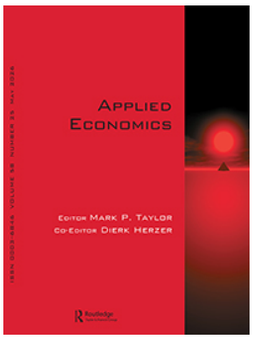

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Mobile money and business performance in the ECOWAS region: the role of the innovation ecosystem

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ABSTRACT

This article examines the impact of mobile money on the labour productivity of firms in nine ECOWAS countries. Using propensity score matching and inverse probability-weighted regression adjustment, we find that firms using mobile money are more productive than those that do not. This result remains robust to endogeneity concerns. Heterogeneity analyses reveal that SMEs benefit from mobile money adoption, whereas large firms do not. Furthermore, we find that mobile money has a positive and significant effect on the productivity of service firms but not that of manufacturing firms. Further investigations reveal that mobile money adoption contributes to firms' performance, particularly in countries with a relatively mature innovation ecosystem, albeit with important nuances. SMEs and service businesses benefit from the adoption of mobile money regardless of the maturity level of the innovation ecosystem. In contrast, large businesses and manufacturing businesses gain nothing from mobile money in contexts where the innovation ecosystem is underdeveloped. These findings highlight the importance for policy makers of strengthening the innovation ecosystem, including by promoting the interoperability of payment systems, removing barriers to mobile money adoption by businesses, and improving and harmonising regulations to foster national and regional interoperability. Lastly, it is important that policies targeting businesses are size and sector specific.

KEYWORDS
Mobile money; labour productivity; innovation ecosystem

JEL CLASSIFICATION
G23; L25

I. Introduction

Economic growth theories emphasise the importance of continuous and inclusive innovation for improving business productivity (Schumpeter, 1934; Solow 1987). Innovation, as a dynamic process, modifies business practices, technologies, markets and institutions, strengthening their competitiveness (Mohamed 2023; Lorenz and Pommet 2021). For example, digital payments, in particular mobile money, represent an important form of innovation in developing countries. Mobile money allows financial services to be offered via cell phones, enabling transactions such as payments, fund transfers and e-money storage without the need to open a traditional bank account (Demirguc-Kunt et al. 2018; Jack and Suri 2014). Since its appearance in the Philippines in 2001 and its successful launch in Kenya in 2007, it has been identified as a key way to advance the financial inclusion of households and businesses in developing countries, which are characterised by high demand for liquidity and limited banking infrastructure (Estel Apeti 2023; Jack and Suri 2014).

In 2022, the Global System for Mobile Communications Association (GSMA, 2024) reported a total of 356 million mobile money accounts in West Africa, of which 84 million were active, with a total transaction volume reaching $347 billion, or 4.1% of regional GDP. The GSMA (2024) anticipates annual growth of 15% between 2024 and 2025, a sharp increase in the adoption of mobile money in the region.

The Economic Community of West African States (ECOWAS) has specific characteristics that make studying the impact of mobile money in that region highly relevant. First, it exhibits significant institutional and economic homogeneity in terms of the integration and development objectives it sets for its member states. It aims, in particular, to harmonise the policies of its member states in the areas of

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(i) trade, customs, immigration, and payments; (ii) industry, agriculture, and natural resources; (iii) transport, telecommunications, and energy; and (iv) social and cultural affairs. The region is the most integrated in Africa and has allowed the free movement of people, capital, and goods since the early 1980s, with a common passport in effect since 2000. ECOWAS countries can thus be considered as a single entity working towards common goals with joint resources beyond national initiatives. In line with its financial-integration goals, the ECOWAS Commission intends to develop a regional payment and settlement system in cooperation with relevant institutions. Indeed, mobile money appears to be one of the key instruments to be explored and utilised in support of this objective. Second, West Africa is one of the areas of the continent in which mobile money has been adopted most rapidly over the past decade, making it the driving force behind mobile money in 2023 (GSMA 2024), with growing use in commercial transactions, service payments, and interpersonal transfers. Third, in an environment where access to formal finance remains limited, mobile money is a key lever for financial inclusion, enabling businesses and households to circumvent certain structural constraints. These characteristics make ECOWAS a prime site for examining the role of financial technologies in economic transformation and offers lessons for other regions with similar characteristics.

Mobile money increases production and sales (Tengeh and Talom 2020), reduces operating and financial-transaction costs (Jack and Suri 2014), facilitates access to credit and loans (Beck et al. 2018) and promotes business investment (Islam, Muzi, and Rodriguez Meza 2018). Despite the rapid expansion of mobile money in West Africa, its impact on business performance remains underexplored, and the results in the empirical literature ar mixed and fragmented depending on the context (Oduro, De Nisco, and Mainolfi 2023). Some studies have identified a positive effect of mobile money on business performance (Mohamed 2023; Beck et al. 2018; Islam, Muzi, and Rodriguez Meza 2018), while others find no direct significant link between these (Bastian et al. 2018; Konte and Korku Tetteh 2023).

