barooah et al., 2018; Sahay and Cihak, 2018; Adegbite and Machethe, 2020; Chen et al., 2021; Asongu and Odhiambo, 2022). To this end, majority of works looking for the causes and mechanisms of reduction of this gap have associated it with several variables. These include education (Pahlevan et al., 2022); socio-cultural norms (AFI, 2016); requirements for holding formal accounts with financial institutions (AFI, 2017); unemployment (Botric and Broz, 2017); legal discrimination (Demirgüç-Kunt et al., 2013); income level (Swamy, 2014); the level of economic development (Mukong et al., 2020) and

fintechs[1] (Sioson and Kim, 2019). Further, the evidence of this gap is sparely studied in developing countries, particularly in SSA despite the fact that it persists (Mndolwa and Alhassan, 2020). With regard to fintechs in particular, very few studies associate them in reducing the financial inclusion gender gap. This is unfortunate given the rise and development of fintechs[2] around the world and particularly in SSA (Soutter et al., 2019; Hinson et al., 2019).

For this purpose, Demirgüç-Kunt et al. (2018) observe that more than half of those who do not benefit from formal financial services live in developing economies, including those in SSA. In addition, women are less likely to manage household finances or participate in the stock market; they have lower bank account ownership rates than men; and therefore, less financially included (Demirgüç-Kunt et al. 2018; Guiso and Zaccaria, 2021). Therefore, to close the gender gap in access to financial services, fintechs present themselves as the solution (Demirgüç-Kunt et al., 2018). Indeed, any impact of fintechs on financial inclusion will be followed by the reduction of the gap in terms of financial inclusion between men and women (Sahay et al., 2020). Fintechs will thus promote the application of any new legislation or the use of any new institutional mechanism to improve financial inclusion in developing economies. Moreover, a better knowledge of the consequences of fintechs on financial inclusion in terms of gender would probably make it possible to remove the ambiguity relating to the latter through the different dimensions of financial inclusion, including access and use (Chen et al., 2021); and certainly, to explain the failure of certain financial inclusion policies, all aimed at accelerating sustainable development (Demirguç-Kunt et al., 2018).

However, the literature dealing with the direct link between fintechs financial inclusion gender gap is still embryonic. To our knowledge, two main approaches are opposed in the analysis of this relationship. The first is the pessimistic approach which clearly states that fintechs cannot bridge the financial inclusion gap between men and women; and could instead make it worse by fostering a gender gap in fintech adoption and use. This is justified by the fact that women are less likely to use fintechs because of their attitude towards the latter and their costs (Chen et al., 2021; Cheah et al., 2021). In this regard using a survey of 28 countries, Chen et al., (2021) find however a significant gender gap in fintechs. More concretely, they find that 29% of men using fintechs products and services against only 21%

[1] Financial Stability Board (2017) defines fintech as technology-based financial innovation that can result in new business models, applications, processes, or products and has a significant effect within the financial system.

[2] Arner et al. (2015) describe the development of fintechs as a continuous process in which finance and technology develop and lead to many incremental innovations such as online banking, mobile payments, crowdfunding, peer-to-peer loans, robotics advice and online identification.

of women; with this gap present in all the countries in their sample; which hinders financial inclusion and promotes a gender gap. Therefore, women being the most affected by poverty, are thus overrepresented among the unbanked in most economies (Molinier and Quan 2019).

It is no less for Cheah et al. (2021); who examine the gender division in the Association of Southeast Asian Nations (ASEAN) payment system (both in terms of traditional and digital forms) and establish that the gender gap persists especially as it pertains to models involving mobile money. The corresponding findings show that traditional payment methods like cash are more likely to be used by women in contrast to fintechs and that age exacerbates the gender division in using financial institutions for payment. This reflects the fact that the development of fintechs will be to the detriment of women in terms of financial inclusion, not least, because they are less willing to use innovative financial services unlike men.

In the same vein, Demirgüç-Kunt et al. (2018) state that one billion of financially excluded adults worldwide own a mobile phone and around half a billion have access to the Internet. However, a significant gender gap is apparent in the use of internet that continues to increase. The gap is greater, at 31%, in countries that are least developed. Subsequently, they report that 72% of men versus 65% of women have a bank account globally. Additionally, they estimate that women are 26% and 33%, respectively, less likely to use mobile internet and mobile money. Marital status is also a significant factor, given that single women are in some circumstances discouraged from owning and using mobile phones while married women whose use it are monitored and controlled by their husbands or fathers and brothers (Kofman and Payne, 2021).

Likewise, for the possession of a mobile phone, gender gap continues to grow. To this end, Demirguç-Kunt et al. (2018) establish that, compared to men, women in middle- and low-income countries are 10% less likely to own a mobile phone. And even in scenarios in which cell phones are owned by women, they tend to use these cell phones less frequently compared to men. This, *inter alia*, shows the interconnected feature of social and technological factors that should be understood for digital financial services with a view to improving people's living conditions. In addition, there are other factors at individual, local and global levels that must be considered for fintechs to deliver their promises.

It is then that the second category of studies, considered optimistic, clearly underlines the contribution of fintechs in reducing the financial inclusion gender gap. Among these works, there is that of Suri and Jack (2016) based on a panel of households in Kenya between 2008 and 2014. They show that fintechs have enabled 194000 Kenyan households to get out

of extreme poverty, with the impact of mobile money being more pronounced for female-headed households. In this regard, the work of Sioson and Kim (2019) shows that digital financial inclusion plays an important role in reducing the gender gap in financial services. Besides, Moufakkir and Mohammed (2020) find that digital financial inclusion strengthens the functions of financial inclusion by filling its gaps through technological innovations. Moreover, through the proper application of digital financial inclusion, the financial inclusion gender gap can be minimized; given that in most developing countries, women still lag behind with respect to the ownership of formal bank accounts.

Sahay et al. (2020) using both digital financial inclusion indicators and a traditional financial inclusion index provide empirical evidence indicating that fintechs promote financial inclusion. Furthermore, they show that the gender gaps in digital financial inclusion are on average smaller than the gender gaps in traditional financial inclusion. This demonstrates that fintechs contribute to closing financial inclusion gender gaps; particularly in Africa since the Covid-19 crisis. It is in this sense that Loko and Yang (2022) point out that the development of fintechs promises to offer greater privacy and security to the traditionally unbanked or underbanked female population.

