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Mobile money innovations, income inequality and gender inclusion in sub-Saharan Africa
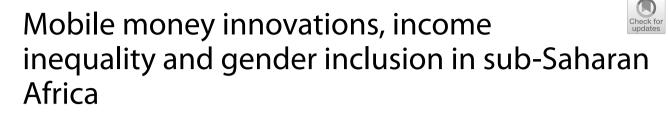
Simplice A. Asongu[1,2]*, Peter Agyemang-Mintah[3], Joseph Nnanna[4] and Yolande E. Ngoungou[5]

*Correspondence:
asongusimplice@yahoo.com;
asongus@afridev.org

[1] School of Economics, University of Johannesburg, Johannesburg, South Africa
[2] Department of Economic and Data Science, New Uzbekistan University, 54 Mustaqillik Avenue, 100007 Tashkent, Uzbekistan
[3] College of Business, Zayed University, P.O. Box 144534, Abu Dhabi, United Arab Emirates
[4] The Development Bank of Nigeria, The Clan Place, Plot 1386A Tigris Crescent, Maitama, Abuja, Nigeria
[5] University of Yaoundé 2, Soa, Cameroon

Abstract

This study assesses the role of mobile money innovations on income inequality and gender inclusion in 42 sub-Saharan African countries from 1980 to 2019 using interactive quantile regressions. It finds that, first, income inequality unconditionally reduces the involvement of women in business and politics. Second, mobile money innovations interact with income inequality to have a positive impact on women in business and politics. Third, the net effects of mobile money innovations on gender inclusion through income inequality are consistently negative. Fourth, as the positive conditional or interactive effects and negative net effects are consistent across the conditional distribution of gender inclusion, thresholds at which mobile money innovations can completely dampen the negative effect of income inequality on gender inclusion are provided. Therefore, policymakers should work toward improving conditions for mobile money innovations. They should also be aware that reducing both income inequality and enhancing mobile money innovations simultaneously leads to more inclusive outcomes in terms of gender inclusion.

Keywords: Financial inclusion, Inequality, Mobile phones, Sub-Saharan Africa, Women

JEL Classification: G20, O40, I10, I20, I32

Introduction

The motivation of the present study, which is focused on the role of mobile money innovations on income inequality and women in business and politics in sub-Saharan Africa (SSA), is based on the following four main factors: first, the exclusion of women in political and economic activities and the importance of involving women economically and politically to boost economic prosperity; second, the policy concern of income inequality and the specificity of SSA in terms of exclusive development (i.e., the inequitable distribution of economic prosperity); third, the role of mobile money innovations in inclusive development; and fourth, gaps in the existing literature.[1] The underlying motivational factors are explained in detail in the following paragraphs.

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[1] Throughout the study, "gender inclusion" is used interchangeably with women in politics and business. As clarified in Table 3 and "Data" section within the context of the study, mobile money innovations are when mobile phones are used to facilitate transactions, such as the payment of bills and sending money.

Asongu *et al. Financial Innovation*   (2024) 10:11

Page 2 of 21

First, the concern of gender inclusion prominently features among the sustainable development goals (SDGs) of the United Nations. For example, SDG 5, which is oriented toward gender equality and female empowerment, is the focus of the present study, analyzing the effects of involving more women in politics and business. Both policy and scholarly literature agree that SSA is one of the regions with the highest levels of gender exclusion, and the gender gap has led to a loss of about 160 trillion USD in gross domestic product (GDP) (World Bank 2018; Asongu et al. 2021a). This study extends the existing literature by assessing how mobile money innovations affect gender inequality in business and politics. This is essential because beyond the concern of gender exclusion, there is also a policy syndrome of income inequality, which is a substantial impediment in achieving some poverty- and inequality-related SDGs.

Second, the concern of income inequality is fundamental to achieving SDGs. For example, Bicaba et al. (2017) recently established that unless the focus of income inequality is promptly tackled in SSA, most countries in the sub-region are unlikely to achieve most SDGs by 2030. Compared with other regions, SSA has one of the highest rates of income inequality (Asongu and Nwachukwu 2016; Tchamyou 2020). Recent evidence revealed that poverty levels are still high in SSA fundamentally because of income inequality. This is because the favorable effects of economic growth are not evenly distributed across the population year after year (Tchamyou 2019). In 2019, SSA outpaced Asia and became the region with the greatest number of people living in extreme poverty (Nwani and Osuji 2020). Consistent with contemporary financial inclusion literature, income inequality can be mitigated through mobile money innovations (Awel and Yitbarek 2022; Kim 2022; Ngono 2021).

Third, the role of mobile money innovations is fundamental in achieving inclusive development, especially as they are associated with at least 8 of the 17 SDGs (UNCDF 2022). According to the narrative on the 17 SDGs, financial inclusion is linked to the first goal or SDG 1, which relates to poverty eradication; the second goal or SDG 2, which is concerned with ending hunger, boosting sustainable agriculture, and ensuring food security; SDG 3, which focuses on health and wellbeing; SDG 5, which is linked to gender equality and the empowerment of women; SDG 8, which is linked to promoting economic growth; SDG 9, which is concerned with boosting the industries, infrastructure, and innovation of nations; SDG 10, which is linked to inequality mitigation; and SDG17, which is related to consolidating the channels of implementation through partnerships, especially considering the role of financial inclusion through consolidated mobilization of investment and consumption resources (Tchamyou et al. 2019a, b; Asongu and le Roux 2019; Abdulqadir and Asongu 2022; UNCDF 2022). Given the importance of financial inclusion in achieving most of the SDGs, this study focuses on understanding how mobile money innovations can be leveraged by policymakers to promote gender inclusion through women's involvement in business and politics. This also fills the gap in the existing literature.

Fourth, the relevant literature can be categorized into two main strands—studies on mobile money innovations and research on gender inclusion. In the first strand, the literature on mobile money innovations has focused on the adoption of mobile money in response to idiosyncratic shocks (Koomson et al. 2021) and drivers of the diffusion of FinTech services in small and medium enterprises (Coffie et al. 2021). The relevance

of mobile money in utility bill payments (Awel and Yitbarek 2022) and the importance of financial inclusion in inclusive development in rural households (Serbeh et al. 2022) have also been considered in this strand. Moreover, other studies have focused on digital currency pricing (Schilling and Uhlig 2019; Biais et al. 2020; Choi and Rocheteau 2021), robust framework for the functioning of digital platforms (Eyal and Sirer 2014; Chiu and Koeppl 2019; Biais et al. 2019; Pagnotta, 2021; Saleh 2021), and digital currency mining and the establishment of related fees (Huberman et al. 2021; Easley et al. 2019).

