Drivers of Digital Payments in Rwanda

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Abstract

In its first National Strategy for Transformation (NST1), Rwanda set a target of increasing the value of electronic payment transactions as a percentage of GDP from 26.9% (2017) to 80% by 2024. This target was surpassed, with the ratio standing at 199.9% in 2023 (MPFSS, March 2024), thanks to a supportive regulatory environment, the Government's active drive via the 'cashless campaign', and increased digitization of public services. Using the 2024 FINSCOPE data set, and to ensure robustness, this study uses fractional logit, fractional probit, Beta regression, and the Tobit model to empirically examine the drivers of the intensity of adopting digital payments in Rwanda. The choice of the models is premised on the fact that the dependent variable is measured as a fraction. Empirical findings from all estimated models consistently indicate that the intensity of adoption is positively affected by the increase in perceived convenience and security of using digital payments. In contrast, the high perceived cost of using digital payments and residing in rural areas has a negative effect. This study stresses the need to encourage the development and use of convenient, secure, less costly, and easy-to-use digital payment products. Also, digital payment products should be tailored to the specific needs of different segments of society to ensure inclusiveness. This requires investment in innovative products and infrastructures, including cybersecurity, and other relevant technologies, in both rural and urban areas.

Keywords: Digital Payments, Intensity of Adoption, Fractional Logit, Fractional Probit, Beta Regression, Tobit Model, Rwanda.

JEL Classification: E42, C34, C35

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1 Introduction

In modern times, many countries are encouraging the adoption of cashless payments, given their desirable attributes. Generally, digital payments [1] are considered convenient, fast, less costly, and safe, which helps alleviate the difficulties associated with cash transactions (Aurazo & Vega, 2021). Since these transactions are digital, their adoption depends on the available infrastructure and other associated considerations, such as cybersecurity concerns and associated fraud risks (Franciska & Sahayaselvi, 2017).

In addition, increased digitization of transactions makes tracking money flow in an economy possible and easy, enabling governments to minimize tax evasion and combat money laundering (Urhie et al., 2021). Contactless digital payment methods can also be useful in terms of containing the spread of diseases as witnessed during the COVID-19 period (World Bank, 2022). Also, the difficulties involved in cash-based payments have facilitated the adoption of digital payments. For example, to use cash payments, society incurs costs related to authentication, counting, storing, sorting, and transportation of paper money and coins (Arvidson, 2018). The conduct of monetary policy is also complicated when a big chunk of money is kept outside of the banking system (Kigabo, 2021).

In countries with less developed financial markets, digital channels can help to increase financial inclusion (Munyegera, 2024). Indeed, the recent World Bank Findex Survey indicates that digital payments have enabled the inclusion of the previously excluded from traditional financial services. The report notes that 64% of adults in developing countries – 84% of bank account holders – transacted digitally at least once in 2021 (Demirgüç-Kunt et al., 2022). Indeed, particular forms of digital channels, such as mobile money, have helped to financially include the under-served rural population in Africa (Akinyemi & Mushunje, 2020).

Furthermore, it has been well documented that a well-developed financial system with an efficient payment system helps promote economic growth and development (Karangwa, 2022). Since it increases access to

[1] Cashless payments, digital, or electronic payments are often used interchangeably in the literature. The World Bank Global Findex report indicates that "digital payments" include the use of a mobile money account, a debit or credit card, or a mobile phone, or the internet to make a payment from an account, or the use of a mobile phone or the internet to send money to relatives or friends or to pay bills. Digital payments also include in-store or online merchant payments; paying utility bills; sending or receiving domestic remittances; receiving payments for agricultural products; or receiving wages, government transfers, or a public pension directly from or into an account (Demirgüç-Kunt et al., 2022).

and usage of financial services, it empowers many economic agents to save, invest, manage risks, and smooth their consumption. Indeed, it has been reported that an efficient payment system enables the reduction in transaction costs and makes the real and financial markets work better, with spillover effects on trade and economic activities in general (Humphrey et al., 1996). This in turn positively influences the welfare of the people as has been confirmed by the IMF that the Human Development Index (HDI) is positively correlated with some selected indicators of financial inclusion such as the number of borrowers, loan accounts and outstanding deposits (Beyene et al., 2024).

Despite these advantages, the adoption of digital payments also faces challenges, particularly in developing economies. On the supply side, issues include fraud arising from unreliable systems, interoperability between different service providers, a lack of physical infrastructure including electricity, network coverage, and the number of cash-in/cash-out points or agents. On the demand side, challenges include limited financial literacy and consumer education (Zimmerman et al., 2014).

Given the importance of digital payments, Rwanda, like other countries, has been promoting increased adoption of cashless payments. An appropriate policy and regulatory environment has been established to develop a digital payments ecosystem and to help increase the adoption of digital payments in Rwanda. This has been complemented by the Government's deliberate policy to fully digitize public services (Munyegera, 2024). To the best of our knowledge, studies in Rwanda focused on the drivers of the adoption of digital payments. Unlike other previous studies, this study examines the drivers of the intensity of the adoption of digital payments in Rwanda, with a particular focus on the importance of the main attributes of digital payments (security, convenience, and cost).

After the introduction covered in Section One, the rest of the paper is organized as follows: Section Two benchmarks Rwanda's cashless journey in a global and regional context, Section Three focuses on the review of the relevant literature, Section Four explains the methodology and data used, Section Five covers the discussion of both descriptive and empirical findings while Section Six gives the summary and conclusion of the study.

2 Benchmarking Rwanda's cashless journey

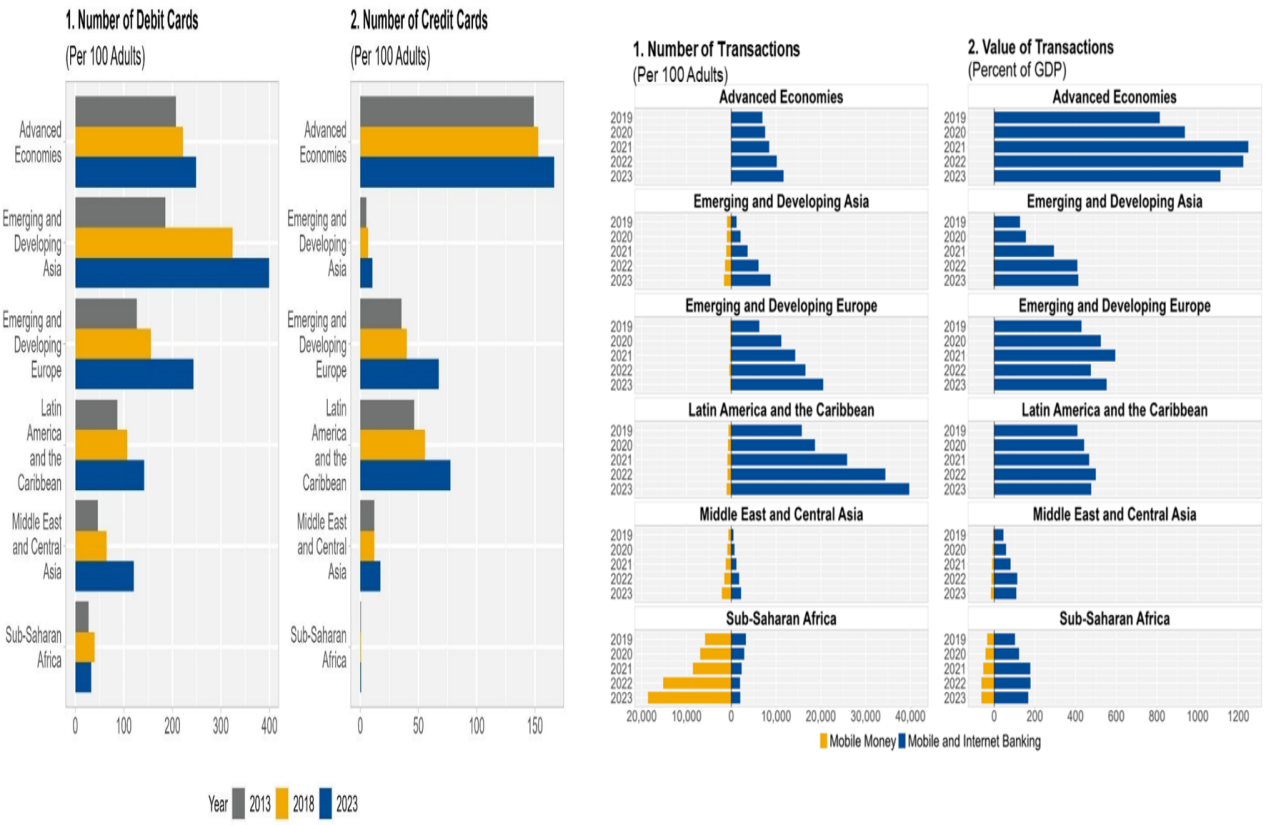
The adoption of both credit and debit cards increased continuously between 2013 and 2023, for all the sub-regions of the World, except in Sub-Saharan Africa (where technology and digital infrastructure are still low). The observed increase in the global use of credit and debit cards was driven by the emergence of digital wallets that helped to securely store card information electronically, facilitating easier and safer transactions. The uptake of mobile internet banking and mobile money has increased over time and in all the sub-regions of the World, especially during and after the COVID-19 period (Demirgüç-Kunt et al., 2022). The adoption of mobile money has particularly grown in Sub-Saharan Africa, with mobile money transactions per 100 adults rising from 5,800 in 2019 to 18,500 in 2023. Recently, the adoption of mobile money has surged in Burkina Faso, Mozambique, Guinea, Rwanda, Senegal, and Mauritius, where the number of mobile money transactions per 100 adults grew by more than 40 percent between 2022 and 2023. Generally, countries that have advanced payment systems experienced high adoption of credit and debit cards and Internet banking compared to those in Sub-Saharan Africa. Innovations, such as using mobile money, have helped to scale up financial inclusion in Sub-Saharan Africa (Beyene et al., 2024).

The increased adoption of mobile money in Sub-Saharan Africa came in the aftermath of the successful implementation of Kenya's mobile money model that started in 2007. Since then, mobile money has become a vital tool for facilitating financial transactions via mobile accounts, especially for those previously excluded from the formal financial system (Beyene et al., 2024).

Globally, there has been a consistent shift towards digital (non-traditional) access points, especially mobile money agents. Empirical evidence shows that the adoption of mobile money in Sub-Saharan Africa is largely higher in countries whose mobile money markets are mature. Maturity here is measured as the number of years the mobile money market has been operational.

Nonetheless, the increased adoption of mobile money in Sub-Saharan Africa has not hampered the use of traditional bank deposit accounts. From 2017 to 2023, deposit and mobile money accounts have been trending upwards, signifying that the two play a complementary role in the financial ecosystem. Using cross-country Sub-Saharan African countries' data for 2023, a scatter plot of deposit and mobile money accounts

Figure 1: Adoption of digital payments

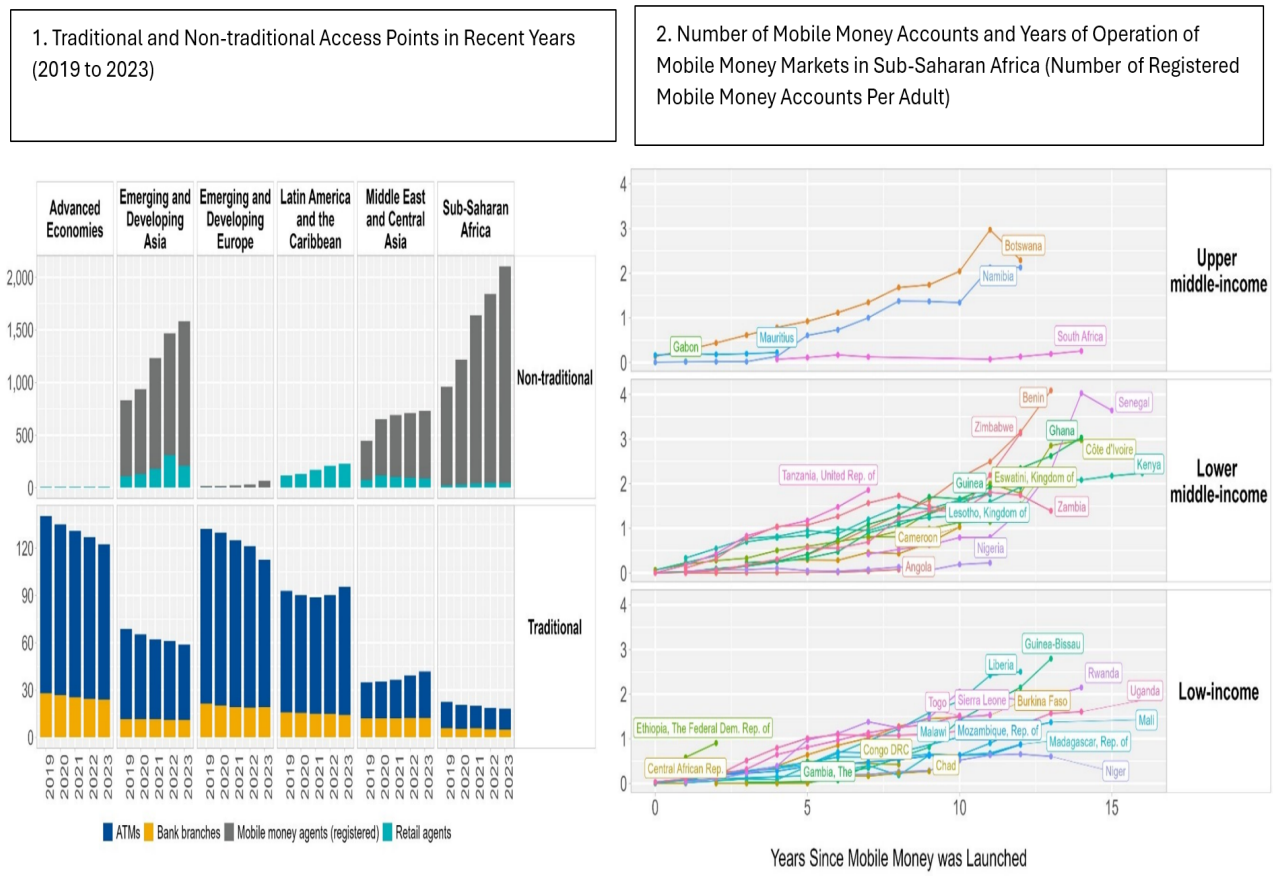


Source: IMF (2024) report on financial access (Beyene et al., 2024)

shows that the two are positively correlated. Ownership of mobile money accounts has been reported to stimulate ownership of bank accounts in developing countries (Demirgüç-Kunt et al., 2022).

