



# **The impact of mobile money on Rwandan household consumption**

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## **Abstract**

Research on consumption patterns in developing countries shows that precautionary savings behaviour is common. This is driven by high-risk exposure to natural and economic shocks, and a lack of formal insurance mechanisms among rural farming households. The spread of mobile phones has introduced mobile money, which offers new financial opportunities to marginalized groups. This study examines mobile money's impact on consumption in Rwanda, using data from the Rwanda FinScope 2020 Survey. It applies probabilistic models and an instrumental variable approach to explore the relationship between mobile money use and consumption. The study finds that mobile money is financially inclusive and increases the likelihood of higher consumption among households. Remittances, representing financial flows between households, are key to this increased consumption smoothing. The findings suggest further research is needed to investigate whether household welfare improvements align with positive consumption patterns.

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# 1. Introduction

The analysis of consumption patterns in households across developing countries has been the focus of considerable research, particularly regarding the factors influencing these patterns (Khanal, Mishra & Nedumaran, 2018; Schmidt-Hebbel, Webb & Corsetti, 1992; Siddiqui, 1982). A common theme emerging from this body of literature is the prevalence of precautionary savings behaviour, driven by elevated risk exposure and lack of insurance mechanisms among rural farming households.

Persistent obstacles faced by rural households in Rwanda include the concentration of banking and financial institutions in urban areas, rural financial systems failing to deliver sufficient and timely financial products and services, and the reliance on unsustainable coping strategies in response to idiosyncratic shocks, particularly for agrarian households (Nkurunziza, Kabanda & McSharry, 2023; Papias & Ganesan 2010). Remaining an agrarian economy, the livelihoods of many Rwandan rural households depend on farming activities. Often, to cope with shocks like natural disasters and economic downturns, households reduce consumption, borrow funds or sell assets (Nkurunziza, Kabanda & McSharry, 2023). The long-term effects of these coping mechanisms include depletion of households' assets and an increase in debt burdens.

Using the Rwanda FinScope 2020 survey dataset, this research identifies factors influencing mobile money adoption, examining the relationship between mobile money usage and consumption growth. Probit models are employed to assess the key variables affecting households' decisions to adopt mobile money. Given that mobile money adoption is non-random, this study accounts for endogeneity using a Probit IV approach. Additionally, robustness checks and sensitivity analysis are conducted, incorporating the Research ICT Africa (RIA) 2017/18 dataset to support the empirical findings.

The main results show that access to mobile money increases the likelihood of engaging in financial transactions, such as sending or receiving money. This indicates that mobile money reduces transaction costs and alleviates liquidity constraints, enabling rural households to smooth their levels of consumption. While access to mobile money is widespread, its adoption is skewed towards wealthier and urban households, suggesting limited uptake among poorer rural households. These findings are robust to issues of selection bias and endogeneity. Overall,

the study highlights the inclusive and welfare-enhancing potential of mobile money services among rural households.

The rapid spread of mobile phones facilitates the introduction of mobile money, offering transformative solutions. By early 2024, Rwanda's mobile penetration rate had reached 86%, providing a platform for rapid adoption of digital financial services (DFS) (World Bank Group, 2024). Mobile money enables individuals to perform financial transactions via mobile phones without requiring a traditional bank account (Suri, 2017). Mobile money is supported by agent networks accessible to rural communities. It reduces transaction costs, increases savings through digital means, and improves insurance coverage against communal and idiosyncratic shocks<sup>1</sup> (Aron, 2018).

This research contributes to the existing literature in three ways. First, it enhances the understanding of household consumer behaviour concerning financial technology (FinTech) within developing economies. Second, it underscores the significance of household consumption in driving economic activity in these contexts through increased remittance use. Third, it provides a focused analysis of mobile money's impact in Rwanda using the FinScope survey, thereby enriching the broader discourse on mobile money across Africa (Apeti, 2023; Batista & Vicente, 2023; Jack & Suri, 2014, 2016; Munyegere & Matsumoto, 2018; Parlasca, Johnen & Qaim, 2022; Tabetando & Matsumoto, 2020).

This study is structured as follows. Section 2 introduces the background on mobile money in Rwanda and its potential benefits. Section 3 presents the Rwanda 2020 FinScope data and key summary statistics. Section 4 explains the empirical methodology used to analyse determinants of mobile money adoption and the relationship with household consumption. Section 5 discusses the empirical results of this analyses. Section 6 highlights limitations in the data and methodology and suggests directions for future research. Finally, section 7 concludes this study by summarizing the key findings and their implications.