In this context, the innovation ecosystem may explain the divergence of results in existing empirical analyses. This article analyzes the impact of mobile money on business performance, as measured by labour productivity, in the ECOWAS region, with regard to the innovation ecosystem.

Adner (2006) defined an innovation ecosystem as a set of collaborative arrangements by which companies combine their individual offerings into a coherent solution for customers. In a broader approach, Adner (2017) saw the innovation ecosystem as the alignment structure of the multilateral set of partners that must interact for a focal value proposition. As such, it is a mapping of a set of components with their own characteristics, leading Granstrand and Holgersson (2020) to define it as an evolving set of actors, activities and artefacts, as well as institutions and relationships, including complementarity and substitution relationships, that are decisive for the innovation performance of an actor or population of actors. It thus constitutes an inter-organisational structure (Lepoutre and Oguntoye 2018) for achieving a common goal, which is referred to as the ecosystem value proposition (EVP), and each actor's contribution is determined by howvalue is distributed within the ecosystem. If, for whatever reason, one actor in the system stops contributing to the production of the EVP, the result is a reduction in the chances of success for the ecosystem as a whole (Lepoutre and Oguntoye 2018).

Using data from the World Bank Enterprise Surveys, we have first assessed the impact of mobile money on firm performance and shown the heterogeneity of this effect according to firm size and sector. The World Bank Enterprise Surveys' dataset is the only one of its kind that covers many countries and allows for analyses and recommendations at the global scale. It is worth mentioning that the enterprise surveys are conducted with the same methodology across countries. It is also, to our knowledge, the only cross-country database that includes detailed information on firms' use of mobile money. Although the data are slightly dated, these surveys remain, to the best of our knowledge, the only source of data currently available for this type of analysis at the ECOWAS level. This study aims to pave the way for future research in the region as new, related data become available.

Second, we have highlighted whether countries' innovation ecosystems matter in explaining the contribution of mobile money to firm performance. We have measured the innovation ecosystem using the Global Innovation Index (GII) from the World Intellectual Property Organization (WIPO).

This study is grounded in Solow's productivity paradox, which posits that there is no clear positive relationship between investment in information and communication technologies (ICT) and productivity (1987). Solow attributed this result to three main factors: the under-measurement of productivity gains from ICT, time lags in technology adoption and organisational adjustment, and the uneven allocation of ICT across sectors. Early empirical studies were often imprecise due to reliance on aggregated data that could obscure substantial sectoral variations in productivity gains (Stiroh 2002). However, more recent research, leveraging firm-level data and advanced empirical methods, has generally identified a positive effect of ICT adoption on productivity (Konte and Korku Tetteh 2023; Cusolito, Lederman, and Peña 2020; Paunov and Rollo 2015). Nevertheless, in the context of our study, it may be that mobile money does not drive firm performance, or the estimated effect may be highly context-dependent. Indeed, developing countries, especially those within ECOWAS, face particular challenges, including limited digital infrastructure, high costs associated with mobile money usage, and a lack of user trust, all of which reflect a poor innovation ecosystem. This may obscure the impact of mobile money on firm productivity. As such, we conjecture that mobile money may drive firm performance, depending on the level of maturity of the innovation ecosystem.

Using propensity score matching (PSM) and inverse probability-weighted regression adjustment (IPWRA), our results show that firms using mobile money are more productive than those that do not. The heterogeneity analyses reveal that small and medium-sized businesses (SMEs) benefit from mobile money adoption, whereas large businesses do not. They also show that mobile money has a significant and positive effect on the performance of service firms but does not affect that of manufacturing firms. Our empirical analysiss also shows that in the ECOWAS region the impact of the adoption of mobilemoney on firms' performance is particularly felt in relatively mature innovation ecosystems. This is particularly the case for large businesses and manufacturing businesses. However, SMEs and service-sector businesses benefit from the adoption of mobile money whatever the maturity level of the innovation ecosystem.

The remainder of the article is organised as follows: Section II presents a review of the literature on the relationship between the adoption of mobile money and business performance and the role of the innovation ecosystem. Section III outlines the methodology employed and the data sources. Sections IV, V, and VI present the results, their robustness, and heterogeneity, and the Section VII concludes.

II. Literature review

Schumpeter (1935) highlighted the decisive role of innovation in driving the economic system through a process of creative destruction. In the context of developing countries where the adoption of ICTs remains relatively low, innovation requires the simultaneous mobilisation of technical features (tangible and intangible) and skills (internal and external) to deliver final features or services (Gallouj and Weinstein 1997). Innovation, whatever its form, can only be meaningful if it is disseminated to the stakeholders for whom it is intended. Broad dissemination can only be achieved through institutional arrangements, such as laws, regulations or other measures that support the actors concerned and help overcome resistance to change (Lèvesque and Lajeunesse-Crevier 2005). This means that every innovation needs an ecosystem that is conducive to its dissemination. The impact of mobile money may also depend on the ecosystem. The ecosystem involves various players, namely mobile operators, retail providers, end users, regulatory bodies and financial institutions. Each of these actors impacts the ecosystem through their roles, capabilities, objectives and challenges.