The second strand on the linkage between mobile money innovations and gender inclusion has focused on the importance of bank mechanisms, microfinance, and mobile money in funding women's entrepreneurship in SSA (Ngono 2021). This strand is also concerned with how the financial inclusion of women is influenced by mobile money (Kim 2022). The relationships between information and communication technology (ICT) usage, mobile money, and financial access of women (Osabuohien and Karakara 2018; Asongu and Odhiambo 2018a), as well as gender disparities in financial inclusion (Mndolwa and Alhassan 2020), have also been considered in the existing literature.

The closest study to this study is that of Ngono (2021), which assessed the importance of microfinance, mobile money, and bank channels in financing women's entrepreneurship in SSA. Ngono (2021) focused on 48 countries from 2004 to 2018 using the generalized method of moments (GMM) estimation approach, finding that banking services do not have a significant impact on the self-employment of women, while mobile money and microfinance services (i.e., considered as alternatives) are significant. The present study is akin to Ngono (2021) on two fronts—(i) the relevance of mobile money in facilitating women's economic empowerment and (ii) the focus on SSA. However, the present study departs from Ngono (2021) in the following four ways: (i) data and period (42 countries from 1980 to 2019 vs. 48 countries from 2004 to 2018), (ii) methodology (quantile regressions vs. GMM estimations), (iii) outcomes of gender enhancement (political and economic empowerment vs. economic empowerment), and (iv) policy relevance (accounting for policy thresholds and initial outcome variables vs. blanket linkages based on mean values of the outcome variable). The last distinctive feature is worth elaborating on.

Regarding the fourth distinctive feature, two points are noteworthy. First, this study argues that providing the linkage between independent variables and outcomes of gender economic inclusion, as was done by Ngono (2021), has less policy and managerial implications. Moreover, the managerial implications of this study are associated with women in business, while the policy implications are related to women in politics. The present study goes beyond establishing whether mobile money has a positive or negative effect on gender economic inclusion to providing critical levels of mobile money innovation that policymakers can act upon to promote gender economic and political inclusions. Moreover, these policy thresholds are contingent on income inequality. This study establishes critical mobile money innovation thresholds that are needed to mitigate the negative effect of income inequality on the involvement of women in business and politics.

Second, the policy implications in the study by Ngono (2021) are blanket because they are based on the mean values of the outcome variable, considering the estimation technique. This study argues that such blanket policy implications can be ineffective unless

Asongu *et al. Financial Innovation*   (2024) 10:11

Page 4 of 21

they are contingent on the initial levels of the outcome variables; thus, the corresponding implications should be tailored toward existing levels of the outcome variables. In the present study, the initial levels of women in business and politics are considered in the estimation exercise such that the established linkages are contingent on the initial levels of women in business and politics. These substantiated distinctive features are framed in a quantile regression estimation framework.

This study contributes to the existing literature on new technology, work, and employment because new technologies such as mobile money innovations are employed to assess how income inequality affects women in business and politics. As argued by Freeman (2005), compared with traditional technologies, modern technologies provide more avenues for the economically excluded (e.g., such as women) to be engaged economically. This is because modern technologies such as mobile money innovations create opportunities for women to engage in work (see Whittall et al. 2009), as clarified in the theoretical underpinnings section.

By assessing the impact of mobile money innovations on income inequality in terms of women in politics and business, this study contributes to the contemporary literature on the importance of new information technologies in promoting work, labor unions, and employment (Geelan 2021; Staples and Whittall 2021; Flanagan and Walker 2021; Hennebert et al. 2021). The rest of the paper is structured as follows. The theoretical underpinnings and corresponding literature are presented in "Theoretical underpinnings and testable hypotheses" section, while the data and methodology are covered in "Data and methodology" section. "Empirical results" section provides the empirical findings, and the study concludes in "Conclusion, implications, and future research directions" section with policy implications and future research directions.

Theoretical underpinnings and testable hypotheses

This section discusses the theoretical underpinnings and corresponding testable hypotheses. It is discussed in three main strands—a discourse of the theoretical underpinnings; contextualization of the theoretical underpinnings, and presentation of the testable hypotheses based on the theoretical underpinnings and corresponding contextual clarification.

First, the theoretical underpinnings for the linkage between financial inclusion and inclusive development build on the study by Tchamyou et al. (2019a), who assessed the linkages among ICT, financial institutions, and income inequality. According to Tchamyou et al. (2019a), both information technology and financial institutions are fundamental in mitigating income inequality. This theoretical premise is consistent with the financial development and inclusive development literature, supporting the perspective that when the population is provided with financial inclusion opportunities, poverty and inequality are likely to be addressed, especially if most of those benefiting from the financial access are poor (Greenwood and Jovanovic 1990; Galor and Zeira 1993; Galor and Moav 2004; Aghion and Bolton 2005; Beck et al. 2007; Tchamyou and Asongu 2017a; Asongu and Odhiambo 2018b). As documented by Tchamyou et al. (2019a), the linkage between financial development and inclusive development is theoretically based on the extensive and intensive margin theories. These two existing theories are substantiated to elaborate the following in detail. (i) Consistent with the intensive margin theory,

inclusive development will be realized when financial services are extended to customers who are already benefiting from existing financial services. Mobile money innovations that are employed in this study as the modulating variables can be employed by financial institutions to improve access to financial services by customers. This is already apparent in most financial institutions that are leveraging on existing mobile phone platforms to improve services to their customers, especially using mobile phones to send money and to pay bills online (Lashitew et al. 2019). The theoretical strand is broadly in accordance with the study by Chipote et al. (2014). (ii) The extensive margin theory maintains that financial access can also be provided to the population that was not previously benefiting from financial services. This is the case when financial institutions leverage on existing technologies to extend their services to a previously unbanked fraction of the population. Such extension of financial services through mobile money innovations (i.e., used as moderating variables in this study) enhances inclusive development outcomes, such as reduction in income inequality and gender empowerment, which are employed in this study as the main mechanism and inclusive development outcome, respectively. This insight into the extensive margin theory is consistent with the literature on the linkage between financial inclusion and inclusive development outcomes (Odhiambo 2014; Orji et al. 2015; Chiwira et al. 2016), and such a theoretical foundation is more apparent in reducing income inequality and poverty when a substantial part of the population is not benefiting from formal financial services (Evans and Jovanovic 1989; Holtz-Eakin et al. 1994; Black and Lynch 1996; Bae et al. 2012; Batabyal and Chowdhury 2015).