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<sup>1</sup> Communal shocks include natural disasters, conflict and medical epidemics that affect large groups at once. Idiosyncratic shocks include theft, illness, family deaths, and household damages (Aron, 2018).

## 2. Literature Review

### *Background on mobile money in Rwanda*

In February 2010, MTN introduced mobile money in Rwanda (Kamande et al., 2021). Tigo and Airtel launched their mobile money products in 2011 and 2013 respectively. These platforms initially focused on basic money transfers but have expanded to include financial services such as credit provision, savings schemes, and insurance products to improve their market share. In 2013 the Bank of Kigali (BK) alongside Opportunity Urwego (UoB) partnered with myVisa to launch their mobile money products. This is reflective of banking services incorporating digital finance to enhance financial inclusion.

Mobile money adoption efforts have accelerated in recent years. During the COVID-19 pandemic, the National Bank of Rwanda (BNR) set rapid economic policies to shift the country to a more cashless system, further incentivising the use of mobile money (Carboni & Bester, 2020). Furthermore, MTN has been the first to introduce person-to-government (P2G) collection services in collaboration with the government. This enables citizens to make direct payments to government entities. These developments have positioned mobile money to improve financial access in Rwanda.

### *Adoption of mobile money: Barriers and Enablers*

Households in Sub-Saharan Africa often rely on informal systems, such as bus companies, friends, and family members, to send and receive money (Bair & Tritah, 2019). These methods are prone to delays and risks, including theft (Jack & Suri, 2014). Access to formal money transfer systems remain restricted due to high costs and limited availability, particularly for rural households where financial institutions are concentrated in urban areas (Papias & Ganesan, 2010).

One critical barrier to mobile money adoption is low financial literacy. Many individuals engage with financial services without fully understanding their mechanisms. Johnen, Parlasca, and Mußhoff (2023) highlight the importance of agent proximity and education in overcoming this barrier. Their analysis of Kenyan households, using the 2015 FinAccess Household Survey, shows that mobile money adoption increases when agents are accessible and receive formal training. Notably, trained agents are particularly effective in encouraging adoption among

individuals with limited education. These findings underscore the significance of local infrastructure and targeted educational initiatives in addressing adoption barriers.

### *Mobile money and Transaction Costs*

Mobile money reduces the costs associated with sending and receiving money compared to traditional mechanisms. Bair & Tritah (2019) find that mobile money increases the probability of sending and receiving money in remote areas of Madagascar. Using an instrumental variable (IV) representation of the linear probability model, the authors demonstrate that mobile money users engage in financial transactions more frequently due to reduced transaction costs. This capability enables households to adopt more effective consumption smoothing practices.

Jack and Suri (2014) document similar benefits in Kenya through M-PESA. Their findings show that lower transaction costs facilitate remittance transfers, which strengthens informal insurance networks and encourages precautionary savings. The study addresses endogeneity in mobile money adoption by using household proximity to agent networks as a proxy for service access<sup>2</sup>. Together with Bair and Tritah (2019), these studies highlight the role of mobile money in enhancing financial inclusion.

### *Mobile money and Household Welfare*

Mobile money accessibility and availability affect household welfare through multiple channels. Munyegera and Matsumoto (2016) find that mobile money positively impacts household welfare and remittance flows in Uganda. Using panel data from 846 rural households, the authors attribute these effects to the increased likelihood and frequency of remittance receipts among mobile money users. The study concludes that mobile money reduces remittance costs, enabling households to overcome liquidity constraints and engage in effective consumption smoothing practices.

Sekabira and Qaim (2017) examine welfare gains among Ugandan farming households using mobile money. Their regression analysis shows that higher remittances received from friends and family are a key pathway for these welfare improvements. More frequent inter-household

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<sup>2</sup> This study will be using the approach as outlined by Jack & Suri (2014), to account for endogeneity in mobile money adoption.

financial transactions allow farmers to earn more non-farm income and increase their consumption. These findings underline the ability of mobile money to reduce liquidity constraints for farmers and expand their financial activities.