In this regard, the diagnosis of a careful reading of these works as well as related studies, in the light of fintechs development in the literature, highlights the absence of consensus in the literature on the nexus between fintechs and reduction of the gender gap in terms of financial inclusion. This underlying absence of a consensus on the externalities of fintechs, especially as it pertains to achieving inclusive development outcomes, motivates further research on the subject (i.e. as conceived within the remit of the present study) for at least three reasons. The first concerns the field of study because most studies focus on developed economies to the detriment of developing economies, in particular those of SSA. The second reason concerns the measurement of fintechs. The few studies on fintechs often approximate fintechs in a singular way by a dummy variable; or by one of its dimensions such as mobile telephony or the internet (Asongu and Nwachukwu, 2016; Chen et al., 2021; Demir et al., 2022). Access to electricity is thus absent from the analysis; yet electricity is an indispensable variable in the approximation of fintechs infrastructure in SSA (Yermark, 2018). The third reason is alarming scarcity of empirical evidence analyzing the precise link between fintechs and closing the financial inclusion gender gap (Chen et al., 2021); and even less in SSA. However, propelled by the adoption of information and communication technology (ICT), the potential of fintechs in terms of contribution to the development of economies is stronger within developing economies such as SSA than in the rest of the world

(Demirgüç-Kunt et al., 2018). Especially since Aterido et al. (2013) show the existence of an unconditional gender gap in sub-Saharan Africa in terms of financial inclusion. Moreover, the extant contemporary literature is consistent on the positions that compared to the rest of the world, concerns of income inequality, poverty and gender exclusion which are most apparent in SSA (Asongu & Odhiambo, 2018, 2019; Ngono, 2021) and represent a significant policy concerns to the achievement of most poverty and inequality-related sustainable development goals (SDGs) if not addressed (Asongu and Nting, 2022; Tchamyou, 2019, 2020). In view of the above, the question of the effect of fintechs development on financial inclusion gender gap in SSA is acute and new technologies such as fintech solutions are more believed to be particularly suited to the barriers women face (Thylin and Duarte, 2019). This article is particularly motivated by these two reasons. Firstly, we offer one of the first empirical assessments of the link between fintechs and the gender financial inclusion gap in SSA. Secondly, unlike previous empirical studies, and taking into account the specificity of SSA economies, we construct using the principal component analysis (PCA) approach following the work of Yermark (2018) an index of fintechs development specific to SSA countries. For this, in addition to considering variables such as the penetration of mobile telephony and access to broadband internet; our index also considers access to electricity for the case of SSA countries.

Our empirical strategy is based on the Tobit model to analyze the effect of fintechs in reducing financial inclusion gender gap in SSA. Thus, our results show that fintechs development are reducing financial inclusion gender gap by mitigating the gender gap in access to and use of financial services.

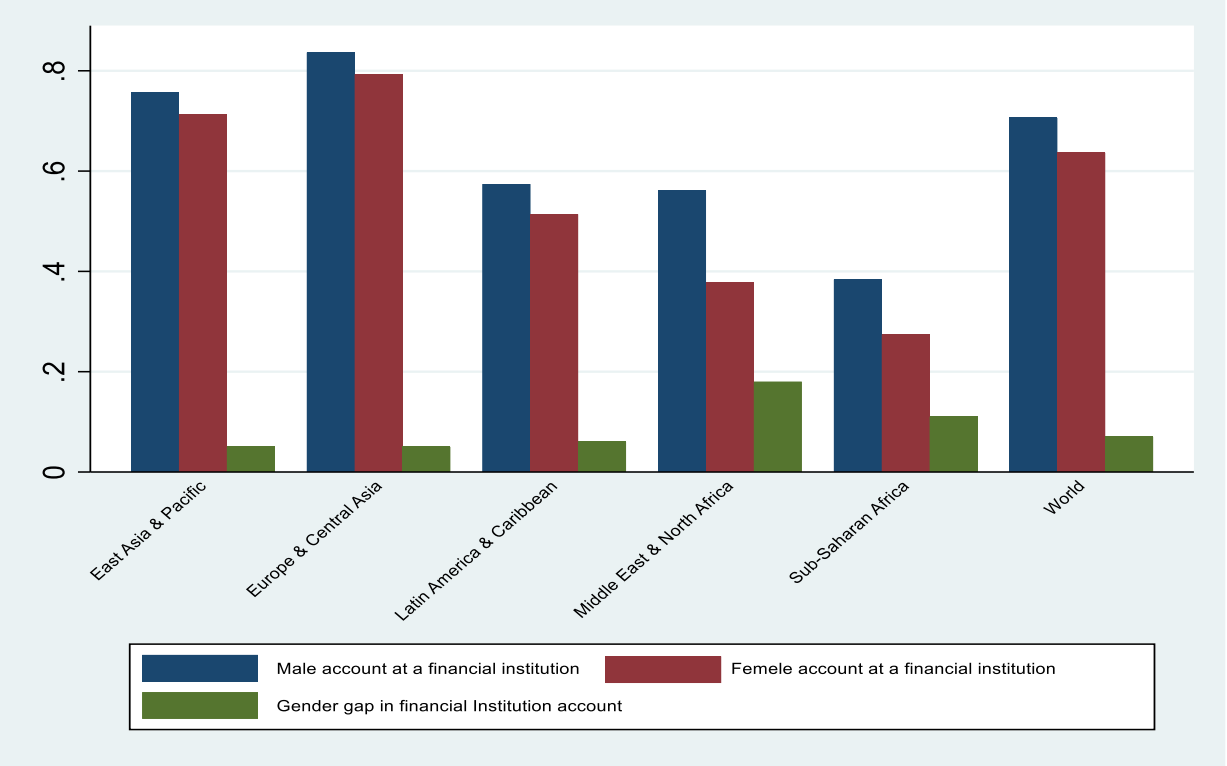
The rest of the article is structured as follows: Section 2 presents some stylized facts about financial inclusion gender gap in SSA. Section 3 presents the methodology used and describes the variables. The preliminary results, baselines and robustness checks are presented and interpreted in section 4. Section 5 concludes the article and proposes some policy recommendations.

## 2. Some stylized facts

The World Bank (2018) notes that greater labor force participation and financial inclusion by women is expected to generate an additional US$160 trillion in income. Only the World Bank (2019) reveals a financial inclusion gender gap. Thus, the comparison in terms of having an account in a formal financial institution in SSA between men and women shows that women hold fewer accounts compared to men. This gender gap in terms of access to

financial services stands out considerably in Africa compared to other regions of the world. As shown in Figure 1, in 2017, this gap was 5% in East Asia & Pacific compared to 5% respectively in Europe & Central Asia; 6% in Latin America & Caribbean; 11% in Sub-Saharan Africa; 18% in Middle East & North Africa and only 7% in the world in general.

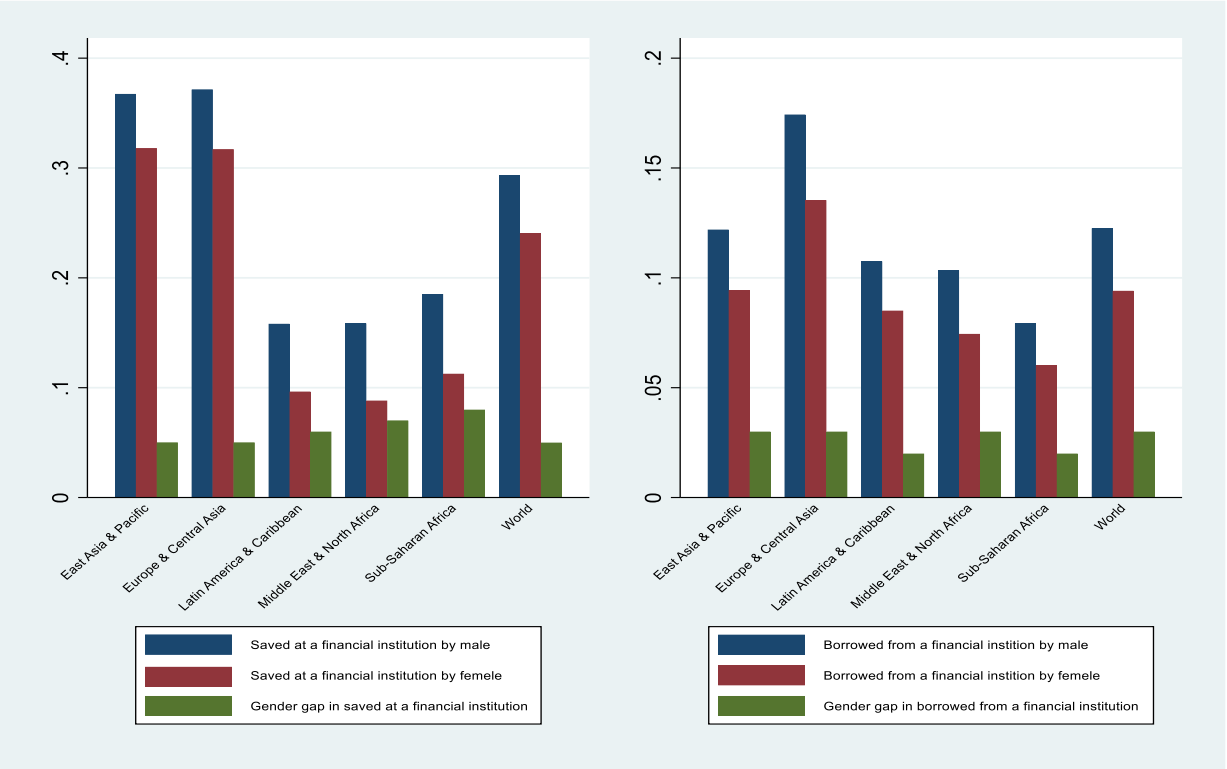
Figure 1. Average gender gap in account penetration at a financial institution across the world