Second, concerning the contextualization of the theoretical underpinnings, it is relevant to clarify that the theoretical underpinnings are premised on the importance of financial inclusion in inclusive development. Mobile money innovations used as the moderating or policy variables in this study constitute financial inclusion, while income inequality and gender empowerment in business and politics denote inclusive development. In the inclusive development context, the main channel—income inequality—is a policy syndrome or negative economic signal, while gender empowerment in business and politics are the macroeconomic outcomes. Hence, the intuition for the study is simple to follow, i.e., financial inclusion moderates the impact of income inequality on gender inclusion as income inequality reduces gender empowerment in business and politics. Accordingly, it has been documented that income inequality is negatively correlated with gender inclusion in SSA (Asongu and Odhiambo 2020).

Third, the first two points reveal that the extensive and intensive margin theories support the position that income inequality reduces inclusive development, and financial inclusion improves inclusive development. Contextualizing these two premises, the following two hypotheses are proposed:

Hypotheses 1 (H1)   Income inequality reduces the presence of women in business and politics.

Hypotheses 2 (H2)   Mobile money innovations moderate the negative influence of income inequality on the presence of women in business and politics.

Asongu *et al. Financial Innovation*   (2024) 10:11

Page 6 of 21

Data and methodology

Data

Constraints in data availability at the time of the study made us focus on 42 countries in SSA from 1980 to 2019.[2] The data are from three principal sources—the World Bank's World Development Indicators, the Global Findex database, and the Global Financial Development Database (Table 3). In this study, two main outcome variables of gender empowerment are employed—(i) women in politics, proxied with the proportion of seats held by women in national parliament (%), and (ii) women in business, proxied by women in businesses and law index score (scale 1–100). The choice of these variables is consistent with contemporary gender-inclusive development literature (Min et al. 2021; Bezinna et al. 2022; Achuo et al. 2022). Consistent with contemporary income inequality literature (Tchamyou 2020, 2021), the Gini index is used as the proxy for income inequality.

In accordance with the existing mobile money innovations literature, two mobile money innovation variables are used in the study as the moderating or policy variables (Lashitew et al. 2019; Asongu et al. 2020, 2021b). The first is mobile phones used to send money, proxied by the percentage of respondents who reported using a mobile phone to send money in the past 12 months (% age 15+). The second is mobile phones used to pay bills online, proxied by the percentage of respondents who reported using a mobile phone to pay bills online in the past 12 months (% age 15+). Missing observations are addressed using the nearest neighbor data engineering technique. This approach was used to address missing observations in the mobile money variables, which is consistent with that of Ofori et al. (2022).

To account for omitted variable bias, the following variables are controlled for and thus involved in the conditioning information set: depth of financial institutions, access to financial institutions, efficiency of financial institutions, inflation, development assistance, government expenditure, GDP growth, foreign direct investment (FDI), remittances, and trade. The choice of the variables in the conditioning information set is consistent with contemporary inclusive development and gender empowerment literature (Tchamyou et al. 2019a; Ofori et al. 2021; Asongu and Nting 2022; Asongu et al. 2021c).

Although the underlying factors in the conditioning information set have been documented to influence gender inclusion in the corresponding literature, the anticipated signs cannot be established with certainty. This is because of the empirical framework used in this study, which is nonlinear. Therefore, an interactive quantile regression technique is adopted in this study. An interactive regression is nonlinear; thus, multicollinearity concerns are always present. To avoid the pitfalls of interactive regressions documented by Brambor et al. (2006), this study controls for the potential concerns of multicollinearity by computing the net effects and thresholds to assess the impact of mobile money innovations on income inequality in terms of gender

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[2] The 42 countries are *Angola; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; Congo Democratic Republic; Congo Republic; Cote d'Ivoire; Ethiopia; Gabon; Gambia, The; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; South Africa; Sudan; Tanzania; Togo; Uganda; and Zambia.*

Asongu *et al. Financial Innovation* (2024) 10:11

Page 7 of 21

economic inclusion. According to the existing contemporary interactive regressions literature (Nchofoung et al. 2021; Nchofoung and Asongu 2022a), such a net effect of income inequality is the sum of the unconditional impact of income inequality and the conditional or interactive effect of income inequality.

The expected signs of the variables in the conditioning information set cannot be established with certainty because, on the one hand, the fact that multicollinearity concern affects the expected signs (see Asongu et al. 2020, 2021a, b, c, d) is overlooked in interactive regressions (Brambor et al. 2006), and, on the other hand, the estimated coefficients are not interpreted as is done in linear additive models as the net effects and thresholds are computed. The definitions and sources of the variables are provided in Table 3, while the summary statistics (employed for the highlighted computation of thresholds and net effects) are provided in Table 4. The correlation matrix is presented in Table 5 to complete the summary statistics.

Methodology

Based on the motivational factors disclosed in the introduction, this study aims to assess the linkages throughout the conditional distribution of the outcome variables. Hence, consistent with the motivational factors, the quantile regressions technique is chosen as an estimation approach because it enables the study to achieve its objective. The choice of the estimation approach is fundamentally motivated by departing from the approach used in the study by Ngono (2021), which is a study closest to the present study, to provide more room for policy implications. Consistent with the relevant literature, the selected estimation approach is tailored such that the corresponding findings reveal linkages with low, intermediate, and high initial levels of the outcome variables (Billger and Goel 2009; Asongu 2017; Tchamyou and Asongu 2017b; Boateng et al. 2018). One main caveat of the quantile regressions technique is that it can only be employed to obtain global impacts; therefore, country-specific studies are still recommended for policy implications.