In Ghana, Abdul-Rahaman and Abdulai (2020) examine smallholder rice farmers and find that mobile money significantly increases input use and farm output, helping farmers overcome liquidity challenges. However, the study highlights inequalities in adoption, as wealthier and better-educated farmers are more likely to use mobile money. Similarly, Baffour, Rahaman, and Mohammed (2020) show that poorer households rely heavily on mobile money for remittances due to its lower transaction costs. Their propensity score matching analysis demonstrates that mobile money users receive higher remittances, improving per capita consumption and overall welfare.

These studies establish the welfare-enhancing potential of mobile money. However, this study contributes by examining the effects of mobile money in the context of Rwanda. By focusing on the role of remittances and barriers to adoption, this research provides new insights into how mobile money impacts households in a rapidly digitizing economy.

### **3. Data and summary statistics**

To evaluate the impact of mobile money on consumption among Rwandan households this study uses the 2020 Rwanda FinScope survey. The FinScope dataset provides insight into the factors driving financial behaviour and those preventing individuals from using financial products and services. The data is weighted and benchmarked to the 2016/17 Integrated Household Survey (EICV5). With 12 480 interviews conducted from September to November 2019, the FinScope Survey 2020 is designed to represent the current household-based population of Rwanda. The sample that will be focused on in this study will be those that have directly mentioned whether they are currently using mobile money or not. The number of interviews within this sample is 9946.

The FinScope Survey covers several individual, household, financial, and technology characteristics. Based on each household's response, the main variable of interest, *mobile money*, is equal to 1 if the household is a registered or not registered active user of mobile

money, and equal 0 otherwise. The term *registered active user* in this context refers to an individual being formally registered with a mobile money service provider (MTN, Airtel, and/or Tigo) and uses mobile money. The term *non-registered active user* refers to an individual who uses mobile money but is not formally registered with a mobile money service provider.

Three levels of control variables are included in the analysis, following a combination of the selection processes of Bair & Tritah (2019), Munyegeera & Matsumoto (2016), and Zhao, Wu & Guo (2023). First, at the individual level, *age* and *age squared* are chosen to consider potential nonlinear effects of generational trends in adopting mobile money, followed by indicators for *gender*, *married* and *education*. Second, for household characteristics, *household size*, *gender of household head*, *dwelling type*, *farming*<sup>3</sup>, and *distance*<sup>4</sup> are considered. Third, financial and technological characteristics, *monthly income*, *credit constrained*<sup>5</sup>, *savings*, *remittance*<sup>6</sup>, *bank account ownership*, and *mobile phone access* are controlled for. Most variables are measured at the individual level, except for *household size*, *gender of household head*, *dwelling type*, *farming*, and *distance*, which are captured at the household level. Detailed definitions of these variables are shown in **Table 1**. The expected signs in **Table 1** are the assumed effect that each variable has on mobile money adoption. These signs are derived from the literature in World Bank Group (2024) and Zhao, Wu & Guo (2023).

**Table 2** provides first impressions of the data, looking at the share of mobile money users and non-users, across each variable. It is observed that 71.27% of individuals in the survey report are mobile money users, either as registered with a mobile money service or not. When observing individual characteristics, the average age of mobile money users is less than non-users. Users are also predominantly female, as well being more likely married and having little to no formal education. A younger and more feminine population of mobile money users is consistent with mobile money supporting financial equity and inclusion (Jack & Suri, 2016). In addition, this reflects higher technology adoption among the youth. These results also suggest that limited or a lack of formal education does not inhibit an individual's ability to use

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<sup>3</sup> For *farming*, since Rwanda remains an agrarian-based economy, it is important to observe the effects of mobile money among households involved in farming activities.

<sup>4</sup> The variable *distance* refers to the distance to the nearest mobile money agent, which remains a determinant for rural households' engagement in mobile money (Jack & Suri, 2014),

<sup>5</sup> Using the variable *credit constrained* is important given the potentially negative impacts it has on Rwandan farming households (Ali, Deininger & Duponchel, 2014). Being credit constrained inhibits households from moving into nonfarming activities and remain liquidity constrained.