The concept of the innovation ecosystem was employed by Lepoutre and Oguntoye (2018) to explain differences between Nigeria and Kenya in terms of mobile-money penetration, even though each country is the largest economy in its respective region (West and East Africa) and

both are English-speaking. The authors highlighted components of the mobile-money ecosystem, with particular emphasis on mobile-money operators and regulators as characteristic elements of each country's institutional and industrial conditions, which, in the case of Nigeria, prevent it from reaching a level of adoption similar to that of Kenya. They also highlighted the knock-on effects or externalities, which, in the case of a payment system such as mobile money, assumes that the resulting value is positively correlated with the number of users and the scale of the network (Avom, Bangakè, and Ndoya 2023).

The literature on the impact of the use mobile money on businesses performance shows that it improves companies' ability to innovate. Lorenz and Pommet (2021) studied the relationship between the adoption of mobile money by businesses and their ability to innovate in three East African countries, namely Tanzania, Uganda and Kenya. They showed that mobile money had a positive impact on the likelihood of businesses in these countries introducing new products to the market and adopting new organisational methods and practices. Similarly, Tiwasing et al. (2024) showed that companies that use mobilemoney services were more likely to develop product and process innovations, compared to those that do not. Using a sample of 5,553 businesses in 16 sub-Saharan African countries, Osei-Tutu and Taylor (2024) used the mean propensity score, supplemented by the instrumental variable method, to show that mobile money positively impacts businesses' ability to innovate in terms of their products and processes.

The use of mobile money promotes businesses investment. Islam, Muzi, and Rodriguez Meza (2018) studied the relationship between the adoption of mobile money and private businesses investment in Tanzania, Uganda and Kenya, concluding that mobile money significantly promoted the purchase of fixed assets by enabling businesses to reduce their transaction costs, increase their liquidity and improve their creditworthiness. Islam and Muzi (2022) showed that the use of mobile money facilitated investment (asset purchases) by women-owned SMEs; the effect was insignificant for their male counterparts.

Mobile money transactions also boost businesses profits through increased sales. Mohamed (2023) showed that the use of mobile money by Somali SMEs improved their performance, as reflected in sales growth. Indeed, a 1% increase in businesses use of mobile money led to growth of 11.14%, through improved access to finance, sales growth, product development and reduced operational risks. In a study of informal businesses in Zambia, Hassan (2024) also found that those that used mobile money were more likely to record higher profits from sales. In the same vein, Nan and Park (2022) concluded that mobile money enabled Zambian businesses using this system to better withstand the economic shocks induced by the COVID-19 pandemic. Companies using mobile money were less likely to experience a drop in sales than their non-user counterparts, whose sales were 31% lower. Tengeh and Talom (2020) focused their analysis on SMEs in Cameroon, showing that mobile money helped increase sales by 73%.

In contrast to the work cited above, Konte and Korku Tetteh (2023) identified no significant direct effect of mobile money on business productivity, based on World Bank survey data from 14 sub-Saharan African countries. Similarly, in a randomised study among women micro-entrepreneurs in Tanzania, Bastian et al. (2018) found that the use of mobile money did not significantly boost investments, sales or profits. Kabengele and Roessling (2022) similarly concluded that mobile money did not contribute significantly to improving the productivity of formal businesses in Zambia, Mozambique and Zimbabwe, based on a sample of 994 micro businesses and SMEs. Considering technologies in a broad sense, Santos Dalenogare et al. (2018) concluded that digital technologies had no significant effect on the financial performance of businesses in the industrial sector in Brazil.

The relationship between the innovation ecosystem and business performance has attracted growing academic interest in recent years (see Faissal Bassis and Armellini 2018; Xie and Wang 2020). It is widely recognised that successful adoption of technology by businesses cannot be achieved in isolation (Fan Li and Garnsey 2014). In addition to companies' internal efforts to improve their

performance, external conditions (often beyond their control) are essential (Faissal Bassis and Armellini 2018). These conditions include, for example, the inclination of customers to use the technology, often facilitated by the emergence of startups offering innovative solutions tailored to these technologies, as well as the establishment of a regulatory framework guaranteeing harmonious interactions.

The maturity of the ecosystem as a whole plays a decisive role in the adoption of new technology (Parente et al. 2021). The mobile money ecosystem is a complex, interconnected network of players that includes government agencies and regulators (who fund research and development , issue regulations and protect the financial system's stability), mobile network operators (who provide communications infrastructure and services, and ensure agent supervision and quality control), financial institutions (who offer mobile banking services, process mobile financial transactions and ensure compliance with financial sector regulations), agents (who perform cash-in and cash-out functions and process mobile money account-opening procedures) and finally, consumers who use mobile money for their well-being (Parente et al. 2021; Xie and Wang 2020). These actors are interdependent in the innovation process, and their interactions influence the performance of the ecosystem as a whole and that of each individual actor.