For the case of Rwanda, the first National Strategy for Transformation (NST1) stressed the objective of moving towards a cashless economy by increasing the value of payment transactions done electronically as a percentage of GDP from 26.9% (2017) to 80% by 2024. In NST2 (2024-2029), the bar was raised even higher, with the Government of Rwanda aiming to attain universal digital literacy to facilitate high adoption of digital and emerging technologies across public and private sectors. The Government also committed to

Figure 2: Traditional and non-traditional access points in Sub-Saharan Africa

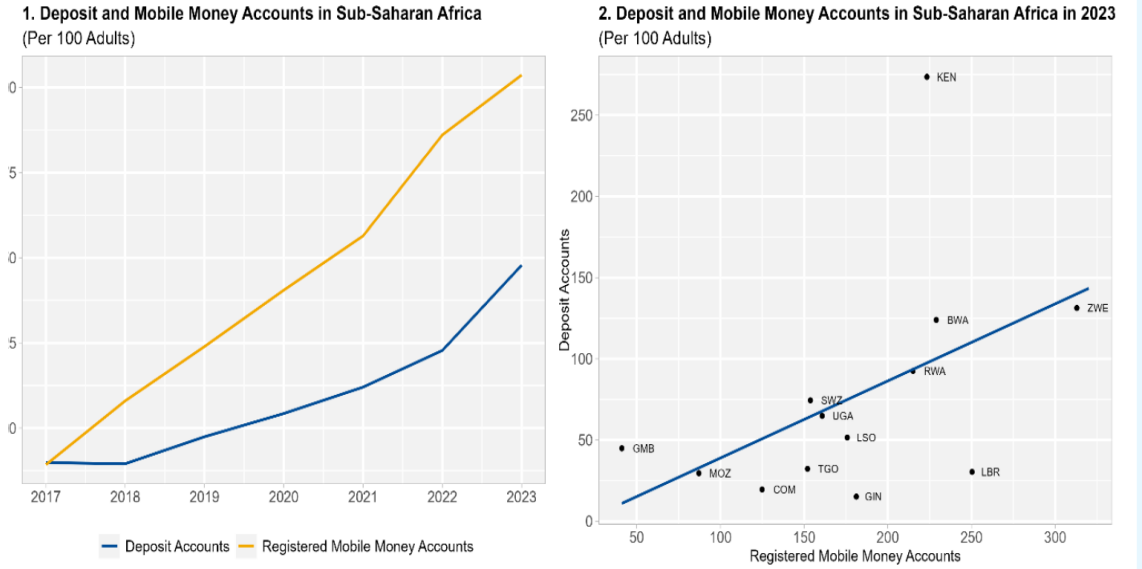


Source: IMF (2024) report on financial access (Beyene et al., 2024)

fully digitize all public services. To attain this ambitious agenda, an enabling regulatory and policy environment was put in place (as detailed in Munyegera (2024)) aimed at enhancing financial sector development, increasing financial literacy, modernization of payment systems, and encouraging investment in technological innovations (such as fintechs).

With a good regulatory and policy environment and increased investment in appropriate infrastructures, several interoperable digital platforms emerged to facilitate the adoption of electronic payments. Starting with the introduction of MTN mobile (2010) & MoMo Pay in 2018, mobile operators introduced essential

Figure 3: Complementarity between mobile money and deposit accounts



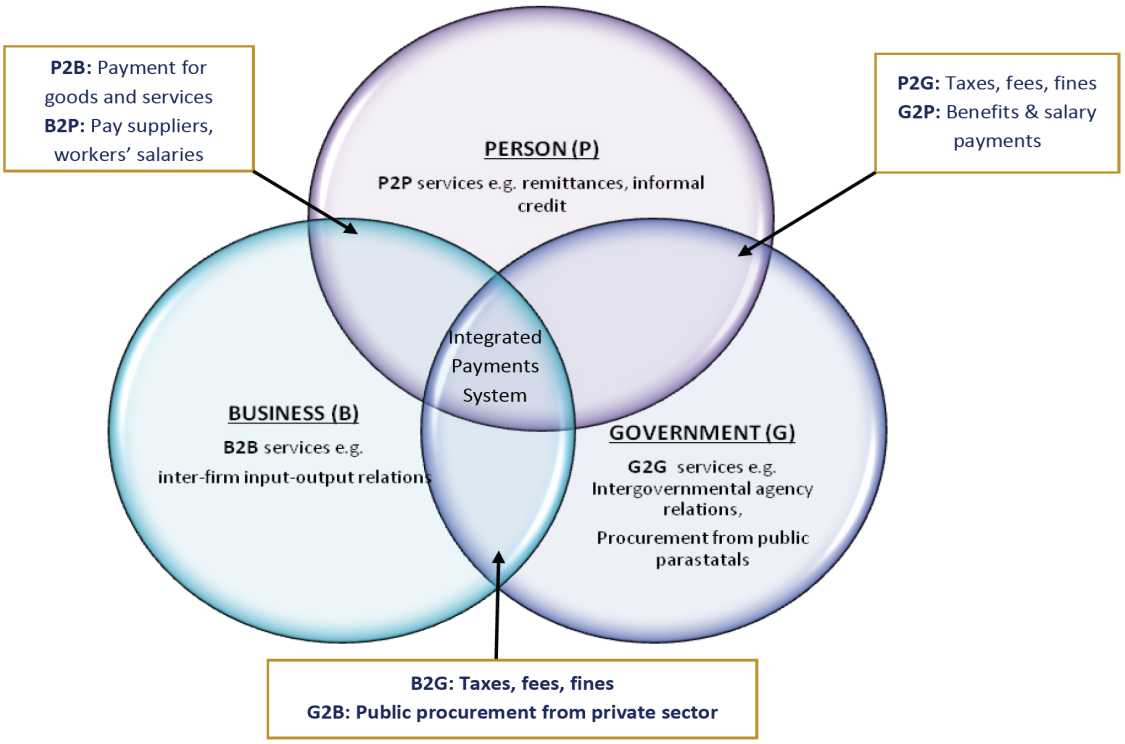
Source: IMF (2024) report on financial access (Beyene et al., 2024)

services and products such as payments (MoMoPay, Bill & Utility Payments, Taxes, Insurance, Transport, and Bulk Payments). The "Irembo" platform was introduced to help digitize public services, such as declaration requests for and/or payment of certificates, land titles, driving permits, and fines and penalties including traffic offenses. At present the digital payments ecosystem has developed with various Person to Person (P2P), Person to Business (P2B), Business to Person (B2P), Business to Business (B2B), Person to Government (P2G), Government to Person (G2P), Government to Government (G2G) and Business to Government (B2G) transactions processed and settled via the Rwanda Integrated Payments Processing System (RIPPS).

Electronic payments have also been adopted across various sectors. Examples include: Tap and Go (Transport sector), Urubuto Pay (Education sector)[2], E-commerce platforms (RwandaMart, SokoMall, e-soko), and Babyl (Health sector). At present, clients of Telecoms can access micro-credit via digital platforms, such as Mokash operated by MTN Rwanda.

[2]A platform that allows payments to be made through mobile money, Visa, Mastercard, American Express, and Bank of Kigali (BK) and I&M Bank. Irembo also has agents who can help citizens who don't have access to services online.

Figure 4: The Digital Payments Ecosystem in Rwanda

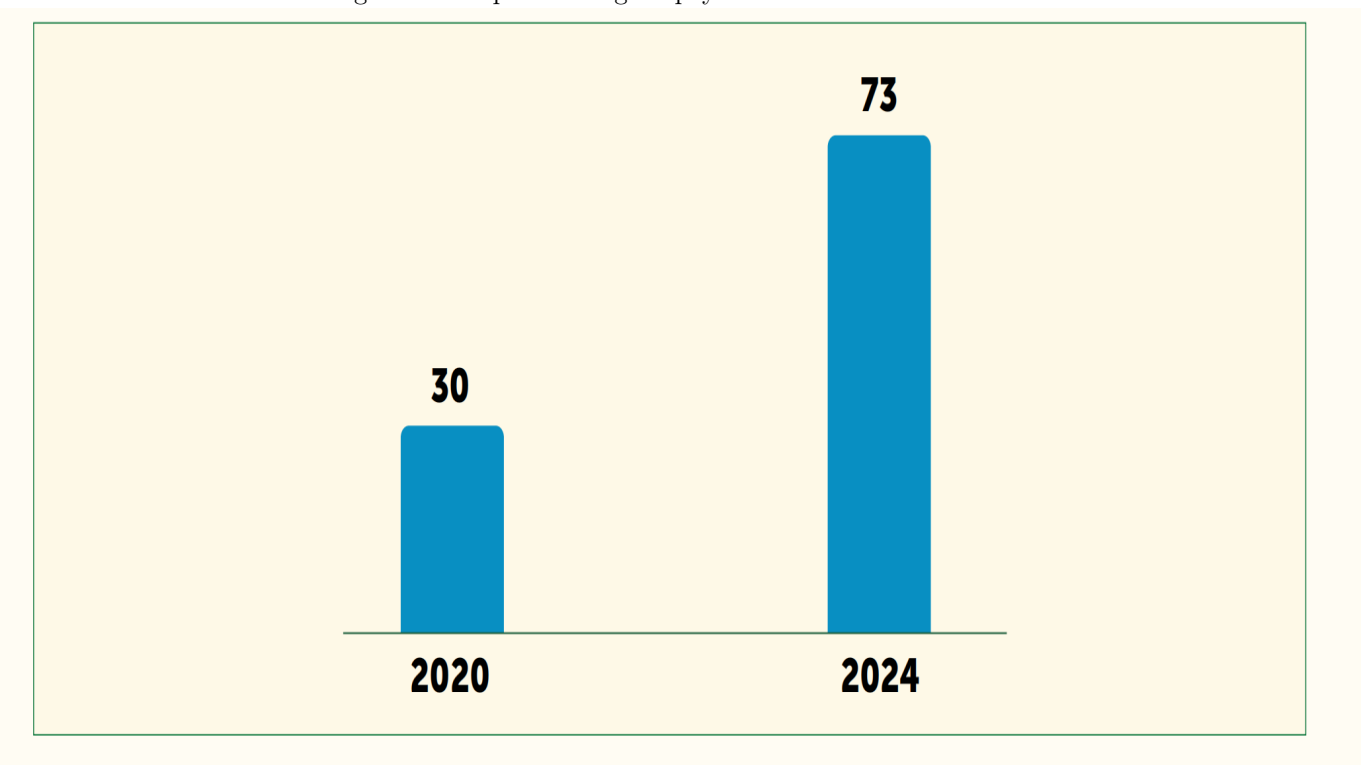


Source: (Munyegera, 2024)

The interoperability of digital payment channels is supported by the Rwanda National Digital Payments System (RNDPS). In addition, eKash was developed in 2022 to ensure the interoperability of payments across mobile money systems. As a result, the use of digital financial services (excluding mobile money cash-in and cash-out) has grown from 30% (2.1 million Rwandans) in 2020 to 73% (5.9 million Rwandans) in 2024.

According to the 2024 Rwanda Finscope report (NISR, 2024), mobile money is the most preferred digital channel and is mainly used for settling transactions related to energy bills (25%), medical expenses (31%), and education fees (14%). Despite the increased uptake of cashless means of payment, the use of cash remains very high. Rwandans receive their income money in cash (76%) and prefer to spend in cash (92%) on the following activities: Food (88%); water and energy bills (34%); education (44%); communication (65%); medical expenses (45%); farming inputs (45%).