<sup>6</sup> This *remittance* variable is defined by sending or receiving money within or outside Rwanda, within the past 6 months.

mobile money. This is in-line with mobile money being made more accessible to unbanked, low-income rural populations (Aron, 2017)

In terms of household characteristics mobile money users have approximately the same number of household members as non-users. Mobile money users are less likely to have the household headed by a woman, be based in a rural dwelling and be involved in farming activities. Finally, mobile money users are more likely to be less than 2km from the nearest mobile money agent. When looking at Finance/Technology characteristics, we see that on average, mobile money users save more, are wealthier, are more likely to send and receive remittances, have access to a mobile phone, and own a bank account. All the above suggests that mobile money users are often better connected and more financially integrated in the economy prior to adopting mobile money. This is the same conclusion found in Bair & Tritah (2019)<sup>7</sup>.

When carrying out analyses the following variable changes are made. The variable *age* is transformed into a categorical variable labelled *Age Group*<sup>8</sup>. *Education*<sup>9</sup> is transformed into a categorical variable, and the logarithmic form of *Savings* is used. These transformations simplify computation and interpretation<sup>10</sup>.

The probability of sending and receiving money is used to proxy for consumption levels among households, which are represented by individuals interviewed. Remittance flows enable rural households to overcome liquidity constraints and invest in productivity-enhancing activities, making them a reasonable proxy for consumption (Zarate-Hoyos, 2008; Zhu et al., 2014). Additionally, remittances play a stabilizing role in less financially developed countries, helping to dampen the effects of consumption instability (Combes & Ebeke, 2010). Zarate-Hoyos (2008) demonstrates that remittances are often used for current consumption in Mexican households, further supporting their use as a proxy for smoothing household consumption patterns.

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<sup>7</sup> The authors find that the more socioeconomically affluent portion of the population in Madagascar are more likely to be mobile money users.

<sup>8</sup> These groups are defined as *Young* (16-44), *Middle* (45-64), and *Old* (65 and above). These groups are defined to better capture generational differences in mobile money adoption.

<sup>9</sup> The levels are broken up into *No education*, *Primary* (those with at most a primary school level of education), *Secondary* (those with at most a secondary level of education), and *Tertiary* (those with at most a tertiary level of education).

<sup>10</sup> The code for these variable changes is recorded in **Appendix B**.

However, there are limitations to using remittances as a consumption proxy<sup>11</sup>. For instance, the magnitude of remittances matters; small remittance amounts may have an insignificant impact on household consumption. Moreover, remittances may serve multiple purposes beyond immediate consumption, such as savings or investments in durable goods or education, which may not directly reflect household consumption levels. This study limits the scope of these limitations. Firstly, remittance use will be applied, rather than magnitude. The reason for this is that the FinScope survey asks for remittance engagement, not amounts sent or received. Secondly, this study focuses on household consumption and assumes that remittances are solely used for consumption smoothing practices. This assumption is supported by Kadozi (2019), who empirically shows the linkage between increased remittance inflows and GDP per capita in Rwanda. For example, remittances bring in additional income, which increases purchasing power and raises consumption expenditure.

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<sup>11</sup> The identity  $Consumption = Income - Remittances - Savings$  presents a viable approach to estimating consumption. However, this formulation is not suitable in the present context, as *Remittances* is defined as a binary indicator rather than a monetary value, and *Savings* is not captured monthly in the same way as *Income* (see **Appendix B**).

**Table 1: Variable definition**

	Variables	Definition	Expected signs
Individual characteristics	Age	Interviewee Age	+
	Age squared	Square of interviewee age	-
	Gender	Interviewee gender. Female = 1; male = 0	-
	Married	Interviewee marital status. Married = 1; others = 0	+
	Education	Interviewee education status. No formal education = 0; Primary education = 1; Secondary education = 2; Tertiary education = 3	+
Household characteristics	Household size	Size of household	+
	Gender of household head	Household head gender. Female = 1; male = 0	+
	Dwelling type	Physical dwelling type classification. Rural = 1; urban = 0	+
	Farming	Household is involved fully or partially in farming. Household is involved solely or partially in farming = 1; household is not involved in farming = 0	+
	Distance	Distance to nearest mobile money agent. Ranges from less than 500m to more than 5Km in ascending levels	+
Finance/Technology characteristics	Monthly Income	Interviewee monthly income. This is split into three income groups capturing relevant income brackets. Poor = 1; Middle = 2; Rich = 3	
	Credit constrained	Credit commitments are a heavy burden. Yes = 1; no = 0	+
	Savings	Amount most recently saved by interviewee	+
	Remittance	Remittances sent or received, within or outside the country, within the past 6 months. Yes = 1; no = 0	+
	Bank account ownership	Interviewee owns a bank account. Yes = 1; no = 0	-
	Mobile phone access	Interviewee has access to a mobile phone. Yes = 1; no = 0	+