Next, compared with ordinary least squares (OLS), which are founded on the assumption that the corresponding error terms are normally distributed, with the quantile regression approach, this assumption does not hold. Moreover, parameters are modeled at various points in the conditional distribution of the gender inclusion outcome variables. The discourse on the quantile regression approach is consistent with both contemporary and noncontemporary literature on the subject (Koenker and Bassett 1978; Keonker and Hallock 2001; Asongu 2017). In the estimation exercise, the θth quantile estimator of women in business and politics is derived by solving the optimization problem in Eq. (1), which is provided without subscripts for simplicity in presentation.

$$\min_{\beta \in R^k} \left[\sum_{i \in \{i: yi \geq xi'\beta\}} \theta \left| yi - xi'\beta \right| + \sum_{i \in \{i: yi < xi'\beta\}} (1-\theta) \left| yi - xi'\beta \right| \right],$$ (1)

where $\theta \in (0, 1)$. Compared with OLS, which is mostly based on the minimization of the total of squared residuals, the quantile regression framework consists of summing the

absolute deviations of all the corresponding quantiles. For example, in the corresponding approach, many quantiles, such as the 50th quantile or the median and the 75th quantile, corresponding to $\theta = 0.10$ and 0.75, respectively, are reduced by approximately weighing the residuals. The conditional quantile of women in business or politics, i.e., yi given xi is as follows:

$$Qy(\theta/xi) = xi'\beta\theta \tag{2}$$

For the comparative θ th quantile that is estimated, parameters that are characterized by unique slopes are modeled. The corresponding formula is parallel to $E(y/x) = xi'\beta$ in the OLS slope within which parameters are examined exclusively using the average of the conditional distribution of women in politics or business. For the model in Eq. (2), the dependent variable yi is the women in business and politics indicator, while xi contains a constant term, *inequality, mobile phones used to send money, mobile phones used to pay bills online, depth of financial institutions, access to financial institutions, efficiency of financial institutions, inflation, development assistance, government expenditure, GDP growth, FDI, remittances, and trade.*

Empirical results

Presentation of results

The empirical results are presented in this section in two tables. Table 1 presents the findings on the linkages among mobile phones used to send money, income inequality, women in politics and business, and Table 2 discloses the corresponding results related to linkages among mobile phones used to pay bills online, income inequality, and women in politics and business. The findings validate the choice of the quantile regression approach because when OLS estimates are compared with the corresponding quantile regressions estimates (i.e., throughout the conditional distribution of the outcome variables), the estimates are distinct in terms of significance, sign, and magnitude of significance.

Given the motivation of the present study and, by extension, the testable hypotheses, the study is consistent with the contemporary interactive regressions literature in computing net effects (Nchofoung et al. 2022; Nchofoung and Asongu 2022b). To examine the impact of mobile money innovation on income inequality and gender-inclusive outcome variables, the overall or net effects are computed. Such net effects embody the unconditional effects of income inequality and the conditional or interactive effects of income inequality. Moreover, consistent with the study by Brambor et al. (2006), regarding the limitations of interactive regressions, thresholds are also computed, which will be further substantiated in "Policy thresholds" section. These thresholds entail both the conditional and unconditional effects of the main independent variable or principal channel through which mobile money innovations influence the gender-inclusive outcome variables of women in business and politics.

It is relevant to substantiate the computation of net effects with an illustrative example. In the first column of Table 1 in the regressions focusing on OLS, the net effect of mobile phones used to send money on income inequality in terms of women in politics is $-0.058 = ([0.0008 \times 10.280] + [-0.067])$. In the corresponding computation, -0.067 is

Table 1 Mobile phones used to send money, inequality and women in politics and business

	Women in politics						Women in business					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
Constant	59.457**	43.114***	53.120***	62.314***	64.483***	69.079***	56.477***	36.943***	51.332***	59.385***	61.847***	68.799***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gini	−0.067***	−0.039*	−0.063**	−0.042***	−0.068	−0.067	−0.268***	−0.247***	−0.248***	−0.315***	−0.261***	−0.239***
	(0.000)	(0.085)	(0.012)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mobsen	0.022	0.307***	0.149*	0.065**	−0.012	−0.049	−0.108	−0.169	−0.266***	−0.142**	0.0003	0.034
	(0.423)	(0.000)	(0.056)	(0.038)	(0.785)	(0.350)	(0.135)	(0.172)	(0.009)	(0.030)	(0.996)	(0.785)
Gini × Mobsen	0.0008*	−0.0007	0.00004	0.00008	0.0008	0.001	0.002*	0.004**	0.004***	0.001	−0.001	0.001
	(0.074)	(0.541)	(0.791)	(0.875)	(0.284)	(0.167)	(0.087)	(0.043)	(0.006)	(0.143)	(0.435)	(0.525)
FinInDepth	3.007**	19.704***	3.408	4.097***	3.253*	0.330	18.107***	−1.633	23.172***	28.282***	23.927***	12.649***
	(0.038)	(0.000)	(0.237)	(0.000)	(0.051)	(0.866)	(0.000)	(0.721)	(0.000)	(0.000)	(0.000)	(0.007)
FinInAccess	−11.305***	−77.524***	−3.183	−0.646	−3.452*	−5.796**	24.158***	20.421***	31.454***	23.884***	14.741***	20.534***
	(0.000)	(0.000)	(0.360)	(0.645)	(0.086)	(0.014)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FinInEffic	−4.990***	3.412*	−3.034	−8.325***	−5.614***	−5.802***	11.339***	13.333***	7.457***	11.597***	15.497***	16.196***
	(0.000)	(0.059)	(0.135)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)
Inflation	0.0006***	0.0009*	0.0007	0.0005**	0.0007**	0.002***	−0.001***	−0.003***	−0.001***	−0.0008	−0.0009	−0.001*
	(0.000)	(0.086)	(0.226)	(0.040)	(0.032)	(0.000)	(0.000)	(0.002)	(0.038)	(0.114)	(0.127)	(0.098)
Foreign aid	−0.007	0.007	−0.008	−0.066***	−0.056***	−0.107***	0.071**	0.121**	0.027	0.060**	0.065*	−0.019
	(0.600)	(0.790)	(0.794)	(0.000)	(0.004)	(0.000)	(0.002)	(0.024)	(0.534)	(0.034)	(0.066)	(0.719)
Gov. Exp	0.004	0.013	−0.0006	−0.003	0.010	0.022**	0.041**	0.037*	0.031*	0.059***	0.113***	0.012
	(0.308)	(0.293)	(0.763)	(0.529)	(0.212)	(0.020)	(0.014)	(0.097)	(0.094)	(0.000)	(0.000)	(0.584)
GDPg	0.083***	0.012	0.133*	0.087***	0.044	0.010	0.239***	0.058	0.226**	0.190***	0.303***	0.426***
	(0.009)	(0.846)	(0.062)	(0.002)	(0.278)	(0.830)	(0.000)	(0.609)	(0.015)	(0.002)	(0.000)	(0.000)
FDI	0.110***	0.031	0.034	0.075***	0.059	−0.034	0.200***	0.056	0.200**	0.144***	0.436***	0.296***
	(0.005)	(0.560)	(0.565)	(0.002)	(0.088)	(0.402)	(0.000)	(0.557)	(0.011)	(0.004)	(0.000)	(0.002)
Remit	−0.038***	−0.007	−0.019	−0.031***	−0.052***	−0.063***	−0.105***	−0.069**	−0.106***	−0.114***	−0.111***	−0.129***
	(0.005)			(0.000)	(0.052)	(0.000)	(0.000)	(0.097)	(0.000)	(0.000)	(0.000)	(0.002)