Figure 5: Adoption of digital payments in Rwanda



Source: Rwanda Finscope Report (NISR, 2024)

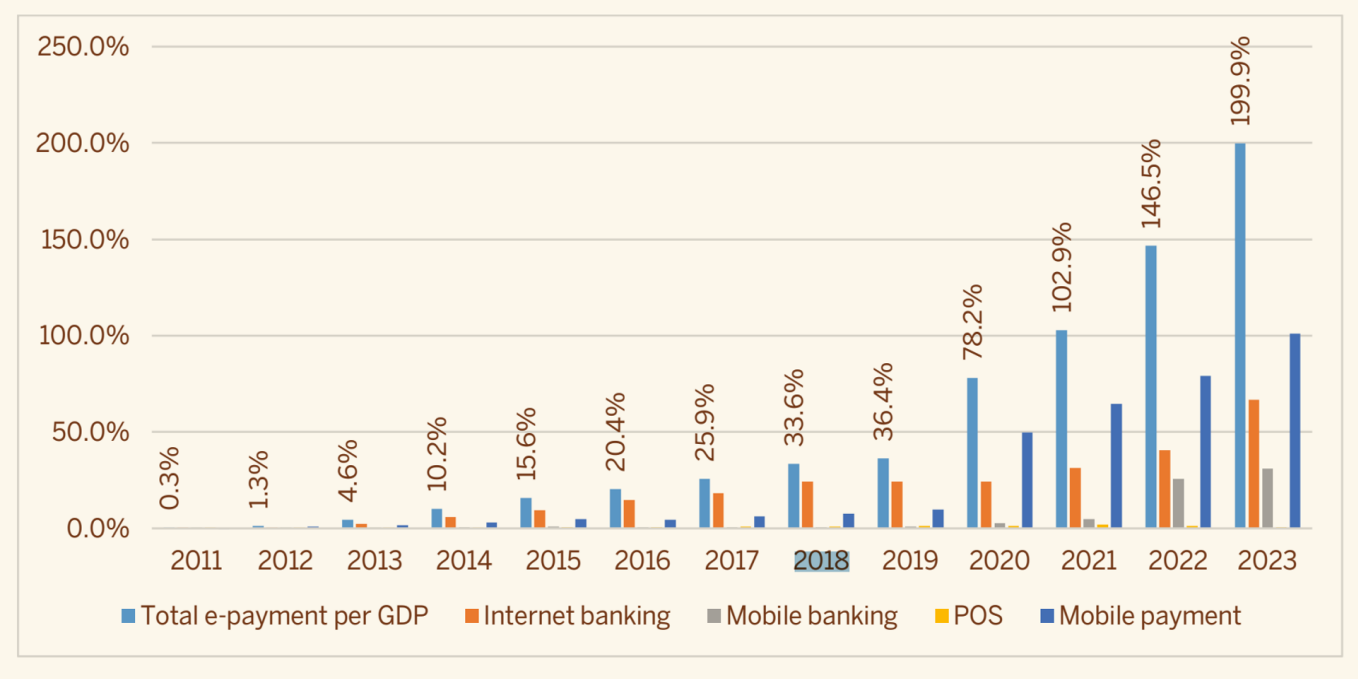
As noted by Munyegera (2024), the demand for digital financial products responds to the supply of service providers or centers. He shows that there is a high correlation between the number of service providers or centers and the volume and value of transactions, taking an example of the correlation between the number of mobile money agents and the volume and value of mobile money transactions as well as the correlation between the number of POS terminals and the transactional volume and value. Thus, investment in the required, affordable, secure, and convenient infrastructures is one of the enabling factors for the potential increase in the adoption of digital payments in Rwanda.

Nonetheless, the ratio of electronic payments to GDP has been growing over time, from as low as 0.3% in 2011 to 199.9% in 2023, mainly driven by the increased uptake of mobile payment, internet banking, and mobile banking. Interestingly, the respective ratios of mobile payment, mobile banking, and internet banking

to GDP, increased significantly during and after the COVID period, a trend that has been observed across the World (Demirgüç-Kunt et al., 2022).

In fact, on March 19, 2020, in response to the COVID-19 pandemic, the National Bank of Rwanda (NBR) in collaboration with mobile money operators, announced temporary measures to allow the public to continue transacting while limiting physical contact. These include zero charges on all mobile money transfers and no merchant fees on payments for all contactless points of sale. This set of measures, which lasted for three months, significantly boosted mobile money usage, with person-to-person (P2P) mobile money transfers jumping to 450% in value between January and May 2020. Despite the reintroduction of fees thereafter, the shift towards digital payments had a lasting impact (Cenfri, 2020)

Figure 6: Value of Electronic Payments to GDP



Source: Monetary Policy and Financial Stability Statement (BNR, 2024)

3 Literature Review

Over time, innovations in the financial sector have constantly turned the use of cash, as a means of payment, into cashless forms of payment (Alkhowaiter, 2020). This has given rise to cashless societies dominated by digital payment modes, including digital cards and electronic gadgets (Balakrishnan & Shuib, 2021). Theoretically, studies have advanced several hypotheses to explain individuals' adoption and usage of new digital payments. These models include the theory of reasoned action (TRA), the social cognitive theory (SCT), and the technology acceptance model (TAM). While the TRA and SCT focus on explaining the willingness of individuals to participate in novel technologies (Vimal et al., 2024), TAM has been explicitly used by many studies to explain and forecast the adoption and usage of digital payment technologies including online banking, mobile banking, and other cashless transaction systems (Shin, 2009; Sarmah et al., 2021; Williams, 2021). According to Ramayanti et al. (2024) who systematically reviewed the literature on digital payments, the use of models such as TAM reveals a growing need to understand the determinants of the adoption of digital payments.

Indeed, the digital payments literature has increasingly focused on empirically explaining specific practical issues on the adoption of digital payments, including the advantages of digital payments over traditional cash payment methods, the implications of the adoption of digital payments on financial inclusion, the identification and quantification of the drivers of the adoption of digital payments, as well as the heterogeneity observed in the adoption of digital payments across geographic regions, among others (Alkhowaiter, 2020; Kajol et al., 2022; Karsen et al., 2019; Aurazo & Vega, 2021).

First, Ramayanti et al. (2024) surveys the literature on digital payments and identifies several advantages of digital payments including convenience due to one-click payments, especially for small amount transactions (Yaokumah et al., 2017; Glowka et al., 2023), a reduced need to carry cash, discounts and cashback programs, tracking small transactions, and security (Effah, 2016). Further, in providing a comprehensive overview of the many forms of digital payment transactions, Franciska & Sahayaselvi (2017) explains that modern-day digital wallet applications, a way of carrying cash digitally, are readily accessible and operational across a multitude of electronic gadgets such as smartphones, tablets, and smartwatches.

Moreover, another critical and recurring theme in the literature on the adoption of digital payments relates to their implications for financial inclusion. Aurazo & Vega (2021) empirically show that measures of digital payment adoption and financial inclusion metrics are robustly and significantly related, using evidence from Peru. Other research studying the adoption and usage of digital payments in emerging economies also put financial inclusion considerations at the forefront in Brazil, China, Argentina, and Mexico (Kumar, 2005; Fungáčová & Weill, 2015; Tuesta et al., 2015; Woodruff & Martinez, 2008). The main argument supporting the linkage between financial inclusion and the adoption of digital payments is that financial inclusion, meaning access to accounts, debit cards, or credit cards is a prerequisite to making digital payments (Allen et al., 2016; World Bank, 2016)

Further, a large body of empirical research deals with identifying and measuring the factors that influence the adoption of digital payments. Broadly, from the literature, we can identify three categories of drivers of the adoption of digital payments: socio-economic factors, payment attributes and transaction features, and incentive-based factors. On the socio-economic factors, the literature identifies demographic variables including age, gender, education, race, place of residence, and marital status, as well as economic factors including income, savings, and employment (Ching & Hayashi, 2010; Klee, 2008; Schuch & Stavins, 2013; Wang & Wolman, 2016; Shy, 2020). For instance, Singh (2019) finds that the 21-35 age group in India is more likely to adopt e-wallet payments than any other age group, citing the digital nature of their consumption preferences such as booking movie tickets and tech-savoriness as the main reasons behind the increased adoption.

Moreover, using qualitative survey responses on adult individuals, Shy (2020) studies the economic drivers of consumer digital payment modes in the United States and finds that low-income individuals are less likely to be banked or use debit or credit cards. According to the respondents in Shy (2020), and in line with Federal Deposit Insurance Corporation (2018) findings, low-income individuals believe they lack sufficient disposable income to keep in bank accounts and find it hard to afford various account and card fees. In addition, several studies have investigated the payment attributes that influence the adoption of digital payments. On the side of payment attributes, Stavins & Shy (2015) find that digital payment platforms embedded discounts and surcharges affect the choice of payment instrument, with surcharges being detrimental to the consumer's choice of adoption. Lastly, Alfonso et al. (2020) identifies the coronavirus pandemic as an incentive-based

factor driving the adoption of digital payments, as many individuals had no choice, or a strong incentive, but to shop online during government-imposed lockdowns.

While digital payments have flourished globally, the speed of adoption has varied across the regions, in line with differences in financial literacy, internet, and mobile phone penetrations. For instance, While digital mobile banking and digital payment cards are widespread in advanced economies; emerging and developing economies, especially in Africa, have instead witnessed the emergence of mobile money due to free registration via mobile sim card, offline availability, and cheap and convenient user experience (Mas & Radcliffe, 2011; Jadil et al., 2021). As evidenced by the introduction of M-PESA in Kenya in 2007, mobile money payments have burgeoned in Sub-Saharan Africa, driven by the increased penetration of Mobile Network Operators in countries such as Rwanda, Uganda, Tanzania, Zimbabwe, Nigeria, Ghana, Senegal, and Somalia, to name a few (Jadil et al., 2021).

The literature on Rwanda's adoption of digital payments has also increased considerably in tandem with the digital transformation of the economy (Maniriho, 2021; Uwamariya et al., 2021; Ky et al., 2019; Khayesi, 2022; Grzybowski et al., 2023; Munyegera, 2024). Maniriho (2021) uses FinScope 2016 data and an endogenous switching regression model to show that economic factors such as wealth and ownership of productive assets are strong determinants of the adoption of digital payments such as mobile money in Rwanda, while the use of mobile money contributes in turn to the promotion of a savings culture, and hence, financial inclusion. Uwamariya et al. (2021) conducted 72 semi-structured interviews with respondents in rural Rwanda and found qualitative evidence that Rwandan rural residents (including farmers) adopt mobile money due to its convenience, but fail to domesticate it continuously due to limited opportunities to learn about its use, barely accessible network agents with enough liquidity in rural areas, and high and non-transparent costs.

Lastly, Munyegera (2024) studies the trends and determinants in the uptake of digital financial services in Rwanda using a mixed-method approach (consisting of regression analysis and qualitative interviews) from 2011 to 2021. This paper finds that the uptake of internet and mobile banking increased from 1.6 million users in 2012 to 5.1 million in 2021, driven by internet connectivity, COVID-19, and innovations in the mobile money landscape. His analysis showed that the adoption of digital payments is high among males compared to females, the young (who are tech savvy) compared to the old, married economic agents

compared to other forms of civil status, and those living in urban areas compared to those in rural areas.

The present study contributes to the above literature as follows: Surveying the literature reveals that only a few studies have examined the intensity of adoption of digital payments before (Świecka et al., 2021; Uwamariya et al., 2021). Therefore, by studying the intensity of adoption, or how frequently digital payments are adopted in Rwanda, the present study logically extends the domestic literature in the right direction. Second, by using FinScope 2024 data, a novel dataset, this paper contributes to the literature on digital payments that use nationally representative surveys Ching & Hayashi (2010); Arango et al. (2015); Chen et al. (2019); Maniriho (2021). Finally, in terms of methodology, the current study proposes a rich menu of models to study the intensity of adoption of digital payments including beta regressions, fractional logit, fractional probit, and a Tobit model, unlike previous studies on digital payments adoption that mostly used simple regression analysis and the probit model (Munyegera, 2024; Maniriho, 2021; Khayesi, 2022).

4 Methodology and data

This section explains the data, variables, and methodology used in this study. Secondary data on Payment statistics sourced from the National Bank of Rwanda website are used to conduct descriptive analysis to uncover the key trends and patterns in electronic payments in Rwanda over time. The 2024 Finscope data are used to do both descriptive and empirical analysis. The descriptive analysis is intended to beef up the story regarding the status of electronic payments in Rwanda to complement trends observed over time using the payment statistics. The empirical analysis is intended to scientifically investigate the driver of the intensity of the adoption of digital payments in Rwanda, focusing on the characteristics of digital channels (e.g. security, convenience, and cost), and geographical factors (e.g. location in rural or urban areas), and demographic characteristics (e.g. age, education, marital status).

4.1 Data and variables

The 2024 Finscope data contains details on how a particular payment channel (e.g. mobile money) is used for different transactions. The data are available for each individual in a household. In total, there are 13,994 individuals grouped into 7,918 households. However, in this study our unit of analysis is the head of the household, meaning that we use 56.6% of the entire Finscope 2024 Consumer Dataset.