Source : Authors based on data from global findex (2017)

The finding of this gender gap is the same with regard to the use of financial goods and services within formal financial institutions. In this regard, as shown in Figure 2, SSA in general lags behind with the highest percentage in terms of gender gap in the use of formal financial goods and services. This is precisely an 8% percentage difference in terms of savings within a financial institution in SSA against respectively 7% in Middle East & North Africa; 6% in Latin America & Caribbean; and 5% in East Asia & Pacific, Europe & Central Asia and the world in general. However, regarding borrowing within a formal financial institution for the year 2017, this gap is substantially the same within these different regions, oscillating between 2%and 3% with each time, women lagging behind men in both access and use of financial services.

Figure 2. Average gender gap in use of financial services at a financial institution across the world




Source : Authors based on data from global findex (2017)

## 3. Data and Methodology

### 3.1. Data

This study covers a sample of 27 countries[3] in sub-Saharan Africa over the years 2011, 2014 and 2017. Given the multitude of variables[4] considered, several data sources were used. Thus, the three main data sources are the Global Findex database, the World Development Indicators (WDI) database; and Heritage foundation.

#### 3.1.1 Financial inclusion gender gap and fintechs development variables

In line with the existing literature, the gender gap in financial inclusion is very often measured by the difference between men and women in accessing and using financial services (Adegbite and Machethe, 2020). Thus, in this study, to capture the gender gap in terms of financial inclusion, we use in turn the difference between men and women in access to and use of financial services within financial institutions (Tok and Heng, 2022).

[3] Confer table A5
[4] Confer **t**able A**1**

The fintech development variable (FINTECH) is measured through a composite index reflecting the development of fintech infrastructures, and constructed according to the PCA. For this, we use three variables which are the penetration of mobile telephony, access to broadband internet and access to electricity following the work of Yermack (2018). All these variables are extracted from the WDI.

### 3.1.2 Control variables

Control variables used are all in line with the empirical literature on financial inclusion. These are age, level of education, income, percentage of rural population, level of development, religion and economic freedom (Demirgüç-Kunt et al., 2013; Minasyan et al. al., 2019; Mndolwa and Alhassan, 2020; Adegbite and Machethe, 2020; Chen et al., 2021). The choice of these explanatory variables as determinants of the gender gap in financial inclusion is not trivial and can be justified for various reasons. In the case of age, the literature supports the fact that young people and old people face financial conditions presented in the market; especially financial institutions that charge more fees and higher interest rates. This is justified by the fact that young and old people are perceived as more at risk than middle-aged and active people (Agarwal et al., 2009).

With regard to education, a lower level of education for women makes it difficult, if not impossible, for them to access formal financial services. Likewise, due to poverty, most women do not attain high levels of education and other socio-economic opportunities (Okoyeuzu, 2020). This explains the gap in terms of financial inclusion between women and men (Demirgüç-Kunt et al., 2013; Mndolwa and Alhassan, 2020). In terms of income level, women are more likely to be poor than men, because of legal discrimination and their low level of education. Thus, making them less likely to be self-employed, formal business owners or employed by an employer. This explains the fact that they are less financially included, unlike men (Demirgüç-Kunt et al., 2013).

Religion, on its own, is also a determining factor in the analysis of the gap between men and women in terms of financial inclusion (Demirgüç-Kunt et al., 2013). Indeed, in the analysis of the role of religion in the opening of an account, credit and savings in a formal financial institution, Kim et al. (2020) provide evidence that religious discrimination represents a significant barrier to financial inclusion. Women, especially in rural areas, do not have acceptable collateral such as title deeds required by most financial institutions. Thus, the percentage of rural population can be considered as an axis of explanation of the gap between men and women in terms of financial inclusion (Manta, 2019). The level of economic

development promotes financial inclusion while allowing women to be autonomous; which could, through the education and development of women, contribute to reducing this gap in terms of financial inclusion (Ashraf et al., 2010; Duflo, 2010; Minasyan et al., 2019).

Finally, the use of the index of economic freedom is justified by the fact that the literature supports this variable as a determinant of financial inclusion. Specifically, followers of the liberal school argue that economic freedom promotes financial inclusion by reducing informality in financial markets and promoting the development of new activities (Zulkhibri and Ghazal, 2017; Wang and Guan, 2017; Bárcena-Martín et al., 2021).

In the appendices, Table A1 presents and describes the variables while the summary statistics is disclosed in Table A2. The construction of the fintechs infrastructure index by means of PCA is provided in Table A3 while the list of countries is disclosed in Table A5. The graphical representation of the fintechs infrastructure index is provided in Figure A4 whereas a mapping of fintech infrastructure development is disclosed in Figure A6.

### 3.2. Estimation strategy

For each country, the data is at both individual and country levels as individuals are nested within countries. Thus, the idea underlying this structure is that the financial inclusion of individuals is influenced by their own characteristics and by the characteristics of the countries in which they reside. Although multilevel data often violates the assumptions of linear regressions (Goldstein, 2011); multilevel models in taking into account the two-level structure of the data help to avoid these problems. The multilevel approach here is based on the fact that, on the one hand, not taking into account the existence of unobserved elements common to a group of individuals or taking into account aggregated data can induce significant errors in the interpretation of certain correlations (Robinson, 1950).

In this respect, we adopt an econometric approach inspired by the empirical strategy of Lashitew et al. (2019). Indeed, the literature provides sufficient information on the adoption of Tobit in the regression strategy when the dependent variable is censored (Ariss, 2010; Asongu and Nwachukwu, 2016; Ajide et al., 2019). In other words, the minimum and maximum values of the dependent variable that fall within a specific interval; are limited (Tobin, 1958). This is the case in this work where our dependent variables are not only in percentage but in a precise interval (table A2). Thus, the multilevel Tobit regression model is therefore required in the analysis of the relationship between fintech development and the gender gap in financial inclusion.