**Table 2: Summary statistics by mobile adoption status**

		(1)	(2)	(3)	(4)
		All sample	MM users	MM non-users	Difference (2) – (3)
	Proportion of mobile money users (%)	71.27			
Individual characteristics	Age (years)	40.11	39.14	42.52	–3.37***
	% of female	55.75	52.59	63.60	–11.01***
	% married	60.34	62.14	55.86	6.28***
	% with no formal education & primary education	68.31	60.60	87.43	–26.83***
Household characteristics	Household size (number)	4.60	4.62	4.54	8.55***
	% of female headed households	17.80	15.94	22.40	–6.5***
	% living in rural area	47.49	40.32	65.28	–24.96***
	% of households involved in farming	77.60	72.53	90.17	–17.63***
	% of households less than 2km from a MM agent	89.96	92.60	82.86	9.74***
Finance/Technology characteristics	% earning 40 000 Rwf or less	60.19	50.69	90.68	–39.99***
	% heavy burdened by credit/borrowing commitments	24.48	24.82	23.64	1.18***
	Savings (Rwf)	70470.87	87285.83	21324.56	65961.27***
	% of remittances sent or received	54.79	71.52	13.27	58.25***
	% owning a bank account	26.90	34.94	6.93	28.01***
	% with access to a mobile phone	97.74	99.06	94.47	4.59***

Notes: \*\*\* indicates statistical difference of means significance at 1%. Calculations done in Stata based on Rwanda FinScope Survey 2020. According to the National Bank of Rwanda, the Rwandan Franc was equivalent to 0,0011 USD in November 2019. The last column in the table shows the difference in means between mobile money users and non-users for each characteristic in the table. A positive number means the value for mobile money users is higher, whereas a negative number means the value is lower for mobile money users. If a value is statistically significant it is important and unlikely to be random. This column highlights meaningful contrasts between the two groups in the sample.

## 4. Methodology

In this section three major equations are estimated: (1) the determinants of mobile money adoption at the individual, household, financial/technological level; (2) the effect of mobile money adoption on household consumption; and (3) the effect of a mobile money adoption instrument on household consumption.

### *Mobile money adoption*

Mobile money adoption is analysed using a discrete choice model, which is suitable given the binary nature of the dependent variable (adoption or non-adoption of mobile money) (Meli et al., 2022). Specifically, this study employs a Probit model, consistent with prior studies (Bair and Tritah, 2019; Munyegera and Matsumoto, 2016), as it appropriately estimates probabilities between 0 and 1 for dichotomous outcomes. The error term is assumed to follow a standard normal distribution, ensuring alignment with Probit model assumptions. In contrast, simple linear regression fails to constrain probabilities within [0, 1] and assumes normality of error terms, making it unsuitable for this context (Pampel, 2000). Therefore, the Probit model is the most appropriate for accurately estimating the likelihood of mobile money adoption under these conditions, offering insights into key drivers and barriers to adoption (Meli, Kamga & Meli, 2024).

The decision to adopt mobile money services depends on observed characteristics of the household and individual in the form

$$Mmoney_i = \alpha + \beta X_{ij} + \varepsilon_{ij}, \quad (1)$$

where  $Mmoney_{id}$  is a dummy variable that takes a value of 1 if individual  $i$  is an active user of mobile money services and 0 if not.  $X_{ij}$  includes household (j) and individual (i) characteristics such as *age groups, gender, marital status, education, household size, household head's gender, dwelling type, farming, monthly income, log savings, bank account ownership, and mobile phone access*. The error term,  $\varepsilon_{ij}$ , captures unobservable characteristics that may influence mobile money use. Post estimation tests are performed to check the statistical appropriateness of the model as a whole and the inclusion of specific variables.