By the design of the Finscope data set, each household head can use each payment channel for various purposes. The Finscope data set does not contain transactional data, but rather data on the perceptions regarding the use of different means of payments for different purposes. The household head is for example asked if he/she uses mobile money to buy food. The answer can be Yes or No. Such binary responses make it possible to define equations 1, 2, and 3. In total, there are 15 payment channels available for use by each household and each of these channels can be used for all or some of the available 16 purposes. Thus, the total use of all payment methods by a given head of the household ($TOTPAY_{hh}$) can be defined as:

$$TOTPAY_{hh} = \sum_{i=1}^{15}\sum_{j=1}^{16} FREQPAY_{ij} \tag{1}$$

Where i refers to the payment channel, j refers to the spending purpose, $FREQPAY_{ij}$ refers to the frequency of use of any payment method i for purpose j. Therefore, $TOTPAY_{ij}$ is the total frequency, at the household level, showing the number of payment methods used for different purposes/transactions. Using the same analogy, the level of use of digital payments at the household level ($EPAY_{hh}$) is defined as:

$$EPAY_{hh} = \sum_{i=1}^{15}\sum_{j=1}^{16} EPAYFREQ_{ij} \tag{2}$$

Where i and j are as defined before, $EPAYFREQ_{ij}$ is the frequency of use of any electronic payment method i for purpose j, while $EPAY_{hh}$ is the electronic payment frequency, at the household level, showing the number of electronic payment methods used for different purposes/transactions. Using equation 1 and equation 2, we define the intensity of the use of digital payments, at the household level, as follows:

$$EPAYINTENSITY_{hh} = \frac{EPAY_{hh}}{TOTPAY_{hh}} \tag{3}$$

In this study, the variable $EPAYINTENSITY_{hh}$ refers to the intensity of use of digital payments by each household and is used as the dependent variable. From equation 3, it is clear that $EPAYINTENSITY_{hh}$ is a fraction, ranging between 0 and 1.

The other variable definitions are:

VARIABLE	DESCRIPTION
Rural	Dummy for the location of the head of the household. Rural =1 if the location is rural and 0 otherwise.
Age_hh	Age of the head of household
Sq_age	Square of age of the household
Married	Dummy for civil status. Married=1 if the head of the household is currently married and 0 otherwise
hh_size	Size of the household
Sq_hhsize	Square of the size of the household
Female	Dummy for the gender of the head of the household. Female =1 if female, 0 otherwise
Convenience	Number of household heads who perceive digital channels to be convenient. Therefore: Convenience represents a lower number; Sq_convenience represents a higher number. **Convenience** is a proxy for low perceived convenience, and its square (**Sq_convenience**) represents higher perceived convenience.
Cost	Number of household heads who perceive digital channels to be costly. Therefore: Cost represents a lower number; Sq_cost represents a higher number. **Cost** is a proxy for low perceived cost, and its square (**Sq_cost**) is a proxy for high perceived cost.
Security	Number of household heads who perceive digital channels to be secure. Therefore: Security represents a lower number; Sq_security represents a higher number. **Security** is a proxy for low perceived security, and its square (**Sq_security**) is a proxy for higher perceived security.
Educ1	No formal education for the household head (used as the benchmark)
Educ2	Education (Primary 1-3)
Educ3	Education (Primary 4-6)
Educ4	Education (Secondary 1-3)
Educ5	Education (Secondary 4-6)
Educ6	Education (University or other higher learning)
Educ7	Education (Vocational)

Table 1: Definition of independent variables

4.2 Empirical models

Since the dependent variable ($EPAYINTENSITY_{hh}$) is a fraction and bounded between 0 and 1, the suitable empirical models are fractional logit, fractional probit, Beta regression, and Tobit model. The empirical model can be generally specified as follows:

$$y_i = x_i\beta + \varepsilon_i \tag{4}$$

Where i is the i^{th} household. At the cross-sectional level, y_i is a general representation of the dependent variable ($EPAYINTENSITY_{hh}$), x_i is a vector of independent variables listed in table 1 above. As mentioned above, the dependent variable is a fraction within the [0,1] interval. To use the fractional regression, the dependent variable should be continuous, greater than or equal to 0, and less than or equal to 1. Versions of fractional regression are fractional logit, fractional probit, and heteroskedastic probit models. Since the dependent variable is within the [0,1] interval, the conditional expectation $E(y/x)$ is also restricted within the [0,1] interval. To do this, fractional regression fits the Probit ($E(y/x) = \phi(x\beta)$), Heteroskedastic probit ($E(y/x) = (\frac{\phi(x\beta)}{exp(z\gamma)})$), and Logit ($E(y/x) = (\frac{exp(x\beta)}{1+exp(x\beta)})$) models.

Fractional regression implements quasi-likelihood estimators. The main advantage of Fractional regression is that there is no need to know the true probability distribution to obtain consistent parameter estimates. What is needed is to have the correct specification of the conditional mean. Also, fractional regression computes robust standard errors by default. Fractional regression is commonly used when the dependent variable is a fraction, a proportion, a rate, an index, or a probability. Note that in probit and logit models, β denotes the likelihoods. In this study, β shows the likelihood that a given independent variable increases/decreases the intensity of adopting electronic payments. However, marginal effects can also be computed.

To use Beta regression, the dependent variable should be greater than 0 and less than 1. The dependent variable is continuous in the (0,1) interval. The Beta regression follows a Beta distribution and uses link functions for the conditional mean. The conditional mean can be defined using link functions of logit ($g(\mu_x) = ln[\mu_x/(1-\mu_x)]$), probit ($g(\mu_x) = \phi^{-1}(\mu_x)$), cloglog ($g(\mu_x) = ln(-ln(1-\mu_x))$), and loglog ($g(\mu_x) = -ln[-ln(\mu_x)]$).

Finally, the Tobit model is also commonly used when the dependent variable is continuous and bounded between the lower and upper limit (which includes the case when it is bounded between 0 and 1). A latent regression model for an observed or unobserved outcome is defined as:

$$y = x\beta + \epsilon \tag{5}$$

The observed outcome for observation i is defined as:

$$y = x\beta + \epsilon \tag{6}$$

The observed outcome for observation i is defined as:

$$y_i^* = \begin{cases} y_i | \alpha < y_i < b \\ \alpha | y_i \leq \alpha \\ b | y_i \geq b \end{cases}$$

Where α is the lower-censoring limit and b is the upper-censoring limit. In this model, ϵ, which is the error term, is assumed to follow a normal distribution. Depending on the problem at hand, the quantity of interest may be the censored outcome (y_i^*) or the uncensored outcome (y_i). The Tobit model can enable the prediction of values that fall below the measurement threshold. In this study, we estimate the fractional logit, fractional probit, Beta regression and Tobit model and compare the results. Ideally, they should give the same results, at least in terms of the direction of effect.

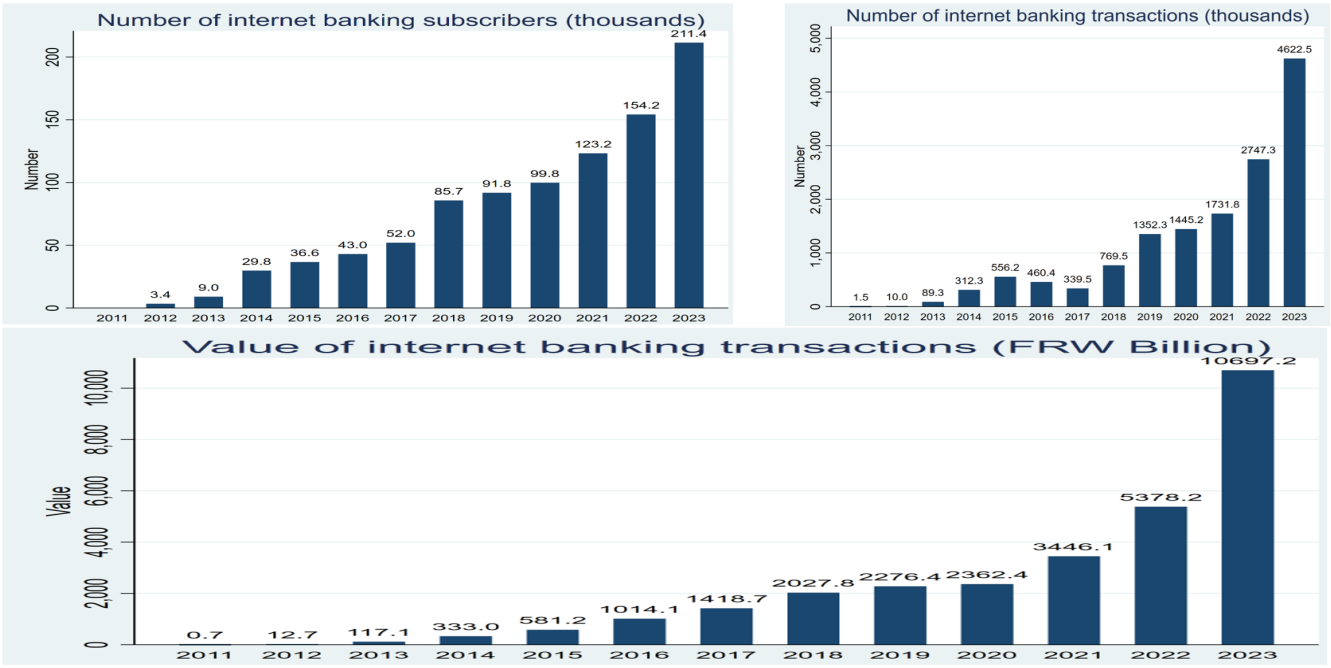
The approach used to define variables has been adapted from (Nakhumwa, 2013), with minor modifications. In adoption studies, fractional regressions (i.e. Logit and Probit) have been extensively used (Owili et al., 2024), including in Rwanda (Misango et al., 2022). Although Beta regressions are commonly used in natural sciences, there have been a few applications in social sciences where the dependent variable is measured as a fraction, proportion, percentage, or index (Ünlü & Aktaş, 2017). Finally, the application of the Tobit model in assessing the intensive use or intensive adoption of technologies has been well documented in both advanced and developing economies (Michels & Musshoff, 2022; McWilliams & Zilbermanfr, 1996).

5 Discussion of empirical results

5.1 Descriptive Analysis

In this study, we are particularly interested in the following types of digital payments: internet banking, mobile banking, mobile payments, and card-based payments.

Figure 7: The Trend in Internet Banking in Rwanda

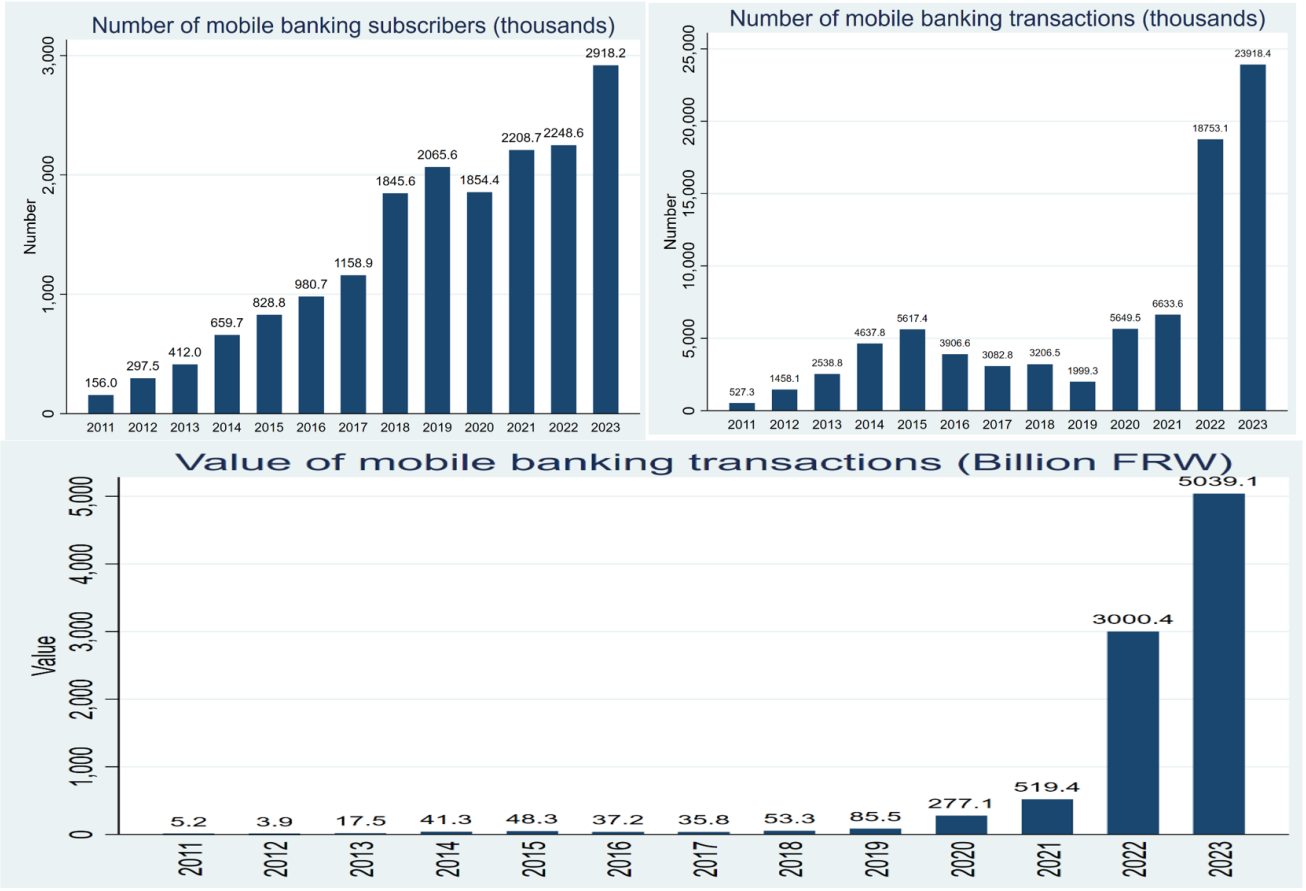


Source: National Bank of Rwanda Payments Statistics

Internet banking: since 2011, the number of Internet banking subscribers has been rising from 3,411 in 2011 to 211,355 in 2023. The number of Internet banking transactions also increased from 1,493 to 4,622,540 while the value of transactions jumped from 708 FRW Million to 10,697,166 FRW Million during the same period. This positive trend was facilitated by the Government's increased investment in Internet infrastructure and financial institutions' high adoption of Internet banking technology to meet changing customer needs, such as offering real-time payments through mobile apps. As more people access the Internet, demand

for Internet banking also increases. The increase in the adoption of smartphones has also contributed to the high adoption of Internet banking and this is expected to increase following MTN and Bank of Kigali's "Macye Macye" program to increase smartphone penetration in Rwanda. This is building on prior programs, such as the Government of Rwanda's "Connect Rwanda" program initiated in 2020 to distribute smartphones to vulnerable rural households.