The choice of the Tobit method is decided by the distribution of the dependent variable. Specifically, the gender gap in financial inclusion is a continuous variable with an asymmetric distribution with a minimum value for each of the proxies considered; be a left-censored data structure. Thus, the Tobit model, as proposed by Tobin (1958), makes it possible to estimate regressions with such skew-distributed dependent variables (McDonald and Moffitt, 1980).

Thus, following the work of Tobin (1958), the following equations reflect our empirical process:

$$y_{ij}^{*} = \beta_0 + x_i\beta + z_{ij}\gamma + \varepsilon_{ij} \quad \textbf{(1)} \qquad \text{with } y_{ij} = y_{ij}^{*} \text{ if } y_{ij}^{*} > \delta \text{; and } y_{ij} = 0 \text{ if } y_{ij}^{*} \leq \delta$$

Where $y_{ij}$ is the dependent variable measuring financial inclusion gender gap. $y_{ij}^{*}$ is the latent variable; countries and individuals being indexed respectively by $i$ and $j$, $x_i$ represents the vector of country-specific characteristics ; $z_{ij}$ the vector of individual characteristics ; $\delta$ a non-stochastic constant; $\beta$ and $\gamma$ parameter vectors; and $\varepsilon_{ij}$ the vector of normally distributed error terms with mean zero and variance equal to 1.

Subsequently, we adopt this Tobit model as an empirical verification based on a multi-level approach that simultaneously estimates data at the individual level and data at the aggregate level (Kreft and de Leeuw, 1998; Maas and Hox, 2005). The model we estimate is written as follows:

$$FIGG_{ijt} = \beta_0 + \beta_1 AGE_{ijt} + \beta_2 EDU_{ijt} + \beta_3 INCOME_{ijt} + \beta_4 FINTECH_{it} + \beta_5 REL_{it} + \beta_6 GDP_{it} + \beta_7 ECOFREE_{it} + \beta_8 RPOP_{it} + \varepsilon_{ijt} \quad \textbf{(2)}$$

Where **FIGG** represents financial inclusion gender gap across the dimensions of access to and use of financial services; **AGE** the age group; **EDU** the level of education; **INCOME** the income quintile; **FINTECH** development of fintechs; **REL** religious domination; **GDP** economic development; **ECOFREE** economic freedom; **RPOP** the percentage of rural population, i, j and t respectively the country, individual and temporal indices; and finally the error term. Furthermore, given that financial inclusion can also influence fintech; this insofar as their development is also explained by the latter (Loo, 2019), we consider the endogeneity of the fintech development variable. As an alternative, we combine in our empirical approach the instrumental variable estimation approach, where we use the development of a fintech start-up in a country of the same legal origin as an instrument of the fintechs in place in a country.

## 4. Empirical results

This section reports and discusses the results of the analysis of the relationship between fintech development and the gender gap in access to and use of formal financial services.

### 4.1. Baseline Results

The empirical results present multilevel mixed effects tobit regressions considering in turn the proxies of the dimensions access and use of formal financial services as dependent variables. Although the substantial interpretation of the significant parameters is not obvious in the tobit regression, the estimates of the marginal effects thus presented in all of our various tables can provide real information on the regressors of interest (McDonald and Moffitt, 1980). Table 1 shows the results on the links between the development of fintechs and the gap in access to formal financial services between men and women through the possession of an account within a financial institution, measuring access to financial services. Table 2 presents the results corresponding to the analysis of the relationship between the development of fintechs and the gap in the use of formal financial services between men and women through savings and borrowing within a financial institution; both measuring the use of financial services.

Our first finding is that fintechs negatively and significantly influence the gender gap in financial inclusion. Indeed, the analysis of the effect of the development of fintechs on access to financial services shows us that fintechs act negatively by reducing the gap between men and women in the possession of an account within a financial institution (Table 1). It is the same for the results reflecting the effect of the development of fintechs on the use of financial services presented in Table 2 through savings (columns 1–4), and borrowing (columns 5–8) within formal institutions. Indeed, we find that fintechs are reducing the gap between men and women in the use of financial services. This is apparent both in savings and in borrowing within a financial institution.

These findings are consistent with some previous studies, such as that of Sahay et al. (2020) who find that fintechs contribute to reducing the gap between men and women in terms of financial inclusion. It is also consistent with the work of Adegbite and Machethe (2020) who find that digital financial inclusion would advance efforts to close the gender gap in financial inclusion.

**Table 1**
**Effect of fintechs on the gender gap in access to financial services**

| | Dependent variables | | | |
|---|---|---|---|---|
| | access to financial services | | | |
| | (1) | (2) | (3) | (4) |
| | Gaccount | Gaccount | Gaccount | Gaccount |
| Fintech | -0.2011*** | | | |
| | (0.0041) | | | |
| Mobile | | -0.0055*** | | |
| | | (0.0001) | | |
| Internet | | | -0.0111*** | |
| | | | (0.0002) | |
| Electricity | | | | -0.0139*** |
| | | | | (0.0003) |
| Education : Secondary | -0.00842*** | -0.0169*** | -0.0061*** | -0.0045*** |
| | (0.0003) | (0.0004) | (0.0003) | (0.0003) |
| Education: higher | -0.0204*** | -0.0015* | -0.0035*** | -0.0166*** |
| | (0.0010) | (0.0008) | (0.0008) | (0.0009) |
| Age: 25–54 years | 0.0011 | 0.0012*** | -0.0005 | 0.0002 |
| | (0.0003) | (0.0004) | (0.0003) | (0.0003) |
| Age: 55 + years | 0.0202*** | -0.0141** | 0.0022*** | 0.0139*** |
| | (0.0076) | (0.0039) | (0.0006) | (0.0007) |
| Poorer quintile | 0.0087 | -0.0006 | -0.0006 | 0.0033 |
| | (0.0005) | (0.0008) | (0.0088) | (0.0058) |
| Middle quintile | -0.0017*** | -0.0007 | -0.0022 | -0.0003 |
| | (0.0005) | (0.0005) | (0.0007) | (0.0005) |
| Richer quintile | -0.0035*** | -0.0006 | -0.0011** | -0.0009 |
| | (0.0005) | (0.0006) | (0.0005) | (0.0006) |
| Richest quintile | -0.0081*** | -0.0003 | -0.0026*** | -0.0037*** |
| | (0.0005) | (0.0005) | (0.0005) | (0.0005) |
| Religion | 0.0659*** | 0.0253*** | 0.0140*** | 0.0328*** |
| | (0.0012) | (0.0007) | (0.0004) | (0.0006) |
| Gdp | -0.253*** | -0.0881*** | -0.0469*** | -0.240*** |
| | (0.0049) | (0.0021) | (0.0007) | (0.0047) |
| Rpop | 0.0061*** | 0.0049*** | 0.0018*** | 0.0051*** |
| | (0.0003) | (0.0009) | (0.0003) | (0.0001) |
| Ecofree | -0.0063*** | -0.0045*** | -0.0056*** | -0.0041*** |
| | (0.0001) | (0.0009) | (0.0003) | (0.0007) |
| Country fixed effects | Yes | Yes | Yes | Yes |
| Observations | 79553 | 79553 | 79553 | 79553 |
| Number of countries | 27 | 27 | 27 | 27 |

Source : Authors
Note : *, **, ***, significance levels of 10%, 5% and 1% respectively. Gaccount, Gender gap in formal account ownership; Gdp, GDP per capita; Rpop, rural population; Ecofree, efficiency of the economy.