A more mature innovation ecosystem, therefore, allows more effective collaboration between these participants The success of mobile money depends both on the intrinsic technology and the synergy of the various elements of the innovation ecosystem that catalyse its adoption and use. In particular, the development of startups offering solutions that facilitate the use of mobile money amplifies the impact of these payments on businesses performance (Robertson, Caruana, and Ferreira 2023). Despite the extensive literature on mobile money and businesses performance, there is little empirical evidence on this point for West African countries. Moreover, the role of the innovation ecosystem in which these payment systems evolve is largely underexplored. This study addresses this gap by analysing the role of the innovation ecosystem in the relationship between mobile money and businesses productivity in the ECOWAS region.

III. Methodology and variables

Our study assesses the impact of mobile money on businesses productivity. In this section, we present the model specification, the empirical approaches, as well as the variables and the sources of data used in the study.

The PSM method

We rely on the PSM method to assess the impact of mobile money on business performance. Using this approach allowed us to compare the performance of businesses that use mobile money and those that do not, conditional on their observed characteristics. Given that the two situations (use and non-use of mobile money) cannot occur simultaneously within the same business at any given time according to our data, the PSM method proposes a suitable way for establishing a rigorous comparison (Koomson, Martey, and Etwire 2023). Businesses decide whether or not to adopt mobile money for their transactions, and this decision is influenced by multiple business-specific characteristics, which may introduce selection bias. Indeed, businesses using mobile money can be differentiated from those not using it by their initial characteristics (Tiwasing et al. 2024). Comparing these two groups without taking these initial differences into account can therefore lead to bias (Rosenbaum and Rubin 1985a).

We mitigate this potential bias associated with confounding variables by relying on the PSM method, which allows for a comparison of businesses that use mobile money to the counterfactual of those that do not, based on the observed characteristics. This makes it possible to more reliably assess causal effects in observational studies like this one (Koomson, Martey, and Etwire 2023). This effectively reduces selection bias and balances confounding variables between the groups being compared (Rosenbaum and Rubin 1985a). The PSM mechanism involves matching businesses in the two groups, those using mobile money (treatment group) and those not using it (control group), by calculating a propensity score that summarises the observed characteristics of the two groups in a single measure (Koomson, Martey, and Etwire 2023). In this way, a comparison can be made

between businesses with similar propensity scores, resulting in more robust results that are comparable between the treatment and control groups (Osei-Tutu and Taylor 2024)

However, the PSM method is based on two fundamental assumptions: i) conditional independence, which is based on observable characteristics (Rosenbaum and Rubin 1985b), and ii) the common support condition. The conditional independence hypothesis is crucial for validating the use of PSM. To this end, we applied three tests commonly used in the literature: kernel density distribution, comparison of means, and the Mantel and Haenszel (1959) test. These confirm the robustness of the PSM approach in our study. The common support hypothesis, meanwhile, guarantees that the propensity score distribution is sufficiently supported to compare treatment and control businesses (Caliendo and Kopeinig 2008).

We assess the impact of mobile money use on business productivity by considering the two groups mentioned above: businesses using mobile money ($MM_i = 1$) and businesses not using it ($MM_i = 0$). The businesses in the treatment group are matched to those in the control group according to the conditional probability P of receiving treatment, given their initial characteristics X_i.

$$P(X_i) = \Pr(\mathrm{MM_i} = 1|X_i) \tag{1}$$

where $P(X_i)$ is the propensity score of the i-th firm, $Pr(MM_i = 1)$ is the probability of the ith business adopting mobile money, and X_i is a set of covariates that are controlled before the results are compared.

The model to be estimated is as follows::

$$Y_i = f(X_i, \mathrm{MM_i}) + \varepsilon_i \tag{2}$$

where MM_i is the treatment variable taking the value 1 if the business uses mobile money and 0 otherwise, Y_i the outcome variable, which designates the business's labour productivity, and X_i is the set of control variables and ϵ_i the error term.

We used the average treatment effect on the treated (ATT) estimator, as recommended in the literature (Becker and Ichino 2002; Takahashi and Barrett 2014), to assess the impact of mobile money on business productivity. This estimator allowed us to assess the average difference in performance between businesses that had adopted mobile money and those that had not by estimating the results that the former would obtain if they did not adopt this technology. We rely on two matching methods: nearest-neighbour and kernel matching. These methods offer distinct trade-offs between matching quality and quantity (Becker and Ichino 2002). Using both methods enables us to assess the robustness of our estimates and improve the validity of the results (Osei-Tutu and Taylor 2024).

Variables

Business performance and likelihood of adopting mobile money are driven by several characteristics. We accounted for business sectors as their behaviour may vary accordingly (Lorenz and Pommet 2021). Geographical location also matters. Being located in an urban area may increase ICT adoption because larger cities offer infrastructure that is better suited to digital technologies (Tiwasing 2021). The manager's gender is also relevant. Women-led businesses often encounter more obstacles in adopting digital technologies (Islam and Muzi 2022). In addition, since older businesses often have more resources to adopt innovations (Cowling, Liu, and Zhang 2018) we have included the age of the business in the controls. We have also controlled for other variables, including business investment, access to credit (Chauvet and Jacolin 2017), power- outage experience (Tiwasing et al. 2024), employee training (Kasim Munyegera and Matsumoto 2016), and manager experience (La Porta and Shleifer 2014). In addition, we control for having a website, using email to communicate with customers or suppliers (Osei-Tutu and Taylor 2024), and holding a quality certification (Motta 2020) , as these factors reflect a business having a greater propensity to adopt modern technologies, including mobile money. Variable definitions are provided in Table A-1 in the Supplementary material.