Figure 8: The Trend in Mobile Banking in Rwanda

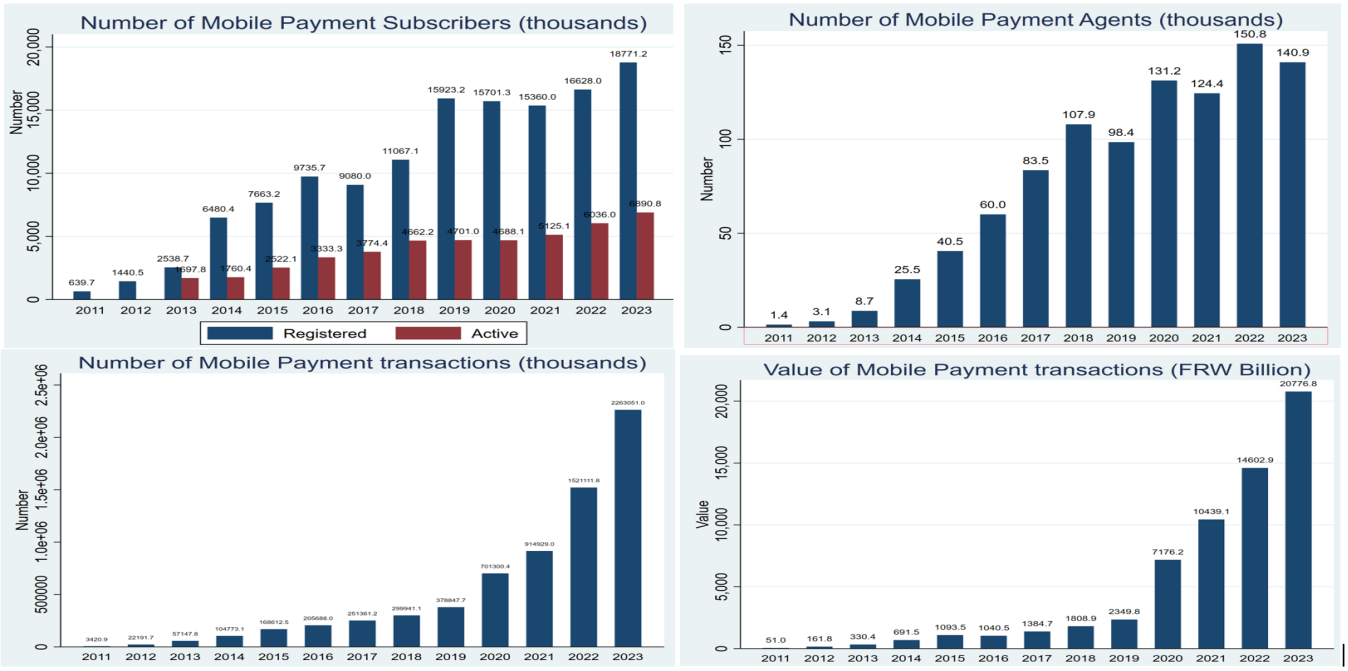


Source: National Bank of Rwanda Payments Statistics

Mobile banking: regarding the use of mobile phones to make banking transactions, except for 2020, the number of subscribers has been steadily increasing since 2011. It jumped from 155,986 in 2011 to 2,918,225

in 2023. During the same period, the number of mobile banking transactions also surged from 527,300 to 23,918,417 while the value of transactions increased from 5,215 FRW Million to over 5 Billion FRW. The trends have been particularly positive for the last two years, and this has been more possible in recent years following the advancement in technologies and the adoption of the integrated payment processing system. Again, the increase in smartphone penetration has positively influenced the adoption of mobile banking. Cross-country evidence shows that customers adopt mobile banking if they perceive it to be less costly, more convenient, and easy to use, and can be trusted (Liza, 2014).

Figure 9: The Trend in Mobile Payments in Rwanda



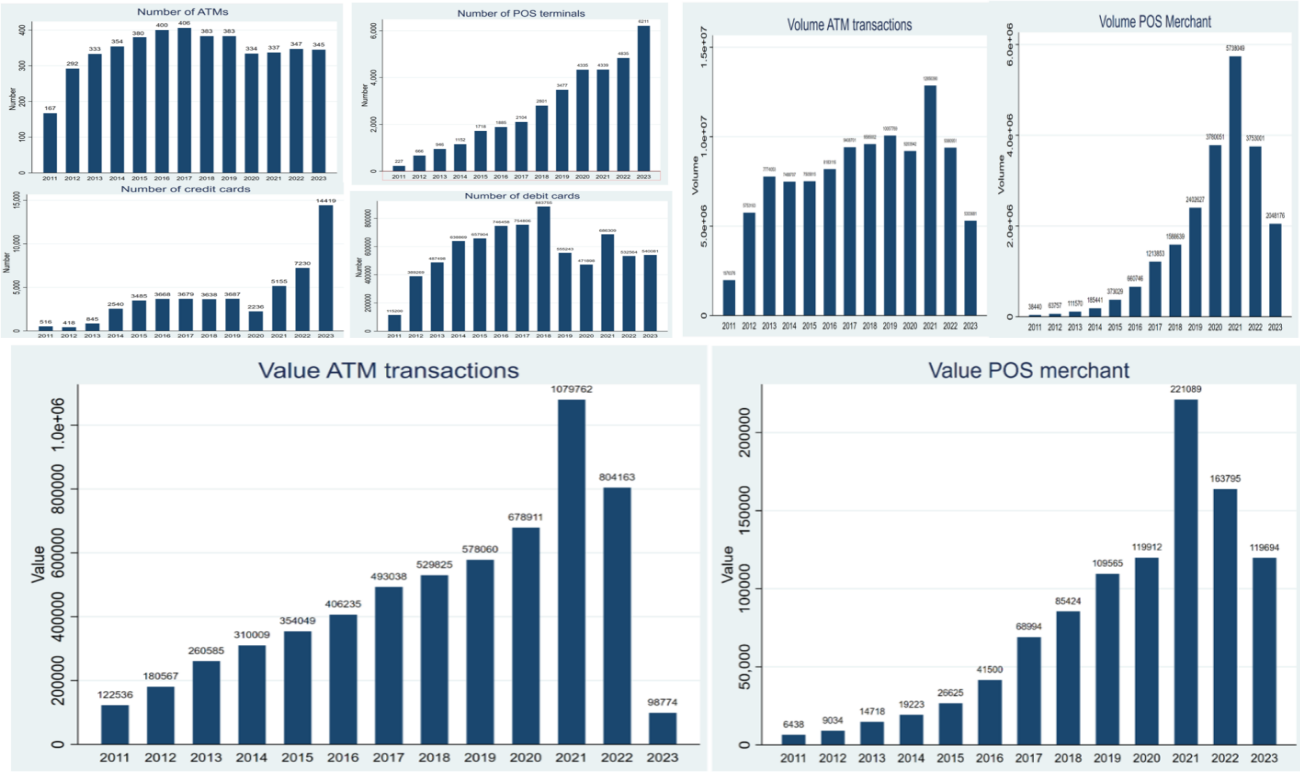
Source: National Bank of Rwanda Payments Statistics

Mobile payments: A transaction is classified as a mobile payment if it involves the use of a mobile device (such as a smartphone or tablet), rather than physical cash, to pay for a good or service. These digital payments can be made using methods like near-field communication (NFC), quick response (QR) codes, or mobile payment apps. For example, mobile payments in Rwanda can be made using MTN MoMo (Airtel Rwanda offers similar services), with or without a smartphone. To send or receive money, a client

only needs to dial *182# and follow instructions. This uses the Unstructured Supplementary Service Data (USSD) technology to enable mobile phones to communicate with the computers of Telecom company so as to process digital transactions.

Furthermore, merchant codes can also be used to pay for purchased goods and services. Looking at the number of registered and active subscribers, the number of mobile payment agents, the number of mobile payment transactions, and the value of mobile payment transactions, it is clear that the uptake of mobile payments has significantly increased in Rwanda since 2011. The number of mobile payment transactions rose from 3,420,885 in 2011 to 2,263,051,143 in 2023. Likewise, the value of mobile payment transactions jumped from 51,024 FRW Million to 20,776,838 FRW Million during the same period.

Figure 10: Uptake of card-based payments



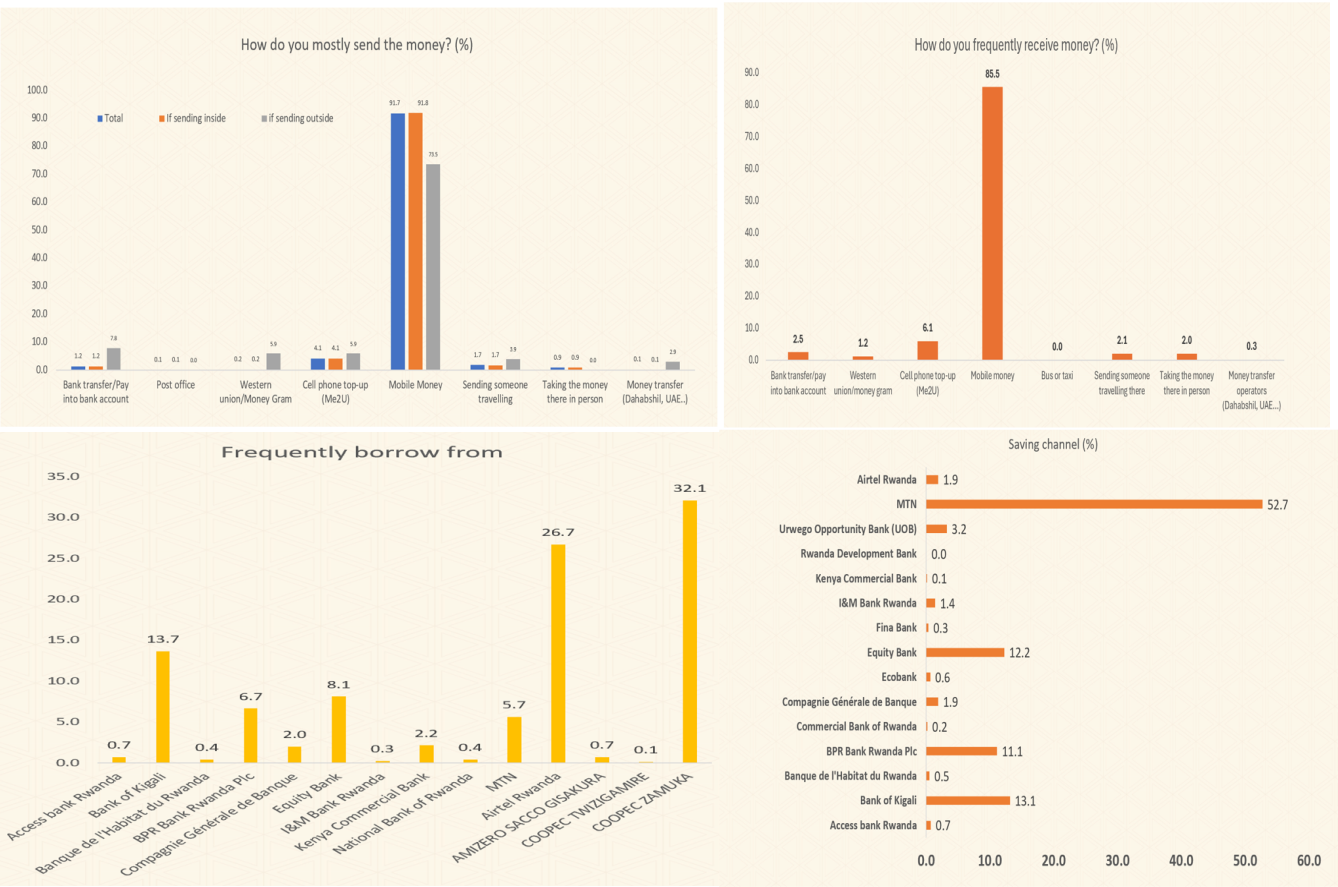
Source: National Bank of Rwanda Payments Statistics

Card-based payments: The uptake of card-based payments shows some mixed trends. The value of ATM transactions increased since 2011, peaking in 2021, after which it dropped. This can be attributed to the emergence and increased use of new technologies, such as mobile money and mobile banking. Indeed, investment in ATM infrastructures has stagnated in recent years, indicating that banks are shifting towards new financial intermediation channels. Despite the increase in POS terminals, the value and volume of POS merchant transactions have reduced, after the observed peaks in 2021. The juxtaposition of fast-increasing mobile money transactions and declining POS transactions implies that clients have shifted their preferences to mobile money since it offers unparalleled convenience and accessibility. Another interesting observation is the recent increase in the number of credit cards and the drop in the number of debit cards.