**Table 2**
**Effect of fintechs on the gender gap in the use of financial services**

| | Dependent variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Use of financial services | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | Gsavings | Gsavings | Gsavings | Gsavings | Gloans | Gloans | Gloans | Gloans |
| Fintech | -0.210*** | | | | -0.0550*** | | | |
| | (0.0031) | | | | (0.0021) | | | |
| Mobile | | -0.0058*** | | | | -0.0015*** | | |
| | | (0.0008) | | | | (0.0005) | | |
| Internet | | | -0.0033*** | | | | -0.0116*** | |
| | | | (0.0001) | | | | (0.0001) | |
| Electricity | | | | -0.0037*** | | | | -0.0145*** |
| | | | | (0.0001) | | | | (0.0002) |
| Education: Secondary | -0.0072*** | -0.0161*** | -0.0001 | 0.0003** | -0.0007*** | -0.0031*** | -0.0048*** | -0.0032*** |
| | (0.0002) | (0.0003) | (0.0001) | (0.0001) | (0.0001) | (0.0002) | (0.0002) | (0.0002) |
| Education: higher | -0.0256*** | -0.0026*** | -0.0001 | -0.0054*** | -0.0047*** | -0.0013*** | -0.0078*** | -0.0131*** |
| | (0.0006) | (0.0005) | (0.0003) | (0.0003) | (0.0004) | (0.0003) | (0.0005) | (0.0005) |
| Age: 25–54 years | -0.0012*** | 0.0022*** | -0.0002 | -0.0003** | -0.0003* | -0.0006*** | 0.0004** | 0.0012*** |
| | (0.0002) | (0.0002) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0002) | (0.0002) |
| Age: 55 + years | -0.0236*** | 0.0009*** | -0.0005 | -0.0032*** | -0.0049*** | 0.0009*** | 0.0048*** | 0.0171*** |
| | (0.0005) | (0.0003) | (0.0002) | (0.0003) | (0.0003) | (0.0002) | (0.0003) | (0.0004) |
| Poorer quintile | -0.0005 | -0.0001 | -0.0003 | -0.0006** | -0.0004** | -0.0003 | -0.0001 | 0.0008** |
| | (0.0003) | (0.0003) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) |
| Middle quintile | -0.0013*** | 0.0013*** | -0.0001 | -0.0001 | 0.0003 | -0.0004* | -0.0002 | 0.0002 |
| | (0.0003) | (0.0003) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) |
| Richer quintile | -0.0026*** | 0.0012*** | -0.0005** | -0.0005** | -0.0085*** | -0.0011*** | -0.0006** | -0.0004 |
| | (0.0003) | (0.0003) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) |
| Richest quintile | -0.0082*** | 0.0041 | -0.0007*** | -0.0004* | -0.0007*** | -0.0014*** | -0.0023*** | -0.0035*** |
| | (0.0003) | (0.0003) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) |
| Religion | 0.0608*** | 0.0345*** | 0.0047*** | -0.0004 | 0.0094*** | 0.0155*** | 0.0066*** | 0.0262*** |
| | (0.0009) | (0.0005) | (0.0002) | (0.0003) | (0.0006) | (0.0003) | (0.0003) | (0.0005) |
| Gdp | -0.2641*** | -0.0922*** | 0.0127*** | -0.0401*** | -0.0438*** | -0.0496*** | 0.0488*** | -0.2501*** |
| | (0.0037) | (0.0016) | (0.0003) | (0.0023) | (0.0025) | (0.0017) | (0.0005) | (0.0035) |
| Rpop | 0.0007*** | 0.0055*** | 0.0004*** | 0.0024*** | 0.0011*** | 0.0004*** | 0.0018*** | 0.0054*** |
| | (0.0002) | (0.0006) | (0.0001) | (0.0005) | (0.0001) | (0.0004) | (0.0002) | (0.0009) |
| Ecofree | -0.0066*** | -0.0047*** | -0.0001*** | -0.0008*** | -0.0014*** | -0.0015*** | -0.0006*** | -0.0043*** |
| | (0.0001) | (0.0006) | (0.0001) | (0.0004) | (0.0007) | (0.0004) | (0.0002) | (0.0003) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 79553 | 79553 | 79553 | 79553 | 79553 | 79553 | 79553 | 79553 |
| Number of countries | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 |

Source : Authors

Note : *, **, ***, significance levels of 10%, 5% and 1% respectively. Gsavings, Gender gap in savings in a formal financial institution in the last 12 months; Gloans, Gender gap in borrowing from a formal financial institution in the last 12 months; Gdp, GDP per capita; Rpop, rural population; Ecofree, efficiency of the economy.

Moreover, we find that most socio-demographic variables are significant indicators of the gap between men and women in terms of financial inclusion. Interestingly, education, age, income levels are correlated with this gap in both access (Table 1) and use of financial services (Table 2). We note for example that secondary and higher education levels are more likely to reduce this gender gap than the primary education level; as well as the highest income quintiles. Furthermore, a high age, (i.e. over 55 in the context of our analysis), favors this gap between the sexes and by extension, aged individuals are more likely to be retired and women who are the most excluded from the labor market are the least likely to benefit from retirement pensions and therefore are the most excluded financially.

These results corroborate the work of Ghosh and Vinod (2017) who find that the level of education and wages are variables that explain the obstacles to female financial inclusion. With regard to the other variables, we notice a negative influence of economic development and economic freedom, reflecting their contribution to the reduction of the gap between men and women in terms of the possession of an account within a financial institution. On the other hand, religion and rural areas present themselves as catalysts of this gap through a positive influence in the worsening of the gap between men and women (Kim et al., 2020). This negative effect of religion could be justified by the fact that it induces social norms or laws that affect the cost-benefit trade-off differently depending on gender; and thereby promotes the gender gap by discriminating against women (Hyland et al., 2020).

### 4.2. Robustness checks

In order to verify the robustness of our results, we directly analyze the effect of the development of fintechs on female financial inclusion by substituting the gender gap variable with the female financial inclusion variable both on the dimension of the access and that of the use of financial services. Indeed, Ghosh and Vinod (2017) show that female financial inclusion contributes strongly to reducing the gender gap in terms of financial inclusion. Thus, Table 3 analyzes the link between the development of fintechs and access to formal financial services by women. Table 4 presents the results of the relationship between fintech development and the use of financial services through savings (columns 1–4), and borrowing (columns 5–8) by women in formal institutions.

These results effectively confirm that fintechs promote female financial inclusion by successively improving access (table 3), savings (table 4, column [1–4]), and borrowing (table 4, column [5–8]) of financial services within formal financial institutions. They partly agree with the work of Khera et al. (2022) who find that digital financial services by facilitating easier access to finance and lowering costs, improve female financial inclusion, although their impact on gender gaps varies from country to country. On the other hand, they are in line with the work of Loko and Yang (2022) who find that the adoption of fintechs considerably improves women's employment, and reduces income inequalities between gender. Therefore, it improves financial inclusion and reduces gender inequalities. Finally, these results corroborate the study by Sioson and Kim (2019) which shows that the development of fintechs by promoting digital financial inclusion plays an important role in reducing the gender gap in financial services.