Data

The data used for this study are from the World Bank Enterprise Surveys, which cover formal, non-agricultural and non-extractive private businesses (in the manufacturing and service sectors) with five

or more employees. Fully state-owned enterprises are excluded. The surveys provide data on business performance and environment. The data are obtained through face-to-face interviews with businesses directors and managers. Surveys are stratified by sector activity, size and geographic area. The size stratification divides businesses into three categories: small, medium and large businesses. Our final sample is made up of 2,170 businesses from nine countries[1] in the ECOWAS region. The data were collected over the period 2013 to 2017.[2]

Following Robertson, Caruana, and Ferreira (2023), we measured the innovation ecosystem of countries using the Global Innovation Index (GII). Launched by WIPO in collaboration with Cornell University and the European Institute of Business Administration, the GII provides a general assessment of countries' innovation ecosystems (Dutta, Lanvin, and Wunsch-Vincent 2019). We have classified businesses into two groups using the country-level GII; we, in fact, computed the arithmetic mean of countries in the ECOWAS region GII. All countries with a GII value below the average are considered low-maturity innovation ecosystems, and those with a GII above or equal to the average are high-maturity innovation ecosystems. However, due to the unavailability of GII data for Sierra Leone and Liberia, companies from these countries are not included in the analyses when exploring the effect of the innovation ecosystem.

Tables A-16 and A-18 (see the Supplementary material) present the descriptive statistics and correlation matrix of the variables used in our study.

IV. Results

Baseline results

Estimating propensity scores

In this subsection, we present the first step of the PSM. We rely on a probit estimation approach to generate propensity scores, or the likelihood of adopting and using mobile money. The general form of the model inspired by Caliendo and Kopeinig (2008) is as follows:

$$\Pr(T_i = 1 \mid X_i) = F(X'\beta) \tag{3}$$

where F is the cumulative distribution function of the standard normal distribution, β is a K×1 vector of coefficients, and T refers to the treatment, that is, using or not using mobile money.

The specific form of Equation (3) is as follows:

$$\begin{aligned} \mathrm{P(T=1)} = {} & \beta_0 + \beta_1 \mathrm{Competition} + \beta_2 \mathrm{Investment} \\ & + \beta_3 \mathrm{Email} + \beta_4 \mathrm{Training} \\ & + \beta_5 \mathrm{Poweroutage} + \beta_6 \mathrm{Certificate} \\ & + \beta_7 \mathrm{Credit} + \beta_8 \mathrm{Experience} \\ & + \beta_9 \mathrm{Gender} + \beta_{10} \mathrm{Age} + \beta_{11} \mathrm{Maincity} \\ & + \beta_{12} \mathrm{Website} + \beta_{13} \mathrm{Sector} + \varepsilon \end{aligned} \tag{4}$$

In other words, the equation above is used to predict propensity scores for the use of mobile money.

Table A-17 in the Supplementary material presents the results from the probit model estimations to predict the probability of businesses adopting mobile money, that is the propensity scores for the adoption of mobile money. The results show that businesses facing competition from the informal sector are more likely to adopt mobile money. The results also show that businesses that have accessed credit from a financial institution are more likely to adopt mobile money. In contrast, businesses with a website are less likely to adopt mobile money.

Testing PSM assumptions

Before presenting the PSM results, we first check whether the PSM assumptions, of conditional independence and common support, hold.

We have relied on three methods to test the conditional independence assumption: the kernel density distribution, the comparison of means and the Mantel and Haenszel (1959) test.

- Balance test: Kernel distribution

The balance of covariates across the treated and the untreated groups is key to validate the hypothesis of conditional independence. To this end, we have used a kernel distribution to visualise the propensity scores in the treatment group and the control group. Figure 1 shows that before the matching businesses

[1] Benin, côte d'ivoire, Ghana, Guinea, Liberia, Mali, Niger, Sierra Leone and Togo.
[2] During this period, the adoption of mobile money remained relatively stable.

using mobile money have higher propensity scores than those that do not, reflecting a difference based on covariates. However, after matching, the two kernel distributions look exactly the same, indicating a satisfactory balance of covariates between the two groups, as recommended in the literature (Caliendo and Kopeinig 2008; Rosenbaum and Rubin 1985b).

We have also presented the kernel distributions for different subgroups. Specifically, the kernel distributions are plotted for SMEs, large businesses, manufacturing businesses, service businesses, businesses in countries with less mature innovation ecosystems and businesses in high-maturity countries (Figures 2a to 2f of Figure A-1 in the Supplementary material). We find a satisfactory balance of covariates between the treated and the untreated businesses within each subgroups after the matching.