Table 1 (continued)

	Women in politics						Women in business					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
	(0.000)	(0.689)	(0.372)	(0.000)	(0.000)	(0.000)	(0.000)	(0.047)	(0.000)	(0.000)	(0.000)	(0.000)
Trade	0.038***	0.053***	0.045***	0.019***	0.048***	0.053***	0.019**	0.062***	0.002	0.010	0.010	0.022
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.046)	(0.001)	(0.895)	(0.332)	(0.414)	(0.265)
Net Effects	−0.058	na	na	na	na	na	−0.247	−0.205	−0.206	na	na	na
Thresholds	83.750	na	na	na	na	na	134.000	61.750	62.000	na	na	na
R²/Pseudo R²	0.100	0.151	0.083	0.081	0.084	0.127	0.346	0.151	0.160	0.257	0.253	0.217
Fisher	21.75***						77.64***					
Observations	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680

R^2 for OLS and Pseudo R^2 for quantile regression. Lower quantiles (e.g., Q 0.1) signify nations where women in politics and women in business are least

The mean value of the mobile used to send money is 10.280. na: not applicable because at least one estimated coefficient needed for the computation of the net effect and/or threshold is not significant. The pseudo-R-squared employed is the Koenker and Machado's

Gini Income Inequality, *MobSend* Mobile phones used to send money, *FinInDepth* Financial Institutions Depth, *FinInAcc* Financial Institutions Access, *FinInEffic* Financial Institutions Efficiency. *Gov. Exp* Government Expenditure, *GDPg* Gross Domestic Product growth, *FDI* Foreign Direct Investment, *Remit* Remittances

*, **, ***Significance levels of 10%, 5% and 1% respectively. OLS: Ordinary Least Squares

Asongu *et al. Financial Innovation*   (2024) 10:11

Page 10 of 21

Table 2 Mobile used to pay bills online, inequality and women in politics and business

	Women in politics						Women in business					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
Constant	59.048***	45.858***	55.138***	62.586***	64.165***	68.336***	55.409***	29.054***	49.176***	58.473***	63.379***	69.713***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gini	−0.070***	−0.083***	−0.095***	−0.052***	−0.067***	−−0.068***	−0.240***	−0.113***	−0.198***	−0.294***	−0.242***	−0.224***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
Mobpay	0.188***	0.457***	0.192	0.148*	0.013	−0.085	−0.056	0.083	−0.210	−0.079	0.016	0.075
	(0.001)	(0.007)	(0.293)	(0.050)	(0.879)	(0.441)	(0.716)	(0.761)	(0.317)	(0.577)	(0.921)	(0.783)
Gini × Mobpay	0.003***	0.005*	0.004	0.0009	0.002*	0.003*	−0.0008	−0.0005	0.001	−0.002	−0.005**	0.002
	(0.000)	(0.054)	(0.127)	(0.467)	(0.055)	(0.055)	(0.746)	(0.912)	(0.648)	(0.431)	(0.042)	(0.669)
FinInDepth	1.895	6.096**	1.984	2.915**	3.078**	0.004	18.465***	0.739	23.901***	27.289***	24.341***	10.089**
	(0.194)	(0.036)	(0.528)	(0.025)	(0.039)	(0.998)	(0.000)	(0.875)	(0.000)	(0.000)	(0.000)	(0.033)
FinInAccess	−10.118***	−57.639***	−2.984	−0.339	−2.931	−4.086*	24.022***	30.304***	30.133***	23.827***	15.423***	24.013***
	(0.000)	(0.000)	(0.430)	(0.828)	(0.102)	(0.075)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FinInEffic	−−4.755***	4.978**	−2.013	−7.613***	−5.792***	−5.211***	11.025***	12.700***	7.795***	11.895***	12.504***	15.998***
	(0.000)	(0.014)	(0.360)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)
Inflation	0.0007***	0.0009	0.0007	0.0005*	0.0008***	0.002***	−0.001***	−0.002***	−0.002***	−0.0008	−0.001*	−0.001*
	(0.000)	(0.130)	(0.255)	(0.064)	(0.009)	(0.000)	(0.000)	(0.003)	(0.007)	(0.104)	(0.093)	(0.096)
Foreign aid	−0.022	−0.012	0.0003	−0.058***	−0.053***	−0.121***	0.078***	0.148	0.041	0.075***	0.061*	−0.052
	(0.128)	(0.723)	(0.992)	(0.000)	(0.002)	(0.000)	(0.001)	(0.007)	(0.331)	(0.008)	(0.062)	(0.342)
Gov. Exp	0.005	0.023	0.007	−0.003	0.011	0.008	0.042**	0.037	0.024	0.052***	0.112***	0.020
	(0.210)	(0.102)	(0.653)	(0.590)	(0.133)	(0.380)	(0.013)	(0.107)	(0.170)	(0.000)	(0.000)	(0.387)
GDPg	0.073**	0.003	0.180**	0.093***	0.038	0.031	0.240***	0.051	0.186**	0.217***	0.266***	0.351***
	(0.021)	(0.957)	(0.021)	(0.004)	(0.294)	(0.499)	(0.000)	(0.661)	(0.037)	(0.000)	(0.000)	(0.003)
FDI	0.119***	0.110*	0.029	0.076***	0.063**	−0.020	0.197***	0.031	0.191**	0.142**	0.385***	0.378***
	(0.001)	(0.068)	(0.655)	(0.005)	(0.040)	(0.610)	(0.000)	(0.748)	(0.011)	(0.006)	(0.000)	(0.000)
Remit	−0.056***	−0.019	−0.036	−0.034***	−0.061***	−0.067***	−0.099***	−0.074**	−0.106***	−0.099***	−0.098***	−0.134***
	(0.000)			(0.005)			(0.000)			(0.000)	(0.000)	(0.000)