**Table 3**
**Effect of fintechs on female's access to financial services.**

| | Dependent variables | | | |
|---|---|---|---|---|
| | access to financial services | | | |
| | (1) | (2) | (3) | (4) |
| | Faccount | Faccount | Faccount | Faccount |
| Fintech | 0.804*** | | | |
| | (0.0104) | | | |
| Mobile | | 0.0224*** | | |
| | | (0.0002) | | |
| Internet | | | 0.0443*** | |
| | | | (0.0005) | |
| Electricity | | | | 0.0555*** |
| | | | | (0.0007) |
| Education: Secondary | 0.0290*** | 0.0629*** | 0.0197*** | 0.0133*** |
| | (0.0005) | (0.0008) | (0.0005) | (0.0005) |
| Education: higher | 0.127*** | 0.0395*** | 0.0596*** | 0.0206*** |
| | (0.0017) | (0.0011) | (0.0012) | (0.0012) |
| Age: 25–54 years | 0.0037*** | 0.0079*** | 0.0011** | 0.0041*** |
| | (0.0005) | (0.0005) | (0.0005) | (0.0005) |
| Age: 55 + years | 0.0923*** | 0.0057*** | 0.0206*** | 0.0674*** |
| | (0.0014) | (0.0007) | (0.0008) | (0.0012) |
| Poorer quintile | 0.0027*** | 0.0005 | 0.0001 | 0.0041*** |
| | (0.000770) | (0.0007) | (0.000769) | (0.000771) |
| Middle quintile | 0.0063*** | 0.0037*** | 0.0023*** | 0.0006 |
| | (0.0007) | (0.0007) | (0.0007) | (0.0007) |
| Richer quintile | 0.0119*** | 0.0029*** | 0.0042*** | 0.0033*** |
| | (0.0007) | (0.0007) | (0.0007) | (0.0007) |
| Richest quintile | 0.0342*** | 0.00293*** | 0.0119*** | 0.0166*** |
| | (0.0008) | (0.0007) | (0.0007) | (0.0007) |
| Religion | 0.1851*** | -0.1801*** | -0.0224*** | 0.0526*** |
| | (0.0032) | (0.0019) | (0.0011) | (0.0017) |
| Gdp | 1.1421*** | -0.2231*** | 0.3171*** | 1.0891*** |
| | (0.0124) | (0.0053) | (0.0018) | (0.0117) |
| Rpop | -0.0058 | -0.0221*** | -0.0099*** | -0.0181*** |
| | (0.0007) | (0.0002) | (0.0007) | (0.0003) |
| Ecofree | 0.0322*** | 0.0115*** | 0.0091*** | 0.0232*** |
| | (0.0003) | (0.0002) | (0.0007) | (0.0002) |
| Country fixed effects | Yes | Yes | Yes | Yes |
| Observations | 79553 | 79553 | 79553 | 79553 |
| Number of groups | 27 | 27 | 27 | 27 |

Source: Authors
Note: *, **, ***, significance levels of 10%, 5% and 1% respectively. Faccount, Ownership formal account by a female; Gdp, GDP per capita; Rpop, rural population; Ecofree, efficiency of the economy.

**Table 4**
**Effect of fintechs on the use of financial services by female.**

| | Dependent variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Use of financial services | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | Fsavings | Fsavings | Fsavings | Fsavings | Floans | Floans | Floans | Floans |
| Fintech | 0.4531*** | | | | -0.1711*** | | | |
| | (0.0038) | | | | (0.0025) | | | |
| Mobile | | 0.0126*** | | | | 0.0048*** | | |
| | | (0.0001) | | | | (0.0007) | | |
| Internet | | | 0.0249*** | | | | 0.0094*** | |
| | | | (0.0002) | | | | (0.0001) | |
| Electricity | | | | 0.0313*** | | | | 0.0118*** |
| | | | | (0.0002) | | | | (0.0002) |
| Education : Secondary | 0.0185*** | 0.0376*** | 0.0133*** | 0.0096*** | 0.0066*** | 0.0138*** | 0.0046*** | 0.0033*** |
| | (0.0003) | (0.0003) | (0.0002) | (0.0003) | (0.0002) | (0.0002) | (0.0001) | (0.0001) |
| Education: higher | 0.0693*** | 0.0198*** | 0.0311*** | 0.0141*** | 0.0249*** | 0.00622*** | 0.0105*** | -0.0068*** |
| | (0.0008) | (0.0006) | (0.0006) | (0.0007) | (0.0005) | (0.0004) | (0.0004) | (0.0004) |
| Age: 25–54 years | 0.0033*** | 0.0057*** | 0.0018*** | 0.0035*** | 0.0006*** | 0.0015*** | 0.00046 | 0.0006*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Age: 55 + years | 0.0522*** | 0.0034*** | 0.0118*** | 0.0381*** | 0.0182*** | -0.0001 | 0.0029*** | 0.0129*** |
| | (0.0006) | (0.0005) | (0.0004) | (0.0005) | (0.0004) | (0.0003) | (0.0003) | (0.0003) |
| Poorer quintile | 0.0012*** | -0.0002 | -0.0002 | 0.0019*** | 0.0008*** | 0.0002 | 0.0003 | 0.0011*** |
| | (0.0004) | (0.0005) | (0.0004) | (0.0004) | (0.0003) | (0.0002) | (0.0002) | (0.0002) |
| Middle quintile | 0.0034*** | 0.0022*** | 0.0011*** | 0.0002 | 0.0011*** | 0.0012*** | -0.0002 | 0.0001 |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Richer quintile | 0.0063*** | 0.0021*** | 0.0019*** | 0.0014*** | 0.0021*** | 0.0011*** | 0.0004* | 0.0003 |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Richest quintile | 0.0191*** | 0.0015*** | 0.0066*** | 0.0092*** | 0.0068*** | 0.0001 | 0.0021*** | 0.0031*** |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Religion | 0.1101*** | -0.0953*** | -0.0067*** | 0.0356*** | 0.0292*** | -0.0485*** | -0.0151*** | 0.0011** |
| | (0.0011) | (0.0007) | (0.0004) | (0.0006) | (0.0008) | (0.0005) | (0.0003) | (0.0004) |
| Gdp | 0.6061*** | -0.1642*** | 0.1401*** | 0.5753*** | 0.2181*** | -0.0731*** | 0.0419*** | 0.2064*** |
| | (0.0045) | (0.0019) | (0.0007) | (0.0043) | (0.0032) | (0.0013) | (0.0004) | (0.0028) |
| Rpop | -0.0007*** | -0.0117*** | -0.0049*** | -0.0109*** | -0.0001*** | -0.0045*** | -0.0019*** | -0.0039*** |
| | (0.0009) | (0.0008) | (0.0002) | (0.0001) | (0.0001) | (0.0005) | (0.0001) | (0.0007) |
| Ecofree | 0.0184*** | 0.0063*** | 0.0053*** | 0.0133*** | 0.0068*** | 0.0025*** | 0.0018*** | 0.0049*** |
| | (0.0001) | (0.0008) | (0.0003) | (0.0008) | (0.0007) | (0.0005) | (0.0002) | (0.0005) |
| Observations | 79553 | 79553 | 79553 | 79553 | 79553 | 79553 | 79553 | 79553 |
| Number of groups | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 |

Source : Authors

Note : *, **, ***, significance levels of 10%, 5% and 1% respectively. Fsavings, Savings in a formal financial institution in the last 12 months by a female ; Floans, Borrowing from a formal financial institution in the last 12 months by a female; Gdp, GDP per capita; Rpop, rural population; Ecofree, efficiency of the economy.