• Balance test: Comparison of means among the treated and control groups

In addition to the kernel density distribution, we compared the mean values of each covariate for the two groups, using a chi-squared test for qualitative variables and Student's t-test for quantitative variables. The results presented in Table A-13 in the Supplementary material show that the distribution of covariates is similar in the treated and control groups after matching. In other words, the matching balanced the sample for more than half of the observable characteristics. The same tests are implemented by sub-group (SMEs, large businesses, manufacturing businesses, service businesses, businesses in less mature and businesses in high-maturity countries) and these yield similar conclusions (Table A-2 to A-12 in the Supplementary material).

We supplemented the statistical mean comparison tests with a graphical presentation. Figure A-2 in the Supplementary material shows that PSM reduced between-group differences for most covariates after matching, indicating an improved balance between the treatment and control groups.

• Mantel–Haenszel sensitivity test

The Mantel and Haenszel (1959) test also assesses the balance between the treatment and control groups after matching. It considers whether the two groups are comparable in terms of the distribution of covariates, and thus whether the initial selection bias has been sufficiently reduced (Rosenbaum and Rubin 1985b). The test results are presented in Table A-14 in the Supplementary material. They show that the analysis of the impact of mobile money on business productivity is not sensitive to biases that are likely to create significant between-group differences.

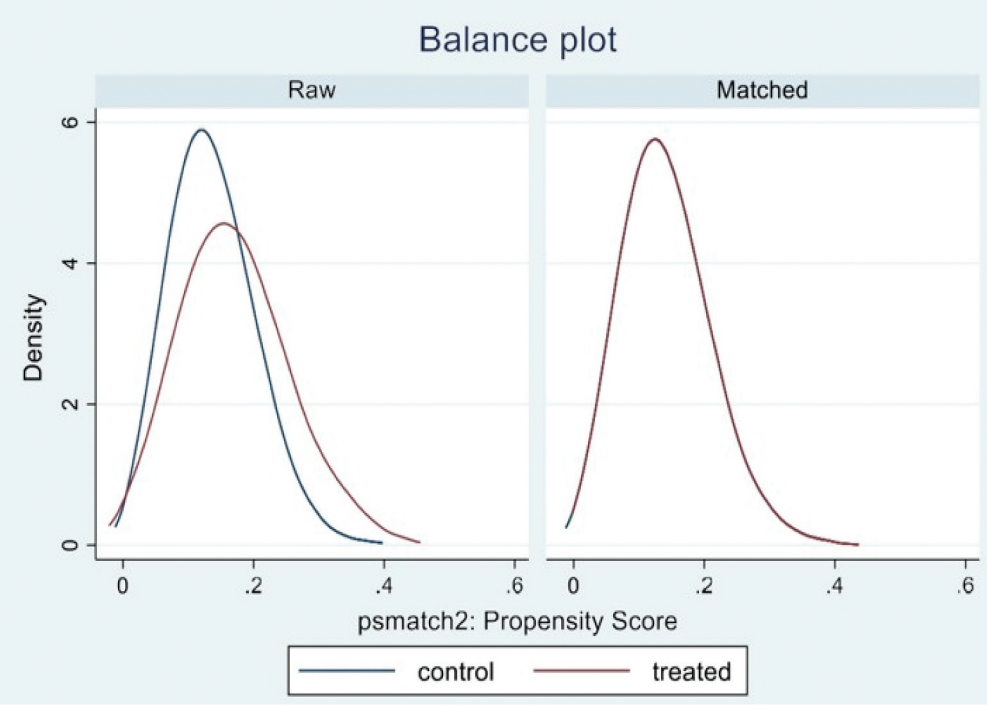

Figure 1. Kernel density distribution of propensity scores.

Regarding the common support (or overlap) assumption, this requires that firms in the treatment group have observable characteristics that overlap with those of firms in the comparison group . Table A-15 reports the estimated propensity scores (step one) and the stratification blocks based on these scores, including the lower limits of each block (step two). The common-support region is defined over the interval [0.0242; 0.3423], which corresponds to the range between the minimum and maximum estimated propensity scores for firms in the treatment group. This overlap implies that, for each treated firm, it is possible to find a comparable control firm with similar covariates, validating the common support condition of the PSM framework. In this context, the stratification procedure yielded four blocks, within which the mean propensity score does not differ significantly between treated and control firms (see Mawussi Djahini-Afawoubo, Kodjovi Couchoro, and Kokou Atchi 2023). This ensures an adequate balance in covariates across groups. The distribution of firms across the blocks is also presented, with the lower limit of each block reported. This distribution further highlights that sufficient numbers of treated and control firms exist within each block, supporting the reliability of the matching process.

In conclusion, the various tests (kernel density distribution, comparison of means and Mantel–Haenszel test) suggest that the conditional independence assumption can be validated. In addition, the common support assumption can be validated. We can, therefore, conclude that the estimated ATT from the PSM procedure is a reliable and unbiased estimate of the causal impact of the use of mobile money on firm performance for the matched sample.