In the 2024 Finscope survey, respondents were asked about the channels they used to send, receive, borrow, and save money. In general, 91.7% of the household heads included in the sample sent money using mobile money. Mobile money was highly used to send money inside the country (91.8%) and outside the country (73.5%) compared to other channels. The use of mobile money also dominates other channels in terms of usage by household heads to receive money (85.5%), save money (54.6% for both MTN and Airtel). Indeed, 5.7% of sampled household heads borrow from MTN, while 26.7% borrow from Airtel. Borrowing here includes micro-credit accessed via MTN MoKash, as well internet and airtime bundles borrowed from both MTN and Airtel. These numbers confirm the trend observed in secondary data of payment statistics that the adoption and use of mobile payments have overtaken other digital channels in Rwanda.

Regarding the channels used to pay for different goods and services, the use of cash dominates (80.87%), followed by Mobile payment (18.79%). The latter is the most dominant digital channel in Rwanda, followed by internet banking (0.35%). The same pattern is observed for the most preferred payment channel: cash (88.52%), mobile money (11.1%), and internet banking (0.39%). The sampled household heads indicated that the main factors they look at when choosing a payment channel are security, transaction fees (cost) and convenience. The other important factors are accessibility and availability of digital payment channels.

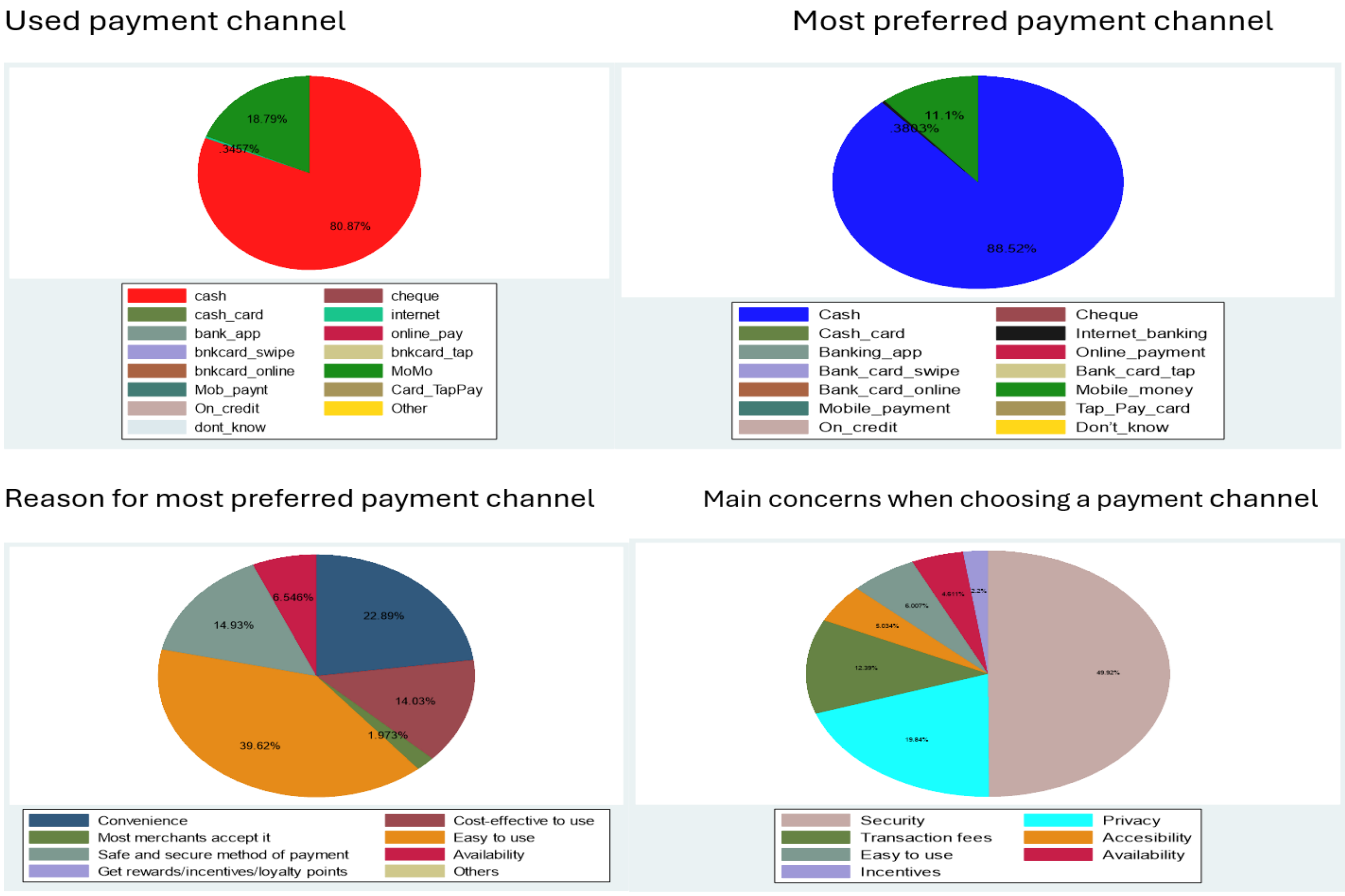
Figure 11: Channel used to send, receive, borrow and save money



Source: Authors' computations using Finscope survey data (2024)

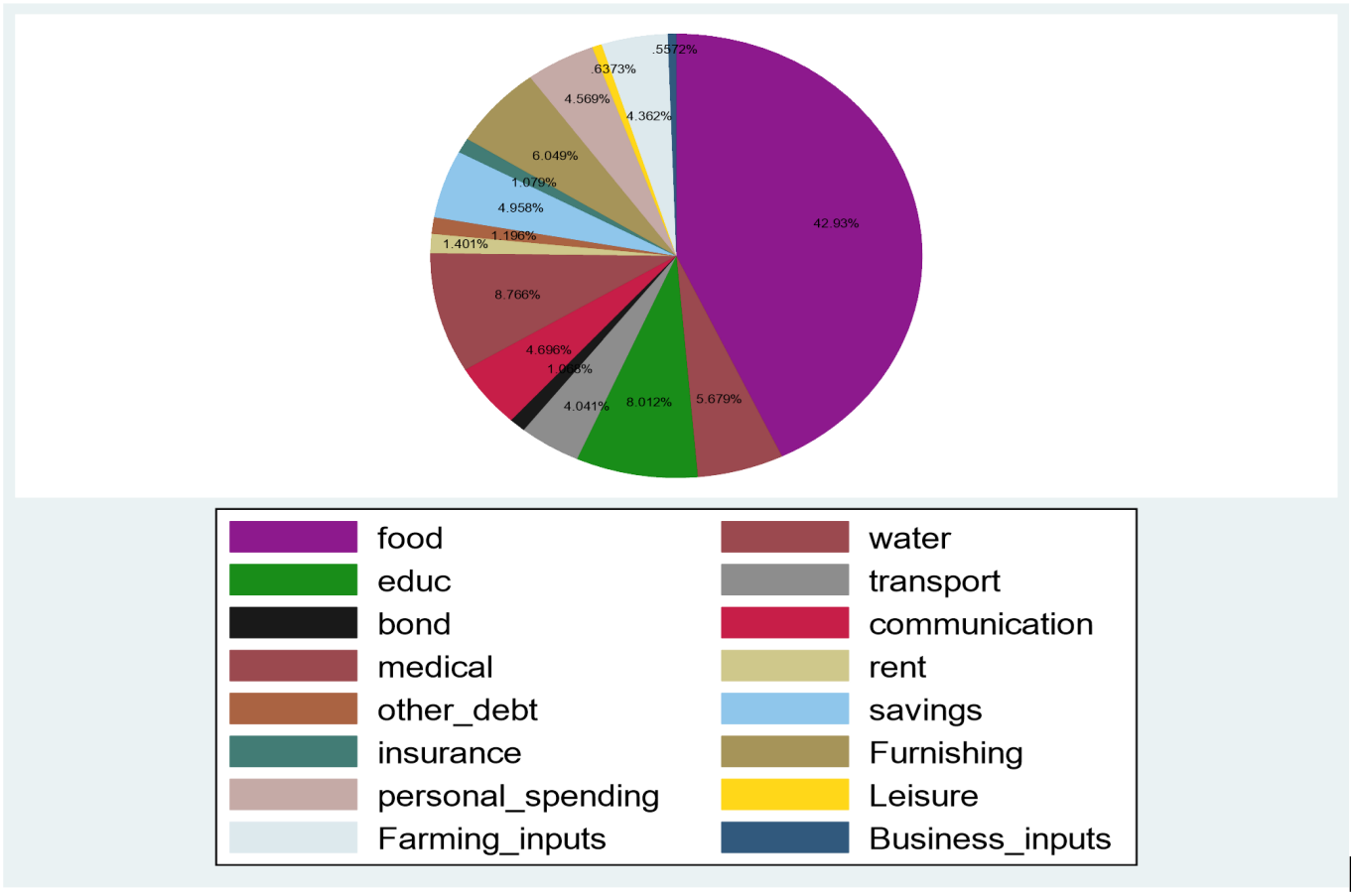
The spending patterns observed from the full sample are almost replicated in the sample of heads of households. Spending on food takes a lion's share (42.93%), followed by medical bills (8.77%), and education (8.01%). These are mostly paid for using cash and mobile money. According to Gemmell (1997), the use of cash may remain high if economic agents value anonymity and traceability. Also, limited financial literacy and transactional costs may be the cause for the reluctant adoption of digital channels. Indeed the most cited reasons for the preference of mobile money over other digital channels by sampled household heads in Rwanda are: accessibility, convenience, cost-effectiveness, and trust.

Figure 12: Choice of payment channel



Source: Finscope survey data (2024)

Figure 13: Households' spending patterns



Source: Finscope survey data (2024)

5.2 Drivers of intensity in digital payments adoption

What emerges from the above descriptive analysis and the introduction is that the adoption of digital payment channels has increased in most parts of the World (including Rwanda), especially during and after the COVID-19 pandemic. The travel and work-related restrictions during this period enabled the testing and operationalization of innovative digital channels. Additionally, there is an observable shift from traditional digital payment channels to recent ones, especially mobile money and Internet banking. Given this fact, we estimate empirical models for the intensity of adopting total digital payments and mobile money.

In the Finscope data set, respondents ranked their preference for different digital payment channels with respect to convenience, trust, accessibility, privacy, transactional costs, acceptability, ease of use, safety and security, availability, and incentives for the use of the platform. However, descriptive analysis shows that the most considered characteristics of a digital payment channel are security, transaction fees (cost), and convenience. Thus, we include only these three attributes in the empirical models, in addition to other explanatory variables.

Empirical findings show that the adoption of digital payment channels is lower for household heads located in rural areas, compared to those living in urban areas. The Logit and Probit models show that the likelihood of adopting digital payments is generally lower for those in rural areas compared to those in urban areas. The results of the Tobit and Beta regressions confirm the same. These findings are consistent with the intensity of adopting either all or any digital payments, or mobile money. As highlighted by Trivedi & Sanchiher (2023), the low adoption in rural areas is due to limited internet and mobile connectivity, high dependency on cash due to low financial literacy, lack of infrastructures (such as bank branches, ATMs, and POSs), low penetration of mobile phones and other factors. These issues are especially more pronounced in Sub-Saharan Africa (IMF, 2020). For the case of Rwanda, similar findings were obtained by previous studies on the same topic (Munyegera, 2024).