Moreover, fintech development contributes to closing the gender gap in financial inclusion by addressing the barriers that women face. These include the shortcomings presented by conventional banking services in being closer to consumers, presenting lower transaction fees, and simpler loan application processes, which allows them to be more able to account for and respect the individual needs of women (Genesis Analytics, 2018). However, these results indicate that fintechs, given the very low values of the coefficients reflecting their effect on financial inclusion and the reduction of the gender gap, may not be sufficient to fill this gap. They therefore suggest that fintech development should be complemented by targeted policy initiatives aimed at directly closing the gender gap and changing social norms and attitudes in the population (Tok and Heng, 2022).

## 5. Conclusion and future research directions

The objective of this article is to analyze the relationship between the development of fintechs and the reduction of the gender gap in terms of financial inclusion, on a sample of 27 SSA countries for the period 2011-2017. We retain a non-restrictive approximation of fintech development approximated by a fintech infrastructure development index constructed by us using PCA. The empirical methodology is essentially based on a multilevel tobit approach adapted to panel data. After testing the robustness of our results through the analysis of fintech development on female financial inclusion, we find that the development of fintech infrastructure by improving it reduces the gender gap in terms of financial inclusion. The results are robust and consistent with the literature on the effects of fintechs on financial inclusion. Furthermore, we find that the effect of fintech infrastructures on financial inclusion is greater when considered together rather than individually. Finally, the low magnitude of the effect of fintech infrastructure development on financial inclusion therefore suggests that in closing the gender gap in financial inclusion, fintech development should be complemented by targeted policy initiatives aimed at directly closing the gender gap in SSA.

In terms of policy implication, policies should be designed to further promote fintechs in the sampled countries. Policies in this direction can include, *inter alia*, measures that make financial services closer to present and potential customers such as services closer to consumers, presenting lower transaction fees, and simpler loan application processes.

In terms of future research direction, the study obviously leaves space for further inquiries especially as it pertains to considering complementary policy initiatives that can be used to improve the gender inclusive externalities of fintechs. This suggested future research direction can be considered within the remit of interactive regressions such that fintechs represent the main channel or independent variables of interest while the moderating or policy variables are the complementary policy initiatives. Furthermore, reconsidering the analysis within the framework of other United Nations' SDGs is worthwhile. In other words, it is both scholarly-motivating and policy-worthwhile to assess how fintechs are affecting other SDGs.

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## Appendices

## Table A1
## Presentation and description of variables

| Variables | Description | Sources |
|---|---|---|
| | **Gender financial inclusion** | |
| Gaccount | Percentage of gender gap in terms of having an account with a financial institution. It is calculated by taking the difference between the percentage of men and women with a formal account. | Global Findex database |
| Gsavings | Percentage of gender gap in terms of savings in a formal financial institution in the last 12 months. It is calculated by taking the difference between the percentage of men and women who have saved. | Global Findex database |
| Gloans | Percentage of gender gap in terms of borrowing from a formal financial institution in the last 12 months. It is calculated by taking the difference between the percentage of men and women who have borrowed. | Global Findex database |
| Faccount | Percentage of adult female with an account at a formal financial institution. | Global Findex database |
| Fsavings | Percentage of adult female who saved in a formal financial institution in the past 12 months. | Global Findex database |
| Floans | Percentage of adult female who borrowed from a formal financial institution in the past 12 months. | Global Findex database |
| | **Individual level variables** | |
| Age : 15–24 years | A dummy variable that takes the value 1 if the respondent is between 15 and 24 years old and 0 otherwise. | Global Findex database |
| Age : 25–54 years | A dummy variable that takes the value 1 if the respondent is between 25 and 54 years old and 0 otherwise. | Global Findex database |
| Age : 54+ years | A dummy variable that takes the value 1 if the respondent is older than 54 and 0 otherwise. | Global Findex database |
| Education : primary | A dummy variable that takes the value 1 if the respondent has completed primary school or less and 0 otherwise. | Global Findex database |
| Education : Secondary | A dummy variable that takes the value 1 if the respondent has completed high school and 0 otherwise. | Global Findex database |
| Education : tertiary | A dummy variable that takes the value 1 if a respondent has higher education and 0 otherwise. | Global Findex database |
| Income: poorest 20% | A dummy variable that takes the value 1 if the respondent belongs to the poorest quintile and 0 otherwise. | Global Findex database |
| Income: poorer 20% | A dummy variable that takes the value 1 if the respondent belongs to the poor quintile and 0 otherwise. | Global Findex database |
| Income: middle 20% | A dummy variable that takes the value 1 if the respondent belongs to the middle quintile and 0 otherwise. | Global Findex database |
| Income: richer 20% | A dummy variable that takes the value 1 if the respondent belongs to the rich quintile and 0 otherwise. | Global Findex database |
| Income: richest 20% | A dummy variable that takes the value 1 if the respondent belongs to the richest quintile and 0 otherwise. | Global Findex database |

| Aggregate-level variables | | |
|---|---|---|
| Fintech | This variable represents the development of fintechs, measured by a fintechs infrastructure development index calculated using a principal component approach based on broadband internet subscription per 100 people, telephone subscription mobile phone per 100 people, and the percentage of access to electricity per 1000 inhabitants. | PCA / WDI |
| Mobile | Subscription to high-speed internet for 100 people. | WDI |
| Internet | Mobile phone subscription for 100 people. | WDI |
| Electricity | Percentage of access to electricity per 1000 inhabitants. | WDI |
| Forgn | Development of a fintech start-up in a country of the same legal heritage. It is measured by a dummy variable which takes the value 1 if there has been development over the study period and 0 otherwise. | Authors |
| Religion | Dummy variable which takes the value 1 if the dominant religion within the country is Islam and 0 otherwise. | Authors |
| Gdp | Logarithm of GDP per capita in constant US dollars ($). | WDI |
| Rpop | Percentage of rural population in total population. | WDI |
| Ecofree | Score for measuring the overall efficiency of the economy. | Heritage fundation |