PSM results

We now present, in Table 1, the results from the second step of the PSM approach, that is, the average difference in performance between those that use and those that do not use mobile money and have similar propensity scores. By doing so, we assess the impact of the use of mobile money on businesses' labour productivity. We have presented results using both nearest-neighbour and kernel-matching techniques. The results show that, whatever the matching technique, the coefficient related to the mobile money variable is positive and statistically significant. In other words, businesses using mobile money have higher productivity than those that do not use mobile money. The positive impact of the use of mobile money can be explained by the fact that it eases businesses' credit constraints and their access to digital credit (Beck et al. 2018) by reducing the impact of information asymmetry on the business (Mohamed 2023).[3] By increasing firms' access to loans, mobile money may foster their innovation and thereby improve their performance (Beck et al. 2018). Mobile money also reduces the transaction costs associated with traditional payment methods, as well as companies' operational costs (Mohamed 2023). It stimulates the growth of online commerce and boosts business sales by improving customer loyalty through simpler, faster and more efficient transactions (Tengeh and Talom 2020).

V. Robustness checks

IPWRA based results

The results from the PSM method indicate that businesses in the ECOWAS region using mobile money perform better than those that do not. We tested the robustness of this result, as the PSM results can be inconsistent if the propensity-score model is misspecified (Robins et al. 2007). We have

Table 1. Impact of mobile money on business productivity.

Sample	N-N matching	Kernel	IPWRA
Total	1.143*** (0.412)	0.851*** (0.315)	0.953*** (0.284)

Notes: Standard deviations are in brackets and ***, **, * indicate significance at the 1%, 5%, and 10% thresholds, respectively. N-N = nearest-neighbour.

[3]The use of mobile money by businesses enables financial institutions to trace their transaction histories, thereby providing a more accurate assessment of their creditworthiness. This mechanism helps mitigate information asymmetry between firms and financial institutions.

relied on IPWRA as an alternative estimation approach.

For the IPWRA estimation, each observation is weighted according to the inverse of the probability of receiving the treatment. This rebalances the sample to make the characteristics of the treated and untreated groups comparable, thereby reducing selection bias (Mulbah et al. 2022). The regression adjustment refines the estimates of treatment effects (Wooldridge 2007).

The results using IPWRA estimation are presented in Table 1. IPRWA estimation yields the same results as the PSM approach. We find that the productivity of businesses using mobile money is higher than that of businesses that do not.

IV-based results

The PSM and IPWRA methods presented above address selection bias. However, these approaches do not correct for potential endogeneity bias stemming from omitted variables. To account for this issue, we employ the instrumental variable (IV) approach. Following Osei-Tutu and Taylor (2024), we use as the instrument the proportion of firms in the same country that use mobile money. The IV regression results are reported in Table 2. These results are consistent with those obtained using PSM and IPWRA, confirming the robustness of our findings. In other words, the IV results also reveal that businesses using mobile money have higher productivity than those that do not.

VI. Heterogeneity analyses

Mobile money effect on firm performance: heterogeneity by size

Table 3 presents the results related to the impact of mobile money on firm performance according to firm size. The results show that the use of mobile money has a positive and significant impact on the productivity of SMEs. However, this impact is not significant for large businesses.

Konte and Korku Tetteh (2023) argue that SMEs have more limited access to formal financing than large enterprises. This result is consistent with Islam, Muzi, and Rodriguez Meza (2018) and Jack and Suri (2014), which show that small businesses benefit more from the adoption of mobile money than large businesses. Konte and Korku Tetteh (2023) also argue that payments via mobile money are generally used for small transfers. Therefore, mobile money should offer a greater benefit to SMEs because they are the ones tha frequently carry out low-value transactions.

Table 2. Impact of mobile money on firm productivity: An IV approach.

Variables	Total sample
Mobile Money	1.669***(0.222)
Informal competition	−0.170*** (0.049)
Credit	0.039(0.049)
Investment	−0.012(0.043)
Employee training	−0.119***(0.046)
E-mail	0.026(0.049)
Load shedding	0.011(0.020)
Manager gender	0.006(0.061)
Quality certification	0.119(0.075)
Main city	0.174***(0.045)
Business age	0.080**(0.033)
Manager experience	0.006***(0.002)
Website	0.086*(0.052)
Constant	0.605***(0.113)
Observations	1,041
Sector dummies	YES
C-D F-Stat	73.708
SY 10% max size	16.38
SY 5% max size	5.53

Notes: Standard deviations are in brackets and ***, **, * indicate significance at the 1%, 5%, and 10% thresholds, respectively.

Table 3. Impact of mobile money on businesses productivity by size and sector.

Sample	N-N matching	Kernel	IPWRA
SMEs	1.510*** (0.415)	1.032*** (0.302)	1.008*** (0.293)
Large businesses	−0.779 (1.262)	−0.611 (1.223)	0.275 (1.245)
Manufacturing sector	0.822 (0.633)	0.521 (0.422)	0.909* (0.445)
Service sector	1.333*** (0.508)	0.975*** (0.383)	0.930*** (0.356)

Notes: Standard deviations are in brackets and ***, **, * indicate significance at the 1%, 5%, and 10% thresholds, respectively. N-N = Nearest-neighbour.

Table 4. Impact of mobile money on business productivity through the lens of the innovation ecosystem.