Table 2 (continued)

Women in politics

	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
	(0.000)	(0.387)	(0.136)	(0.001)	(0.000)	(0.000)
Trade	0.038***	0.038***	0.031**	0.014***	0.049***	0.055***
	(0.000)	(0.002)	(0.020)	(0.007)	(0.000)	(0.000)
Net effects	− 0.058	− 0.064	na	na	− 0.059	− 0.056
Thresholds	23.333	16.600	na	na	33.500	22.666
R²/Pseudo R²	0.140	0.200	0.106	0.087	0.090	0.131
Fisher	34.82***					
Observations	1680	1680	1680	1680	1680	1680

Women in business

	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
	(0.000)	(0.040)	(0.000)	(0.000)	(0.000)	(0.000)
Trade	0.019*	0.062***	0.005	0.006	0.004	0.011
	(0.055)	(0.002)	(0.744)	(0.533)	(0.715)	(0.567)
Net effects	na	na	na	na	− 0.260	na
Thresholds	na	na	na	na	nsa	na
R²/Pseudo R²	0.345	0.147	0.160	0.260	0.257	0.215
Fisher	83.19***					
Observations	1680	1680	1680	1680	1680	1680

R^2 for OLS and Pseudo R^2 for quantile regression. Lower quantiles (e.g., Q 0.1) signify nations where women in politics and women in business are least

The mean value of the mobile used to pay bills online is 3.718. na: not applicable because at least one estimated coefficient needed for the computation of the net effect and/or threshold is not significant. nsa: not specifically applicable because a negative synergy is apparent. The pseudo R-squared employed is the Koenker and Machado's

OLS Ordinary Least Squares, *Gini* Income Inequality, *MobApp* Mobile used to pay bills online, *FinInDepth* Financial Institutions Depth, *FinInAcc* Financial Institutions Access, *FinInEffic* Financial Institutions Efficiency, *Gov. Exp* Government Expenditure, *GDPg* Gross Domestic Product growth, *FDI* Foreign Direct Investment, *Remit* Remittances

*, **, ***Significance levels of 10%, 5% and 1% respectively

the unconditional effect of income inequality on women in politics, while 10.280 is the mean or average value of mobile phones used to send money. The interactive or conditional effect of income inequality is 0.0008.

Given the above criteria, the following are established from Tables 1 and 2. First, except for the top quantile of Table 1, H1 is valid because income inequality has a negative unconditional effect on the outcome variables. Second, the validity of H2 is apparent in the (i) bottom quantiles of the right-hand side of Table 1 (i.e., focusing on women in business and mobile phones used to send money) and (ii) the 10th and top quantiles of Table 2 (focusing on women in politics and mobile phones used to pay bills online).

Third, following Brambor et al. (2006), although the criteria provided above on the validity of H1 and H2 are informative, to robustly assess the hypotheses, it is important to compute net impacts to overcome the limitation of interactive regressions documented by the authors. Moreover, as clarified in the footnotes of the corresponding tables, the net effects are computed exclusively in cases where both the conditional and unconditional effects of income equality on the outcome variables are statistically significant. Fourth, based on the computed net effects, except for the 75th quantile on the right-hand side of Table 2 (for which a negative synergy is apparent), the computed net effects are overwhelmingly negative. From the disclosed findings, the net negative effects are apparent in the (i) bottom quantile of the left-hand side of Table 1 in the regressions about mobile phones used to send money and women in business and (ii) the 10th quantile and top quantiles of the left-hand side of Table 2 in the regressions about mobile phones used to pay bills online and women in politics.

A comparison of the first three findings from the perspective of the unconditional effects, conditional or interactive effects, and net effects reveals that mobile money innovations are necessary but not a sufficient condition for the complete mitigation of the negative impact of income inequality on the outcome variables. The study finds that (i) income inequality reduces the number of women in business and politics, and (ii) mobile money innovations moderate the negative impact of income inequality on gender-inclusive outcomes. However, the positive conditional effects substantially contrast with the negative net effects as the moderating mobile money innovation variables must reach some critical levels of penetration before the corresponding mobile money innovations can completely nullify the negative impact of income inequality on the targeted gender-inclusive outcome, which is the focus of the next section on policy thresholds. Fifth, most of the control variables are significant. However, as we have clarified earlier, owing to the concern of multicollinearity that is apparent in interactive regressions, the expected signs of the variables in the conditioning information set cannot be established with certainty.

Policy thresholds

This section extends the analysis by assessing the policy thresholds. As we have discussed earlier, the purpose of the section is to establish critical aspects of the moderating variables that policymakers can directly act on to influence the targeted gender-inclusive outcomes in the desired direction. Moreover, for policymakers to act on the suggested policy thresholds, these thresholds must have economic meaning and make statistical

sense. Thus, the computed thresholds can be policy-relevant only and only if they are within the range of the summary statistics provided in Table 4. The computed thresholds should be within the minimum and maximum values disclosed in the summary statistics if policymakers are to make any tangible claims of leveraging on the suggested thresholds for policy decision-making. These underpinnings for the relevance of the policy thresholds are consistent with contemporary interactive regressions literature (Nchofoung et al. 2022; Nchofoung and Asongu 2022a).

Building on the example provided in Table 1, in the second column of the table, mobile phones used to send money thresholds at which the negative incidence of income inequality on women in politics is completely mitigated is 83.750 (0.067/0.0008) (% age 15 +). Unfortunately, the computed threshold is not policy-relevant because it is not within the statistical range (0.000–50.122) of mobile phones used to send money, as apparent in Table 4. The maximum penetration level from which policymakers can take feasible measures to increase the level of mobile phones used to send money is 50.122 (% age 15 +). By extension, all the computed policy thresholds corresponding to Table 1 do not make economic sense and thus are not policy-relevant. This is not the case for policy thresholds provided in Table 2. The thresholds for mobile phones used to pay bills online make economic sense and are policy-relevant because they are all within the statistical range provided in the summary statistics. Thus, they are within 0.000 (the minimum) and 37.104 (the maximum) because the highest threshold provided in the table is 33.500 mobile phones used to pay bills online (% age 15 +).