**Source:** Authors

**Table A2**
Descriptive statistics

| Variables | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Panel A: Gender financial inclusion** | | | | | |
| Gaccount (%) | 80687 | 0.0642065 | 0.0494234 | -0.0394446 | 0.2398557 |
| Gsavings (%) | 80687 | 0.0371993 | 0.0329568 | -0.0259714 | 0.1752866 |
| Gloans (%) | 80687 | 0.0148222 | 0.0266867 | -0.0520089 | 0.1083851 |
| Faccount (%) | 80687 | 0.222848 | 0.1817161 | 0.0145192 | 0.8663591 |
| Fsavings (%) | 80687 | 0.1008342 | 0.0765608 | 0.0070884 | 0.3429973 |
| Floans (%) | 80687 | 0.054881 | 0.0325424 | 0.0065359 | 0.1390758 |
| **Panel B: Individual level variables** | | | | | |
| **Educational Level** | | | | | |
| primary | 79687 | 0.5078997 | 0.4999407 | 0 | 1 |
| Secondary | 79687 | 0.4469361 | 0.4971794 | 0 | 1 |
| tertiary | 79687 | 0.0451642 | 0.2076655 | 0 | 1 |
| **Age group** | | | | | |
| Age : 15–24 years | 80544 | 0.3001838 | 0.4583406 | 0 | 1 |
| Age : 25–54 years | 80544 | 0.580366 | 0.4935021 | 0 | 1 |
| Age : 54+ years | 80544 | 0.1194502 | 0.3243196 | 0 | 1 |
| **Income** | | | | | |
| Income: poorest 20% | 80687 | 0.1593813 | 0.3660336 | 0 | 1 |
| Income: poorer 20% | 80687 | 0.1693953 | 0.375103 | 0 | 1 |
| Income: middle 20% | 80687 | 0.1858168 | 0.3889612 | 0 | 1 |
| Income: richer 20% | 80687 | 0.2137395 | 0.4099476 | 0 | 1 |
| Income: richest 20% | 80687 | 0.2716671 | 0.4448219 | 0 | 1 |
| **Panel C: Aggregate-level variables** | | | | | |
| Fintech | 80687 | 0,3034968 | 1,120772 | -1.370094 | 5.57464 |
| Mobile | 80687 | 79.4487 | 35.08801 | 23.43621 | 163.2901 |
| Internet | 80687 | 0.9387566 | 2.950718 | 0.0006778 | 19.45435 |
| Electricity | 80687 | 40.91998 | 24.94539 | 6.649646 | 99.4 |
| Lorgn | 80687 | 0.4819364 | 0.4996767 | 0 | 1 |
| Religion | 80687 | 0.3705925 | 0.4829665 | 0 | 1 |
| Gdp | 80687 | 7.113478 | 0.9430088 | 5.834123 | 9.230092 |
| Rpop | 80687 | 59.26683 | 16.85994 | 11.024 | 84.328 |
| Ecofree | 80687 | 55.72963 | 8.561909 | 22.1 | 76.50977 |

Source: Authors

**Table A3**

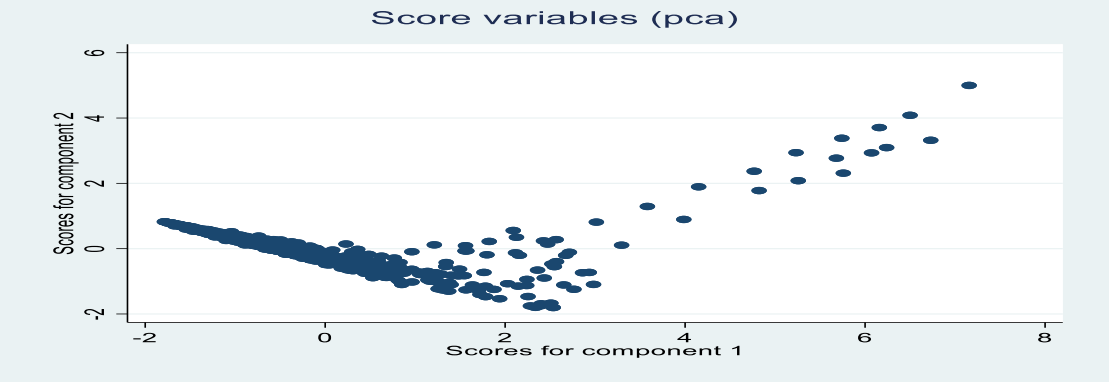
PCA result for the construction of fintechs infrastructure index

| PC | Initial Eigen values | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| Mobile | 2.053 | 68.438 | 68.438 | 2.053 | 68.438 | 68.438 |
| Electricity | 0.534 | 17.802 | 86.240 | 0.534 | 17.802 | 86.240 |
| Internet | 0.413 | 13.760 | 100.000 | | | |

Source: Authors' construction. PC: Principal component. Mobile: Penetration of mobile phone. Electricity: access to electricity. Internet: high speed internet access.

**Figure A4**

Graphical representation of the construction of the fintechs infrastructure index




Source: Authors

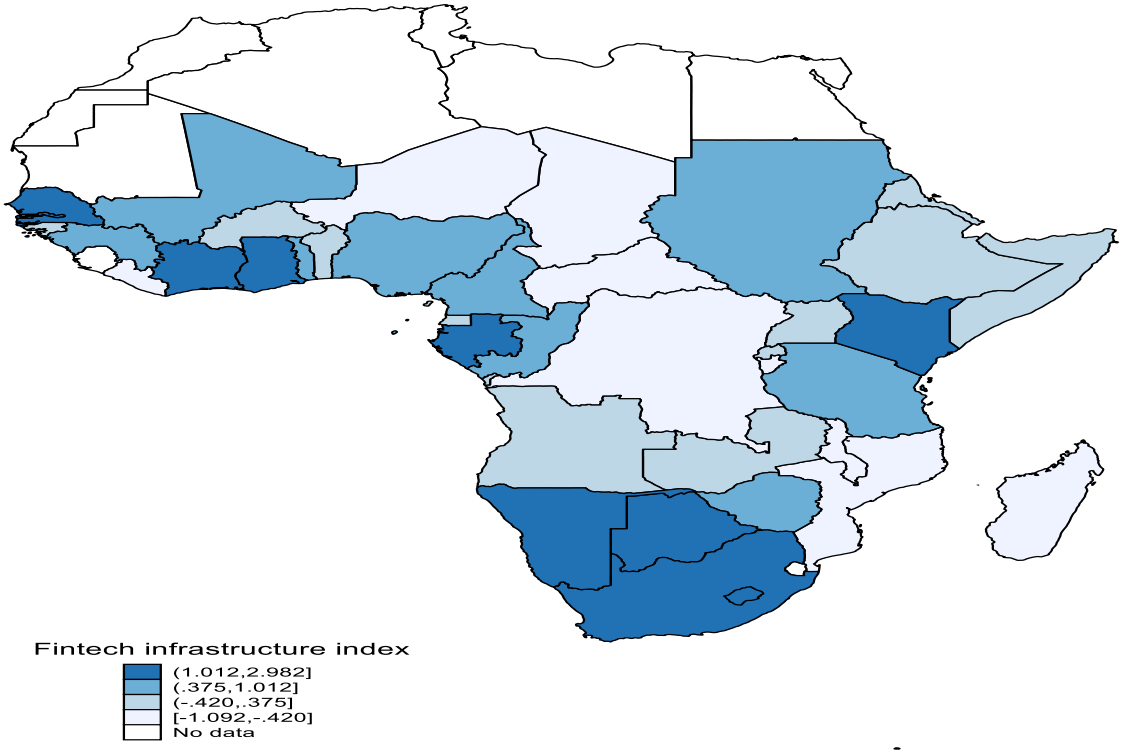
**Table A5**

List of countries

| **Dominant religion** | | | |
|---|---|---|---|
| **Christianity** | | **Islam** | **Hinduism** |
| Benin | Republic of Congo | Burkina Faso | Mauritius |
| Botswana | Rwanda | Chad | |
| Cameroon | South Africa | Guinea | |
| Democratic Republic of Congo | Tanzania | Mali | |
| Gabon | Togo | Mauritania | |
| Ghana | Uganda | Senegal | |
| Kenya | Zambia | Niger | |
| Madagascar | Zimbabwe | Nigeria | |
| Malawi | | Sierra leone | |

Source: Compiled by Authors

**Figure A6**
**Mapping of fintechs infrastructure development in SSA in 2018.**




Source: Authors' construction from World Development Indicators (WDI) database