Sample	N-N matching	Kernel	IPWRA
Matured innovation ecosystem	1.192** (0.540)	1.589*** (0.407)	1.518*** (0.376)
Less-mature innovation ecosystem	0.165 (0.467)	−0.074 (0.311)	−0.196 (0.321)
SMEs in a matured innovation ecosystem	1.437*** (0.425)	1.038*** (0.322)	1.040*** (0.286)
SMEs in a less-mature innovation ecosystem	1.312*** (0.419)	0.975*** (0.346)	0.981*** (0.288)
Large businesses in a matured innovation ecosystem	0.838 (0.531)	1.249*** (0.414)	1.420*** (0.376)
Large businesses in a less mature innovation ecosystem	−0.470 (0.599)	0.296 (0.426)	−0.371 (0.427)
Manufacturing businesses in a matured innovation ecosystem	1.265*** (0.479)	1.107*** (0.332)	1.399*** (0.342)
Manufacturing businesses in a less mature innovation ecosystem	0.112 (0.543)	0.310 (0.425)	0.558 (0.379)
Service businesses in a matured innovation ecosystem	1.342*** (0.443)	1.175*** (0.356)	1.176*** (0.327)
Service businesses in a less mature innovation ecosystem	0.901** (0.457)	0.774** (0.372)	0.718** (0.333)

Notes: Standard deviations are in brackets and ***, **, * indicate significance at the 1%, 5% and 10% thresholds, respectively. N-N = Nearest-neighbour.

Mobile money effect on firm performance: heterogeneity by sector

We investigated the heterogeneity of the effect of mobile money on firm performance by sector. The results, reported in Table 3, reveal that mobile money has no significant effect on the productivity of manufacturing businesses, but it positively drives the performance of firms in the service sector. One possible explanation is that the firms in the service sector have greater adaptability in adopting digital tools, including mobile money. This enables them to easily incorporate mobile money into their business models, thereby enhancing productivity through reduced operational costs, improved access to credit, and increased investment (Islam, Muzi, and Rodriguez Meza 2018).

VII. Mobile money and firm performances: does the innovation ecosystem matter?

Next, we explored whether the innovation ecosystem comes into play in explaining the impact of the use of mobile money on business performance. Table 4 presents the related results after classifying countries as having either relatively matured or less mature innovation ecosystems. We have presented both the PSM and the IPWRA results to demonstrate robustness. The results are also presented by business size and sector. The results reveal that the impact of mobile money on firm performance is greater in a matured innovation ecosystem. This result holds for SMEs whatever the maturity of the innovation ecosystem. Large businesses benefit from the use of mobile money in the relatively mature innovation ecosystem.

The results also reveal that while the use of mobile money benefits service firms whatever the maturity of their innovation ecosystem, those in manufacturing only benefit from mobile money adoptionin relatively mature innovation ecosystems. A dynamic innovation ecosystem helps alleviate constraints on adoption and strengthens the use of digital means of payment to the benefit of businesses performance (Reischauer, Güttel, and Schüssler 2021).

The general conclusions here align with the work of Lepoutre and Oguntoye (2018), who demonstrated that the success or failure of mobile money systems is largely shaped by multilevel contextual factors, including digital infrastructure, innovation-supporting policies, and networks. Indeed, in contexts where the innovation ecosystem is supportive of tech start-ups and includes active institutional backing, mobile money has scaled more effectively, generating positive externalities for local businesses. This finding is also consistent with Aker and Mbiti (2010), who emphasised the importance of institutional and technological complementarities in shaping the economic effects of digital finance.

VIII. Conclusion and policy implications

Our study has analysed the effect of the adoption of mobile money on business performance in the ECOWAS region. Our empirical analysis relied on the World Bank Enterprise Surveys data and leveraged several estimation methods (PSM, IPWRA and IV). The results reveal that, in general, firms using mobile money are more productive than those that do not. The heterogeneity analyses reveal that SMEs benefit from the adoption of mobile money, whereas large businesses do not. We also found that mobile money has a significant positive effect on the performance of service firms, but it does not affect manufacturing firms.

Supplementary investigations reveal that the use of mobile money contributes to firms' performance particularly in relatively mature innovation ecosystem in the ECOWAS region. While this finding applies to large businesses and those in manufacturing, SMEs and firms in the service sector benefit from mobile money adoption whatever the maturity of the innovation ecosystem.

National and regional policy makers should prioritise investment in interoperable payment systems to eliminate constraints on the adoption of mobile money by businesses. There is also a need for harmonied regulation of mobile money across ECOWAS to encourage national and regional interoperability. Regulation is also needed to support startups, which need clarity, stability (in terms of taxation, venture capital investment, businesses creation and registration) and copyright protection. This regulatory framework should consider the development of national startup legislation to create incentives for collaborative innovation among fintech startups, telecom operators, and business incubators.

The lack of data on the post-COVID-19 period is probably a limitation of this study and future studies could address this. Indeed, since the pandemic, attitudes towards the use of ICT, and particularly mobile money, have changed considerably. The COVID-19 pandemic has accelerated the democratisation of ICT use among the customers and businesses, thereby transforming the perception of ICT, which are now an integral part of everyday life. Future research should, therefore, focus on new data, as behaviours towards mobile money may also have evolved.

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