The establishment of mobile money innovation thresholds that mitigate the negative impact of income inequality on gender inclusion is consistent with the literature on the positive impact of mobile money innovations on gender inclusion. For example, Khera et al. (2022) demonstrated that digital financial services facilitate financial access, lower the costs of financial transactions, and enhance inclusive finance. Loko and Yang (2022) and Yeyouomo et al. (2023) also established that financial technologies improve inclusive development by reducing gender income inequalities, improving gender financial inclusion, and boosting the employment of women. This is also broadly consistent with the study by Sioson and Kim (2019), who demonstrated that improvements in financial technology are fundamental in mitigating the financial service gender gap. Moreover, the contingency of the mobile money innovation thresholds on initial levels of gender inclusion is consistent with the literature on the importance of complementing mobile innovation technologies with complementary measures when the overall impact on gender inclusion is not apparent. This perspective of complementary policies is consistent with the study by Tok and Heng (2022), especially as it pertains to variations in social norms and behavior of the population.

In summary, the results that innovations in mobile money promote gender inclusion are consistent with both empirical and theoretical literature. On the theoretical front, the findings are consistent with both the intensive and extensive margin theories discussed in "Theoretical underpinnings and testable hypotheses" section (Tchamyou et al. 2019a) that innovations in mobile money can improve gender inclusion opportunities for both existing customers (i.e., the intensive margin theory) and new customers (i.e., the extensive margin theory) of mobile money, thereby promoting the businesses of females and encouraging them to engage in politics. From an empirical standpoint,

as clarified earlier, the findings are consistent with empirical studies that support the importance of financial technologies and mobile money innovations in inclusive development outcomes, especially in households that are led by females (Suri and Jack 2016; Sioson and Kim 2019; Moufakkir and Mohammed 2020; Loko and Yang 2022; Yeyouomo et al. 2023).

Conclusion, implications, and future research directions

The criticality of gender inclusion had been fundamental in sustainable development even before the advent of the SDGs underpinning the post-2015 sustainable development agenda (United Nations 2013). The present study has contributed to scholarly and policy debate by assessing the role of mobile money innovations on income inequality and women in business and politics in 42 SSA countries from 1980 to 2019. Mobile money innovations are proxied by mobile phones used to send money and mobile phones used to pay bills online. Income inequality is proxied by the Gini index. The empirical evidence is based on interactive quantile regressions. The following are found:

First, income inequality unconditionally reduces the involvement of women in business and politics. Second, mobile money innovations interact with income inequality to have a positive effect on women in business and politics. Third, the net effects of mobile money innovations on gender inclusion through income inequality are consistently negative. Fourth, as the positive conditional or interactive effects and negative net effects are consistent across the conditional distribution of gender inclusion, thresholds at which mobile money innovations can completely mitigate the negative effect of income inequality on gender inclusion are provided. The results are contingent on existing levels of gender inclusion, proxies for gender inclusion, and the type of mobile money innovation. The policy implications are discussed next.

First, the findings are consistent with the existing income inequality literature (e.g., Bicaba et al. 2017) positing that unless income inequality is addressed, most sustainable development targets in the region will not be achieved. In this study, we have demonstrated that gender inclusion is one of such outcomes that cannot be achieved in the sub-region unless income inequality is addressed. Therefore, policymakers in the sampled countries should take the necessary measures to mitigate income inequality to provide a conducive environment for other sustainable development outcomes.

Second, as apparent in the positive interactive estimates and relevant policy thresholds, mobile money innovations not only directly mitigate income inequality but also have an indirect positive effect on gender inclusion. By implication, policymakers should work toward improving conditions for mobile money innovations because doing so will engender a plethora of positive inclusive development externalities. However, in implementing the suggested policy requirement, a distinction should be made between mobile phones used to send money and mobile phones used to pay bills online. While the recommendation for mobile phones used to pay bills online is directly apparent, the corresponding recommendation on mobile phones used to send money should be interpreted cautiously. This is essential because compared with mobile phones used to pay bills online, the thresholds of mobile phones used to send money are beyond the policy range.

Third, reducing both income inequality and enhancing mobile money innovations simultaneously leads to more gender inclusion. Hence, beyond considering idiosyncratic policy measures of either reducing income inequality or increasing the penetration of mobile money innovations, simultaneous policies that mitigate income inequality and improve mobile money innovations should be considered. Fourth, the pertinence of the above three policy recommendations is contingent on three main factors. The findings depend on proxies for gender inclusion (women in business vs. women in politics). The findings also depend on existing levels of gender inclusion (bottom quantiles vs. top quantiles of gender inclusion) and the type of mobile money innovation (mobile phones used to send money vs. mobile phones used to pay bills online).

Fifth, the underlying implications also double as managerial implications because women in business is employed as an outcome variable. This is because while the outcome variable of women in politics is about the role played by women in political governance, the outcome variable of women in business is about female managers. Therefore, industry leaders should pay attention to the fact that industries can contribute to improving the involvement of females in business by allocating funds for more research and development to provide more innovations in mobile phones, especially as it pertains to using mobile phones to send and receive money and pay bills. Moreover, policies of equal pay between men and women will go a long way to reduce income inequality, which is essential for promoting gender economic inclusion. Furthermore, the main theoretical implication is that mobile money innovations support both the intensive and extensive margin theories on the relevance of inclusive finance in inclusive development in terms of gender inclusion.

The results of this study make room for future research, especially as concerns the engagement of other policy channels (i.e., positive economic measures) and policy syndromes (i.e., negative economic measures) through which innovations in mobile phones can affect gender inclusion in terms of women in politics and business. As income inequality, gender empowerment, and financial inclusion through mobile money innovations are the main indicators of interest associated with the targeted SDGs, future research can consider other SDGs to provide more insights into the linkages among income inequality, financial inclusion, and sustainable development. In this suggested future research direction, emphasis should be placed on continents and regions in which concerns about exclusive development are high.