### *Effect on household consumption*

To assess the effect of mobile money adoption on household consumption, the following equation is estimated:

$$r_i = \theta + \beta_1 Mmoney_i + \beta_2 \tilde{X}_{ij} + \epsilon_{ij}, \quad (2)$$

where  $r_i$  is the measure of remittances sent or received by individual  $i$  using mobile money as the channel of transmission. The variable  $\tilde{X}_{ij}$  includes all the variables of  $X_{ij}$  in equation (1). The assumption is that conditional on the variables included in  $\tilde{X}_{ij}$  the decision to send or receive funds is affected by mobile money adoption. However, the decision to adopt mobile money may be correlated with unobservable characteristics that also affect remittance behaviour. For instance, households with a history of receiving remittances may be more likely to adopt mobile money as a convenient and cost-effective option (Munyegera & Matsumoto, 2016). Such endogeneity can lead to biased estimates when using the Probit model.

### *Instrument effect on household consumption*

To address this issue, an instrumental variable approach is employed. Following previous studies (Jack, Ray & Suri, 2013; Munyegera & Matsumoto, 2016), the distance to the nearest mobile money agent is used as an instrument for mobile money adoption. This assumption holds that the distance to a mobile money agent is uncorrelated with household or individual characteristics that influence remittance behaviour. It is therefore crucial to control for determinants of financial transfers that may be correlated with the instruments (Bair & Tritah, 2019).

The instrumental variable model is represented as follows:

$$r_i = \theta + \delta Z_j + \beta X_{ij} + \epsilon_{ij}, \quad (3)$$

where all variables are defined the same as in equation (2), but now  $Z_j$  is the instrumental variable (IV) of  $Mmoney_i$ , representing levels of closeness (in km) to the nearest mobile money agent. Potential variables correlated with the instrumental variable are captured in  $X_{ij}$ . For instance, *dwelling type*, *farming*, *monthly income*, and *log savings* all represent aspects of wealth and geolocation. Both factors are important considerations for the deployment and spread of mobile money agents, who can reach the poorest members of the population living in remote rural areas, at low cost. By controlling for these factors, the selected instrument remains exogenous. A potential drawback of the identification of equation (3) is that the

endogenous regressor appears in a binary choice model. Despite the advantage of simplicity, the fitted probability in the Probit model can go below 0 and above 1, reproducing bias estimated coefficients (Lewbel, Dong & Yang, 2012). To avoid this type of model misspecification post-estimation tests are performed for both the presence of endogeneity and the validity of the instruments used. This includes testing for whether mobile money is an endogenous variable and whether the instrument selected over- or under-identifies mobile money.

## 5. Results

### *Determinants of mobile money adoption*

**Table 3** presents the determinants of mobile money adoption, considering individual, household, financial and technological characteristics. The first column reports the Linear Probability Model (LPM) and the second column the marginal effects of the Probit model. Presenting the LPM alongside the Probit model highlights the consistency in the results, showing that there are no qualitative changes between the two representations.

The Probit model results show that older individuals have a statistically negative relationship with mobile money adoption, suggesting that younger individuals are more likely to use mobile money. This could be due to slower adoption rates among older groups, who apply a more conservative approach to changing their financial habits. This signals a gap in financial services, with older population groups missing out on the benefits of mobile money. Rwanda has a youthful demographic, with 60 percent of its population under 31 years old as of early 2024 (World Bank Group, 2024). This indicates that digital finance services are focused on appealing to younger people, and the lack of appeal to older individuals is not a significant issue.

Regarding gender dynamics, women are generally less likely than men to adopt mobile money services. The estimated coefficient (5.52%) suggests only a slight difference in adoption rates, pointing to a minor gender imbalance. One possible explanation is the unequal representation of men and women among survey respondents, as highlighted in the Rwanda 2020 FinScope report, which shows that formal financial inclusion is significantly higher among men (81%) (Access to Finance Rwanda, 2020). However, a contrasting trend emerges when observing household leadership. Households headed by women are more likely to adopt mobile money.

This aligns with the broader financial role of women in Rwanda, where they often serve as the primary managers of household finances, which include planning for the future and emergencies (World Bank Group, 2024).

Education has a statistically significant positive effect on the likelihood of adopting mobile money. This indicates that higher educated interviewees are more likely to engage in digital financial services. It is a plausible suggestion that higher education levels equate to being more adaptable to newer technologies. However, education follows a non-linear trajectory, suggesting that the more educated individuals still prefer traditional formal institutions. This corresponds with Rwanda boasting a bank-centric economy (World Bank Group, 2024). Finally, for individual characteristics, the effects of being married and household size are small and statistically insignificant.