This study also examined whether convenience, transactional cost, and security influence the choice of economic agents regarding their decision to intensively use digital payments. Convenience refers to the consumers' perception on how quick, simple and accessible a payment method is. A payment method is

considered secure if consumers feel safe and confident when using it. Advances in technology have enabled the strengthening of security by use of a two-step authentication procedure, and the adoption of encryption, and fraud detection systems. Consumers are also often compelled to use a given payment method if it is perceived to be affordable in terms of transactional costs incurred or if it provides additional incentives, such as cashback offers or reward points (Lin et al., 2023).

In this study, convenience is, at the household level, defined as a dummy variable, equaling 1 if the household head perceives a payment channel to be convenient, and 0 otherwise. On aggregate, convenience shows the number of household heads who perceive digital payment channels as convenient. We also include the square term, to capture the non-linear effect to test whether or not the intensity of adoption increases as the number of convenient household heads increases. Thus, convenience stands for "lower perceived convenience" while its square term stands for "higher perceived convenience". Empirical findings from all the estimated models consistently show that lower perceived convenience in digital payment channels reduces the intensity of adoption. Conversely, as convenience increases, the intensity of adoption also increases. Lower convenience also reduces the intensity of adopting mobile money and vice-versa. Similar findings (on the effect of convenience on the adoption of electronic payments) are obtained in a panel of countries (Brown et al., 2021), and for developing countries like Kenya (Nakhumwa, 2013).

Using a similar analogy, cost is, at the household level, defined as a dummy variable, equaling 1 if the household head perceives a payment channel to be costly, and 0 otherwise. On aggregate, "Cost" is used as a proxy for lower perceived cost while "Sq_cost" is a proxy for higher perceived cost. Empirical findings show that when perceived cost is low (denoted by the variable Cost), the adoption of digital payments increases. Conversely, when perceived cost is high (denoted by the variable Sq_cost), the adoption of digital payments reduces. In the literature, the square term of perceived cost has been found to hinder the adoption of cashless payments across the World (Vimal Raj et al., 2023), and in developing countries (Batiz-Lazo et al., 2023).

Similarly, security is on aggregate used as a proxy for lower perceived security in digital payments, while Sq_security is a proxy for higher perceived security. Empirical estimations in this study show that higher perceived security positively influences the adoption of cashless payments in Rwanda. With lower perceived security, the intensity of adoption reduces. The effect of lower/higher security on the intensive use of mobile

money is the same as for total digital payments, in terms of the direction of effect.

Lastly, unlike in the case of Munyegera (2024), this study finds no significant effect of demographic characteristics (age, gender, marital status, household size, and education) on the intensity of adoption of digital payments in Rwanda. Studies with similar findings elsewhere include Yadav et al. (2021). The same findings hold for the adoption of mobile payments in Rwanda.

	Fractional regression				**Beta regression**		**Tobit regression**	
	Logit_all	Logit_MoMo	Probit_all	Probit_MoMo	All	MoMo	All	MoMo
Rural	***-0.0814****	***-0.0770****	***-0.0448****	***-0.0423****	***-0.0897*****	***-0.0857*****	***-0.0125****	***-0.0118****
	(-3.22)	***(-3.07)***	***(-3.12)***	***(-2.97)***	***(-3.53)***	***(-3.39)***	***(-3.20)***	***(-3.05)***
Age_hh	-0.00529	-0.00500	-0.00314	-0.00298	-0.00486	-0.00455	-0.000849	-0.000805
	(-1.03)	(-0.98)	(-1.06)	(-1.00)	(-1.02)	(-0.96)	(-1.04)	(-0.99)
Sq_age	0.0000619	0.0000592	0.0000365	0.0000350	0.0000603	0.0000572	0.00000998	0.00000955
	(1.21)	(1.16)	(1.23)	(1.18)	(1.25)	(1.19)	(1.21)	(1.16)
Married	0.00167	0.00103	0.000464	0.000109	0.00890	0.00864	0.000278	0.000173
	(0.06)	(0.03)	(0.03)	(0.01)	(0.32)	(0.31)	(0.06)	(0.04)
hh_size	-0.0392	-0.0432	-0.0222	-0.0244	-0.0324	-0.0367	-0.00565	-0.00625
	(-1.12)	(-1.24)	(-1.10)	(-1.21)	(-0.99)	(-1.12)	(-1.02)	(-1.14)
sqq_hhsize	0.00594	0.00606	0.00341	0.00347	0.00505	0.00524	0.000875	0.000892
	(1.40)	(1.44)	(1.39)	(1.42)	(1.22)	(1.27)	(1.31)	(1.35)
Female	0.0411	0.0385	0.0238	0.0224	0.0429	0.0398	0.00656	0.00616
	(1.41)	(1.32)	(1.43)	(1.35)	(1.48)	(1.38)	(1.44)	(1.35)
Convenience	***-0.554*****	***-0.549*****	***-0.302*****	***-0.299*****	***-0.570*****	***-0.566*****	***-0.0756*****	***-0.0748*****
	(-8.79)	***(-8.73)***	***(-8.67)***	***(-8.62)***	***(-11.84)***	***(-11.82)***	***(-9.14)***	***(-9.08)***
Sq_convenience	***0.0528*****	***0.0521*****	***0.0289*****	***0.0285*****	***0.0544*****	***0.0538*****	***0.00732*****	***0.00721*****
	(6.86)	***(6.80)***	***(6.63)***	***(6.58)***	***(9.09)***	***(9.06)***	***(6.92)***	***(6.86)***
Cost	***0.211****	***0.212****	***0.112****	***0.113****	***0.238****	***0.240****	***0.0305****	***0.0307****
	(2.32)	***(2.35)***	***(2.23)***	***(2.25)***	***(3.06)***	***(3.10)***	***(2.38)***	***(2.40)***
Sq_cost	***-0.0499****	***-0.0500****	***-0.0269****	***-0.0270****	***-0.0545****	***-0.0548****	***-0.00732****	***-0.00733****
	(-2.44)	***(-2.45)***	***(-2.38)***	***(-2.40)***	***(-3.11)***	***(-3.15)***	***(-2.57)***	***(-2.58)***
Security	***-0.147*****	***-0.154*****	***-0.0842*****	***-0.0883*****	***-0.122****	***-0.128****	***-0.0231*****	***-0.0242*****
	(-3.68)	***(-3.87)***	***(-3.68)***	***(-3.87)***	***(-3.10)***	***(-3.27)***	***(-3.62)***	***(-3.80)***
Sq_security	***0.0173****	***0.0185****	***0.0101****	***0.0108****	***0.0145****	***0.0155****	***0.00276****	***0.00294****
	(2.90)	(3.12)	(2.93)	(3.15)	(2.22)	(2.38)	(2.89)	(3.10)
educ2(P1-P3)	0.0463	0.0482	0.0281	0.0290	0.0491	0.0509	0.00778	0.00799
	(0.83)	(0.88)	(0.89)	(0.93)	(0.86)	(0.90)	(0.90)	(0.94)
educ3(P4-P6)	-0.00148	0.00309	0.00184	0.00429	-0.00163	0.00245	0.000547	0.00120
	(-0.03)	(0.07)	(0.07)	(0.17)	(-0.03)	(0.05)	(0.08)	(0.18)
educ4(S1-S3)	-0.0256	-0.0171	-0.0132	-0.00860	-0.0284	-0.0210	-0.00379	-0.00255
	(-0.44)	(-0.30)	(-0.40)	(-0.26)	(-0.49)	(-0.37)	(-0.43)	(-0.29)
educ5(S4-S6)	-0.0403	-0.0380	-0.0225	-0.0213	-0.0425	-0.0399	-0.00598	-0.00563
	(-0.77)	(-0.73)	(-0.76)	(-0.73)	(-0.80)	(-0.76)	(-0.77)	(-0.74)
Educ6(Univ/Higher)	0.0615	0.0734	0.0378	0.0444	0.0550	0.0666	0.0103	0.0121
	(1.02)	(1.22)	(1.09)	(1.28)	(0.95)	(1.15)	(1.08)	(1.28)
educ7(Vocational)	0.00667	0.0164	0.00505	0.0104	0.0187	0.0269	0.000923	0.00236
	(0.09)	(0.22)	(0.12)	(0.25)	(0.21)	(0.30)	(0.08)	(0.21)
_cons	-0.664***	-0.666***	-0.434***	-0.435***	-0.749***	-0.752***	0.305***	0.304***
	(-3.46)	(-3.49)	(-3.96)	(-3.99)	(-4.39)	(-4.44)	(10.43)	(10.49)
N	954	953	954	953	954	953	954	953

t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Educ 1 (No formal education is the benchmark).

Table 2: Drivers of the intensity of adopting digital payments in Rwanda

Unlike studies such as Munyegera (2024)and Singh (2019), which found that men were more likely to adopt digital payments, our findings suggest that gender does not play a significant role in Rwanda. This discrepancy may be attributed to Rwanda's progressive gender policies and inclusive digital initiatives. For instance, the "Connect Rwanda" campaign has been instrumental in bridging gender gaps by distributing smartphones to vulnerable households, many of which are headed by women. Additionally, financial literacy campaigns tailored to women and initiatives promoting women's participation in digital and economic ecosystems may have equalized gender disparities in digital payment adoption. Furthermore, Rwanda's high female representation in leadership and workforce participation likely fosters an environment where women are empowered to access and utilize digital financial services. This progressive backdrop suggests that previous gender-based barriers to technology adoption have been significantly mitigated in the Rwandan context.

The lack of a significant relationship between education and digital payment intensity in our study contrasts with findings such as Maniriho (2021) and Klee (2008), which highlight the role of higher education in facilitating digital payment adoption. A key factor explaining this divergence is the design of Rwanda's mobile money ecosystem. Service providers of mobile money use simplified, USSD-based interfaces, making them accessible to individuals with limited formal education. This accessibility reduces the dependency on education as a driver of adoption. Additionally, Rwanda's government has actively promoted financial inclusion through policies and infrastructures that prioritize user-friendly digital platforms. Programs like "Irembo" and partnerships with mobile operators ensure that even individuals with minimal formal education can seamlessly engage in digital transactions. These efforts diminish the influence of education as a barrier to digital payment usage. In line with Rwanda's universal primary education policy, the majority of Rwandans, especially the youths, have some minimum level of formal education.

6 Summary and Conclusions

This study investigated the factors influencing the uptake and intensive use of digital financial channels in Rwanda. Insights from the descriptive analysis revealed that despite the still high use of cash, the adoption of cashless payment channels (to spend, save, borrow, or send money) has increased especially during and after the COVID-19 pandemic. Additionally, there is an observed shift from traditional to non-traditional electronic payment channels, with the use of mobile money dominating. The development of the digital ecosystem and the increased adoption of digital payment channels was facilitated by a conducive policy and regulatory framework, the government's increased investment in digital infrastructures, the various financial awareness campaigns, innovations that came up with sector-specific products, and the Government's agenda to fully digitize public services.

Using fractional logit/probit, beta regression, and Tobit models, empirical findings show that the intensive use of digital payments is positively influenced by perceived low transactional cost, perceived high convenience, and perceived high security. Conversely, household heads living in rural areas have lower adoption of digital payments compared to those in urban areas, perhaps due to limited infrastructures, low financial literacy, and lower penetration of mobile phones.

The first recommendation that comes out of this study is that rural areas should not be left out. All stakeholders should work together to increase financial literacy campaigns in rural areas. Additionally, investment in the necessary digital infrastructure, such as internet connectivity, should be scaled up in rural areas. Initiatives, such as "Connect Rwanda" and "Macye Macye" to increase mobile phone penetration are steps in the right direction.

However, other innovative products tailored to client needs should be thought of. Technological innovations, such as a two-step authentication procedure, and the adoption of encryption, and fraud detection systems, are required to guarantee the security of digital payment channels for all segments of the Rwandan population. Still on security, strong coordination mechanisms should be put in place between regulators and security organs to limit fraud incidents, often viewed by consumers as signs that their mobile wallet is not safe.

Also, there is a need to come up with more convenient digital payment products that are easy to use, fast, efficient (i.e. with minimal system breakdowns), and contextualized to the characteristics of different segments of the population (e.g. specific products to cater for the convenience of the disabled, youth, women or workers and businesses in the informal sector).

Finally, the emphasis should be placed on less-costly yet effective digital payment channels bearing in mind the challenges (such as limited infrastructure) often encountered in developing countries. The recent shift from the use of ATMs and POs towards mobile money is a testament to this. A review of existing prices is needed to balance the need for low-cost digital payment solutions and keep incentives for the operators to keep investing in the sector.

References

Akinyemi, B. E., & Mushunje, A. (2020). Determinants of Mobile Money Technology Adoption in Rural Areas of Africa. *Cogent Social Sciences*, *6*(1), 1815963.

Alfonso, V., Tombini, A., & Zampolli, F. (2020). Retail Payments in Latin America and the Caribbean: Present and Future. *BIS Quarterly Review*.

Alkhowaiter, W. A. (2020). Digital Payment and Banking Adoption Research in Gulf Countries: A Systematic Literature Review. *International Journal of Information Management*, *53*, 102102.

Allen, F., Demirguc-Kunt, A., Klapper, L., & Martinez Peria, M. S. (2016). The Foundations of Financial Inclusion: Understanding Ownership and Use of Formal Accounts. *Journal of Financial Intermediation*, *27*, 1–30.