Furthermore, as clarified in the methodology section, a limitation of the quantile regressions technique is that it can only be employed to obtain global impacts, and, therefore, country-specific studies are still recommended for policy implications that are specific to countries. Hence, in future research, cross-country cluster analysis on the extent of payment innovations should be considered to further elucidate the engagement of women in politics and business. For instance, countries in SSA are different in terms of political, economic, social, and cultural perspectives (e.g., South Africa vs. Somalia). Accounting for these factors in future research will add value to this field of research.

Appendix
See Tables 3, 4, and 5.

Table 3 Definitions and sources of variables

Variables	Definitions	Sources
Women in politics	Proportion of seats held by women in national parliament (%)	WDI (World Bank)
Women in business	Women businesses and law index score (scale 1–100)	WDI (World Bank)
Income inequality (Gini)	"The Gini coefficient is a measurement of the income distribution of a country's residents"	WDI (World Bank)
Mobile send	The percentage of respondents who report using a mobile phone to send money in the past 12 months (% age 15+)	GFDD (World Bank)
Mobile payment	The percentage of respondents who report using a mobile phone to pay bills in the past 12 months (% age 15+)	GFDD (World Bank)
Financial institutions depth index	"*The Financial Institutions Depth (FID) Index, which compiles data on bank credit to the private sector, pension fund assets, mutual fund assets, and insurance premiums (life and non-life) as percentages of GDP*"	Findex (World Bank)
Financial institutions access index	"*The Financial Institutions Access (FIA) Index, which compiles data on the number of bank branches and the number of automatic teller machines (ATMs) per 100,000 adults*"	Findex (World Bank)
Financial institutions efficiency index	"*The Financial Institutions Efficiency (FIE) Index, which compiles data on the banking sector's net interest margin, the lending–deposits spread, the ratios of non-interest income to total income and overhead costs to total assets, and the returns on assets and equity*"	Findex (World Bank)
Inflation	Inflation, consumer prices (annual %)	WDI (World Bank)
Foreign aid	Net Official Development Assistance received (% of GNI)	WDI (World Bank)
Government Expenditure	General government final consumption expenditure (% of GDP)	WDI (World Bank)
Economic growth	GDP growth (annual %)	WDI (World Bank)
Foreign investment	Foreign direct investment, net inflows (% of GDP)	WDI (World Bank)
Remittances	Remittance inflows (%GDP)	WDI (World Bank)
Trade	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product	WDI (World Bank)

GDP Gross Domestic Product, *GNI* Gross National Income, *WDI* World Development Indicators, *IMF* International Monetary Fund, *GFDD* Global Financial Development Database

Table 4 Summary statistics

	Mean	S.D.	Min	Max	Obs
Women in politics	56.527	8.310	25.000	73.100	1680
Women in business	54.703	15.147	17.500	91.900	1680
Inequality (Gini)	53.250	19.829	0.000	86.832	1680
Mobile send	10.280	13.011	0.000	50.122	1680
Mobile payment	3.718	5.154	0.000	37.104	1680
Financial institutions depth	0.097	0.147	0.000	0.880	1680
Financial institutions access	0.077	0.128	0.000	0.880	1680
Financial institutions efficiency	0.494	0.199	0.000	0.990	1680
Inflation	32.026	593.191	− 13.056	23,773.13	1680
Foreign aid	11.345	11.527	− 0.250	94.946	1680
Government expenditure	5.353	25.868	− 17.463	565.538	1680
GDP growth	3.635	5.173	− 50.248	35.224	1680
Foreign direct investment	2.938	6.456	− 28.624	103.337	1680
Remittances	4.385	17.842	0.000	235.924	1680
Trade openness	67.240	35.588	6.320	311.354	1680

SD Standard Deviation, *Min* Minimum, *Max* Maximum

Table 5 Correlation matrix (uniform sample size: 1680)

	WoPol	WoBiz	Gini	Mobsen	Mobpay	FID	FIA	FIE	Infl	NODA	Gov	GDPg	FDI	Remit	Trade
WoPol	1.000														
WoBiz	0.098	1.000													
Gini	−0.127	−0.363	1.000												
Mobsen	0.126	−0.007	−0.051	1.000											
Mobpay	0.234	−0.058	−0.035	0.873	1.000										
FID	−0.014	0.299	0.001	0.024	0.056	1.000									
FIA	−0.092	0.406	−0.156	−0.081	−0.100	0.412	1.000								
FIE	−0.150	0.297	−0.034	−0.089	−0.087	0.312	0.305	1.000							
Infl	0.037	−0.072	0.012	−0.017	−0.017	−0.025	−0.022	0.001	1.000						
NODA	0.021	−0.098	0.097	0.083	0.117	−0.251	−0.164	−0.264	−0.013	1.000					
Gov	0.018	0.095	0.017	0.016	0.001	0.036	0.018	0.073	−0.095	−0.092	1.000				
GDPg	0.055	0.114	0.005	0.043	0.044	0.001	0.029	0.069	−0.062	−0.017	0.146	1.000			
FDI	0.118	0.190	−0.094	−0.031	−0.040	0.058	0.196	−0.010	−0.017	0.069	0.031	0.081	1.000		
Remit	−0.016	−0.107	0.044	0.037	0.180	0.111	−0.013	−0.052	−0.009	0.034	0.088	0.031	0.014	1.000	
Trade	0.115	0.181	−0.040	−0.062	−0.005	0.255	0.380	0.005	−0.028	−0.056	0.083	0.059	0.308	0.305	1.000

WoPol Women in Politics, *WoBiz* Women in Business, *Gini* the Gini Coefficient, *Mobsen* Mobile phones used to send money, *Mobpay* Mobile used to pay bills online, *FID* Financial Institutions Depth, *FIA* Financial Institutions Access, *FIE* Financial Institutions Efficiency, *Infl* Inflation, *NODA* Foreign Aid, *Gov* Government Expenditure, *GDPg* Gross Domestic Product growth, *FDI* Foreign Direct Investment, *Remit* Remittances

Abbreviations

SSA   Sub-Saharan Africa
SDGs   Sustainable development goals
GDP   Gross domestic product
ICT   Information and communication technology
GMM   Generalized method of moments
FDI   Foreign direct investment
OLS   Ordinary least squares

Availability of data and materials

The data for this paper is available upon request.

Declarations

Competing interests

The authors have neither financial nor non-financial competing interests.

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