**Table 3:** Determinants of mobile money adoption: Results from Probit and Linear Probability Models

		(1)	(2)
Variables		LPM	Probit (marginal effects)
Individual characteristics	Age Group (Ages 16-44 omitted)		
	Middle (45-64)	-0.0358*** (0.0124)	-0.0341*** (0.01268)
	Old (65 and above)	-0.1844*** (0.0279)	-0.1643*** (0.0262)
	Gender	-0.0564*** (0.0114)	-0.0552*** (0.0112)
	Married	0.012 (0.0121)	0.0147 (0.0119)
	Education (No education omitted)		
	Primary	0.1636*** (0.0217)	0.1148*** (0.0184)
	Secondary	0.2535*** (0.0224)	0.2152*** (0.0203)

	Tertiary	0.1975*** (0.0242)	0.182*** (0.0358)
Household characteristics	Household size	-0.0015 (0.0028)	-0.0031 (0.0028)
	Household head gender	0.0301* (0.0183)	0.0325* (0.0167)
	Dwelling Type	-0.0683*** (0.0127)	-0.0481*** (0.0106)
	Farming	-0.0335*** (0.0106)	-0.0458*** (0.0144)
Financial/Technology characteristics	Monthly Income (Income bracket of earnings 40 000 Rwf or less omitted)		
	Middle (40 001 – 100 000 Rwf)	0.1256*** (0.0126)	0.1167*** (0.0135)
	Rich (more than 100 000 Rwf)	0.0877*** (0.0137)	0.126*** (0.0195)
	Ln savings	0.0187*** (0.0032)	0.0173*** (0.0032)
	Bank account ownership	0.0731*** (0.0115)	0.1036*** (0.0151)
	Mobile phone access	0.2433*** (0.0515)	0.1491*** (0.0346)

Notes: The significance levels of 1%, 5%, and 10% are denoted by \*\*\*, \*\*, and \*, respectively. Robust standard errors are reported in parenthesis. For the Probit model the reported estimates are the marginal effects at the mean. Source: Rwanda 2020 FinScope Survey.

Household characteristics play a significant role in mobile money adoption. The data shows a statistically negative relationship between rural living/farming and mobile money adoption. Households residing in a rural dwelling or engaging in farming activities are less likely to adopt mobile money. This could be due to limited access to mobile money agents or reliance on traditional savings practices. The economic implications include rural households having reduced access to credit and formal financial services, limiting their ability to invest in farming or manage risks. A potential solution is to implement financial literacy programs and improve mobile money infrastructure in rural areas, to encourage a cultural shift towards formal savings.

Households in middle- and rich-income brackets are more likely to adopt mobile money than low-income households. Wealthier households often have improved access to mobile phones, financial services and the internet, making them more likely to adopt mobile money (Bair & Tritah, 2019). Lower-income households are less likely to adopt mobile money because they face barriers, like infrastructure and education, limiting them from accessing mobile money (Nonvide & Alinsato, 2022). Wealth inequalities could worsen because of the disproportionate benefit wealthier and more educated households receive from mobile money adoption. Policy makers could remedy this through targeted interventions, like subsidies to increase adoption among low-income populations.

Those who already have access to a formal financial institution are more likely to use mobile money. Bank account ownership is likely to be linked with increased financial literacy and familiarity with formal financial products. As mentioned earlier Rwanda retains a bank centric financial system, and it could be that mobile money initiatives are mainly being taken on by the banked population. However, this suggests that the unbanked population are marginalised from the benefits of mobile money. Mobile money providers need to offer incentives or additional services to incorporate the unbanked population.

Finally, it is unsurprising to find that households with mobile phone access are more likely to adopt mobile money. This highlights the basic requirement for mobile money adoption. In areas where mobile phone access is low it is likely the case that mobile money adoption is limited. The significance of mobile phone ownership underlines the importance of mobile infrastructure development in promoting financial inclusion. This means that efforts to increase adoption should focus on improving access to phones and mobile network services.

#### *Mechanism: Mobile money and household remittances*

**Table 4** reports the estimates of the effect mobile money has on the likelihood to engage in remittances. The dependent variable is whether a household has sent or received remittances domestically or internationally in the last six months. This variable is used to proxy for consumption levels, given how often remittances are used to act as insurance and consumption tools.