Arango, C., Huynh, K. P., & Sabetti, L. (2015). Consumer Payment Choice: Merchant Card Acceptance Versus Pricing Incentives. *Journal of Banking & Finance*, *55*, 130–141.

Arvidson, N. (2018). The Future of Cash. *The Rise and Development of FinTech*, 107–120.

Aurazo, J., & Vega, M. (2021). Why People Use Digital Payments: Evidence from Micro Data in Peru. *Latin American Journal of Central Banking*, *2*(4), 100044.

Balakrishnan, V., & Shuib, N. L. M. (2021). Drivers and Inhibitors for Digital Payment Adoption Using the Cashless Society Readiness-Adoption Model in Malaysia. *Technology in Society*, *65*, 101554.

Batiz-Lazo, B., Maixé-Altés, J. C., & Peon, D. (2023). Behavioral Drivers of Cashless Payments in Africa. *Available at SSRN 4521894*.

Beyene, E., Katia, H.-Z., Andrea, Q., & Miguel, S. (2024). *Access Survey - 2024 Highlights: Marking 15 Years of Supporting Financial Inclusion* (Tech. Rep.).

BNR. (2024). *Monetary Policy and Financial Stability Statement, March 2024* (Tech. Rep.).

Brown, M., Hentschel, N., Mettler, H., & Stix, H. (2021). The Convenience of Electronic Payments and Consumer Cash Demand–Causal Evidence from the Staggered Introduction of Contactless Debit Cards. *University of St. Gallen, School of Finance Research paper*(2020/02).

Cenfri. (2020). COVID-19's impact on mobile money in Rwanda. *Cenfri Articles*. (Available at: https://cenfri.org/articles/covid-19s-impact-on-mobile-money-in-rwanda/)

Chen, H., Huynh, K. P., & Shy, O. (2019). Cash versus card: Payment Discontinuities and the Burden of Holding Coins. *Journal of Banking & Finance*, *99*, 192–201.

Ching, A. T., & Hayashi, F. (2010). Payment Card Rewards Programs and Consumer Payment Choice. *Journal of Banking & Finance*, *34*(8), 1773–1787.

Demirgüç-Kunt, A., Klapper, L., Singer, D., & Ansar, S. (2022). *The global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of Covid-19*. World Bank Publications.

Effah, J. (2016). Institutional Effects on E-payment Entrepreneurship in a Developing Country: Enablers and Constraints. *Information Technology for Development*, *22*(2), 205–219.

Federal Deposit Insurance Corporation. (2018). *2017 Fdic National Survey of Unbanked and Underbanked Households* (Tech. Rep.). Federal Deposit Insurance Corporation.

Franciska, A. M., & Sahayaselvi, S. (2017). An Overview on Digital Payments. *International Journal of Research*, *4*(13), 2101–2111.

Fungáčová, Z., & Weill, L. (2015). Understanding Financial Inclusion in China. *China Economic Review*, *34*, 196–206.

Gemmell, P. S. (1997). Traceable e-cash. *IEEE spectrum*, *34*(2), 35–37.

Glowka, A., Kosse, A., & Szemere, R. (2023, January). *Digital Payments Make Gains but Cash Remains* (BIS Commentary). Bank for International Settlements. Retrieved from https://www.bis.org/publ/commentary.htm (Accessed: 2024-12-03)

Grzybowski, L., Lindlacher, V., & Mothobi, O. (2023). Mobile Money and Financial Inclusion in Sub-Saharan Africa. *Information Economics and Policy*, *65*, 101064.

Humphrey, D. B., Pulley, L. B., & Vesala, J. M. (1996). Cash, Paper, and Electronic payments: A Cross-Country Analysis. *Journal of Money, Credit and Banking*, *28*(4), 914–939.

IMF. (2020). Digitalization in Sub-Saharan Africa. In IMF (Ed.), *Regional Economic Outlook, April 2020, Sub-Saharan Africa COVID-19: An Unprecedented Threat to Development* (pp. 33–51). Washington DC: Author.

Jadil, Y., Rana, N. P., & Dwivedi, Y. K. (2021). A meta-analysis of the UTAUT Model in the Mobile Banking Literature: The Moderating Role of Sample Size and Culture. *Journal of Business Research*, *132*, 354–372.

Kajol, K., Singh, R., & Paul, J. (2022). Adoption of Digital Financial Transactions: A Review of Literature and Future Research Agenda. *Technological Forecasting and Social Change*, *184*, 121991.

Karangwa, M. (2022). *PhD Thesis (Universidad do Minho, Portugal): The Determinants of Economic Growth in Africa.* Retrieved 2024-12-12, from https://repositorium.sdum.uminho.pt/bitstream/1822/84241/1/Mathias%20Karangwa.pdf

Karsen, M., Chandra, Y. U., & Juwitasary, H. (2019). Technological Factors of Mobile Payment: A Systematic Literature Review. *Procedia Computer Science*, *157*, 489–498.

Khayesi, J. (2022). Financial Technologies and Rapid Development Growth in Emerging Economies. In *Handbook of innovation & appropriate technologies for international development* (pp. 154–167). Edward Elgar Publishing.

Kigabo, T. R. (2021). *Monetary Policy in Rwanda.* Springer Verlag, Singapore.

Klee, E. (2008). How People Pay: Evidence from Grocery Store Data. *Journal of Monetary Economics*, *55*(3), 526–541.

Kumar, A. (2005). *Access to Financial Services in Brazil.* World Bank Publications.

Ky, S. S., Rugemintwari, C., & Sauviat, A. (2019). Is Fintech Good for Bank Performance? The Case of Mobile Money in the East African Community. *SSRN Electronic Journal,DOI:10.2139/ssrn.3401930*.

Lin, L.-H., Lin, F.-C., Lien, C.-K., Yang, T.-C., Chuang, Y.-K., & Hsu, Y.-W. (2023). Electronic Payment Behaviors of Consumers under Digital Transformation in Finance—A Case Study of Third-Party Payments. *Journal of Risk and Financial Management*, *16*(8), 346.

Liza, F. Y. (2014). Factors Influencing the Adoption of Mobile Banking: Perspective Bangladesh. *Global Disclosure of Economics and Business*, *3*(2), 199–220.

Maniriho, A. (2021). Mobile Money for Financial Inclusion in Rwanda: Application of Endogenous Switching Regression Model. *Available at SSRN 3904897*.

Mas, I., & Radcliffe, D. (2011). Mobile Payments Go viral: M-PESA in Kenya. In P. Chuhan-Pole & M. Angwafo (Eds.), *Yes, Africa Can: Success Stories from A Dynamic Continent* (pp. 353–370). Washington, D.C.: World Bank Group. Retrieved from https://documents.worldbank.org/en/publication/documents-reports/documentdetail/358821468211142775/yes-africa-can-success-stories-from-a-dynamic-continent (Accessed: 2024-12-03)

McWilliams, B., & Zilbermanfr, D. (1996). Time of Technology Adoption and Learning by Using. *Economics of Innovation and New technology*, *4*(2), 139–154.

Michels, M., & Musshoff, O. (2022). A Tobit Regression Model for the Timing of Smartphone Adoption in Agriculture. *Heliyon*, *8*(11).

Misango, V. G., Nzuma, J. M., Irungu, P., & Kassie, M. (2022). Intensity of Adoption of Integrated Pest Management Practices in Rwanda: A Fractional Logit Approach. *Heliyon*, *8*(1).

Munyegera, G. K. (2024). Development of the Digital Financial Ecosystem in Rwanda: Drivers, Lessons and Way Forward.

Nakhumwa, J. N. (2013). *Adoption of E-Commerce Payment Systems by Commercial Banks in Kenya* (Unpublished doctoral dissertation). University of Nairobi.

NISR. (2024). *Rwanda Finscope Report 2024* (Tech. Rep.).

Owili, S. O., Otieno, D. J., Chimoita, E. L., & Baijukya, F. P. (2024). Factors Influencing Adoption of Agro-Ecological Pest Management Options for Mango Fruit Fly Under Information Constraints: A Two-Part Fractional Regression Approach. *International Journal of Pest Management*, 1–19.

Ramayanti, R., Rachmawati, N. A., Azhar, Z., & Azman, N. H. N. (2024). Exploring Intention and Actual Use in Digital Payments: A Systematic Review and Roadmap for Future Research. *Computers in Human Behavior Reports*, *13*, 100348.

Sarmah, R., Dhiman, N., & Kanojia, H. (2021). Understanding Intentions and Actual Use of Mobile Wallets by Millennial: An Extended TAM Model Perspective. *Journal of Indian Business Research*, *13*(3), 361–381.

Schuch, S., & Stavins, J. (2013). How consumers pay: Adoption and Usage of Payments. *Accounting and Finance Research*, *2*(2), 1–21.

Shin, D.-H. (2009). Towards an Understanding of the Consumer Acceptance of Mobile Wallet. *Computers in Human Behavior*, *25*(6), 1343–1354.

Shy, O. (2020). Low-income Consumers and Payment Choice. *Research in Economics*, *74*(4), 292–300.

Singh, G. (2019). A Review of Factors Affecting Digital payments and Adoption Behaviour for Mobile E-wallets. *International Journal of Research in Management & Business Studies*, *6*(4), 89–96.

Stavins, J., & Shy, O. (2015). Merchant Steering of Consumer Payment Choice: Evidence from a 2012 Diary Survey. *Journal of Behavioral and Experimental Economics*, *55*, 1–9.

Świecka, B., Terefenko, P., & Paprotny, D. (2021). Transaction Factors' Influence on the Choice of Payment by Polish Consumers. *Journal of Retailing and Consumer Services*, *58*, 102264.

Trivedi, H., & Sanchiher, S. (2023). Challenges in Digital Payment Adoption in India. *International Journal of Education, Modern Management, Applied Science & Social Science*, *5*(2), 32–38.

Tuesta, D., Sorensen, G., Haring, A., & Cámara, N. (2015). Financial Inclusion and Its Determinants: The Case of Argentina. *BBVA Research Working Papers*, *15*(03). Retrieved from https://www.bbvaresearch.com (Accessed: 2024-12-03)

Ünlü, H., & Aktaş, S. (2017). Beta Regression for the Indicator Values of Well-Being Index for Provinces in Turkey. *Journal of Engineering Technology and Applied Sciences*, *2*(2), 101–111.

Urhie, E., Amonu, O. C., Mbah, C., Ewetan, O. O., Matthew, O. A., Adediran, O., ... Adekeye, A. (2021). Banking Technology and Cashless Economy in Selected Sub-Saharan African countries: Does Education matter? *Journal of Money Laundering Control*, *24*(3), 584–595.

Uwamariya, M., Loebbecke, C., & Cremer, S. (2021). Mobile Money Adoption in Rural Rwanda: A Domestication Perspective. *Africa Journal of Management*, *7*(2), 314–337.

Vimal, R. L., Amilan, S., & Aparna, K. (2024). Factors Influencing the Adoption of Cashless Transactions: Toward a Unified View. *South Asian Journal of Marketing*, *5*(1), 74–90.

Vimal Raj, L., Amilan, S., & Aparna, K. (2023). Factors Influencing the Adoption of Cashless Transactions: Toward a Unified View. *South Asian Journal of Marketing*, *5*(1), 74–90.

Wang, Z., & Wolman, A. L. (2016). Payment Choice and Currency Use: Insights from Two Billion Retail Transactions. *Journal of Monetary Economics*, *84*, 94–115.

Williams, M. D. (2021). Social Commerce and the Mobile Platform: Payment and Security Perceptions of Potential Users. *Computers in Human Behavior*, *115*, 105557.

Woodruff, C., & Martinez, J. (2008). Assessing Changes in Household Access to Financial Services in Mexico: An Analysis of the BANSEFI/SAGARPA Panel Survey of 2004-2007. *Well-Being and Social Policy Working Paper Series*, *5*(1), 1–30.

World Bank. (2022). *Covid-19 Drives Global Surge in Use of Digital Payments.* Retrieved 2024-12-12, from https://www.worldbank.org/en/news/press-release/2022/06/29/covid-19-drives-global-surge-in-use-of-digital-payments#:~:text=The%20pandemic%20has%20also%20led,the%20start%20of%20the%20pandemic.

World Bank, . (2016, April). *Payment Aspects of Financial Inclusion* (Tech. Rep.). World Bank Group.

Yadav, M., et al. (2021). Problems and Challenges in Adoption of Cashless Payment Mode by Online Consumers. *IUP Journal of Management Research*, *20*(2), 20–36.

Yaokumah, W., Kumah, P., & Okai, E. S. A. (2017). Demographic Influences on E-payment Services. *International Journal of E-Business Research*, *13*(1), 44–65. doi: 10.4018/IJEBR.2017010103

Zimmerman, J., Bohling, K., & Parker, S. (2014). *Digital Financial Services: Challenges and Opportunities for Emerging Markets* (Tech. Rep.). Bill & Melinda Gates Foundation. Retrieved from https://documents.worldbank.org/en/publication/documents-reports/documentdetail/188451468336589650/the-opportunities-of-digitizing-payments?utm_source=chatgpt.com