In developing economies, mobile money often impacts household welfare through increased remittance flows. The Probit model results show that on average, mobile money users are

36.69% more likely to remit than non-users. This translates into greater financial accessibility for low-income households, which is consistent with prior studies, like Jack and Suri (2014), emphasizing the role of remittances in smoothing household consumption.

#### *IV Probit results*

The IV Probit results address *potential* endogeneity in mobile money adoption. Endogeneity arises because the likelihood of adopting mobile money, particularly in rural environments, often depends on the proximity to mobile money agents. In this study endogeneity in mobile money adoption is accounted for by using an IV Probit method for consumption.

Qualitatively, the effects of mobile money users engaging in remittances are similar in column 2 of **Table 4** as they are in column 1. This is after considering the endogeneity of mobile money using the IV Probit. In this latest estimation, access to mobile money increases the probability to send or receive funds by 77.17%. The economic implications of this are that mobile money makes financial transfers faster, cheaper, and more reliable. This increases remittance flows, enabling low-income households to smooth consumption (Jack & Suri, 2014). The results align with findings from similar studies, such as Bair & Tritah (2019) and Munyegera & Matsumoto (2016), that show mobile money improve financial inclusion through inter-household financial channels.

The appropriateness of selecting proximity to nearest mobile money agent is supported by endogeneity tests in **Table A3**. The results show that the chosen instrument is not weak and remains exogenous, meeting the assumptions of a IV Probit model. This strengthens the choice for the endogenous variable and the results shown in **Table 4**.

**Table 4:** Mobile money and household remittances: Results from Probit and IV Probit Models

Dependent variable:	1 if remittances received or sent	
Variable	Probit	IV Probit
	(marginal effect)	(marginal effect)
Mobile money	0.3669***	0.7717***
	(0.012)	(0.1984)
Observations	5 334	5 334

Notes: The significance levels of 1%, 5%, and 10% are denoted by \*\*\*, \*\*, and \*, respectively. Robust standard errors are reported in parenthesis. Probit and IV Probit model reported estimates are the marginal effects of the mean. Additional control variables include interviewee age group, gender, marital status, highest level of education, household size, gender of the household head, dwelling type, household involved in farming, monthly income brackets, log savings, bank account ownership, and access to a mobile phone. For the IV Probit column dummies for whether a household is within 2Km or less are used as excluded instruments. Source: Rwanda 2020 FinScope Survey.

### *Robustness checks*

In this study robustness checks and tests were conducted to verify the estimated effects of mobile money adoption and the impact of mobile money on remittance flows. The results are presented in the Appendix. The approaches outlined in the methodology were replicated and applied to the Research ICT Africa (RIA) 2017/18 Household Survey. The dataset measures the impact of information and communication technologies on the livelihoods of individuals and businesses in African countries. This makes the dataset an appropriate alternative to the Rwanda 2020 FinScope Survey. The variables used differ from those in the main analysis<sup>12</sup>.

**Table A1**, presents the determinants of mobile money adoption. *Age, gender, and married* have no effect on the likelihood of adopting mobile money. However, the effect of *education* on mobile money adoptions is significantly positive, consistent with **Table 3**. Notably, **Table A1** shows that holding a tertiary-level qualification increases the likelihood of adopting mobile money compared to those with no formal education. Residing in a rural or urban location has no effect on the likelihood of mobile money adoption. Like **Table 3**, households engaged in

<sup>12</sup> The following variables are used in the RIA survey analysis: *Age Group, Gender, Married, Education, Dwelling Type, Farming, Ln Income, Bank account ownership*. All variables apart from *Ln Income* are defined the same as in the Rwanda FinScope survey analysis. *Ln Income* represents the logarithmic form of income which is defined as total income earned by the interviewee in the RIA 2017/18 metadata. *Mobile phone access* is negated because of perfect collinearity between the variable and *Mobile money*. The coding of these variables is detailed in **Appendix C**.

farming activities are less likely to adopt mobile money. The results of income and bank account ownership are also consistent with that of **Table 3**. Overall, the results from **Table A1** agree with the empirical findings in **Table 3**. This reinforces the validity of the main findings.

**Table A2** presents robustness checks of Models (1) and (2). It is observed that there is no multicollinearity in either model. For Model (1), the inclusion of all variables, apart from *married* and *household size*, are statistically significant. In addition, the model is appropriate to use and draw interpretations from. Model (2), is like Model (1) in every respect, apart from the variables deemed statistically appropriate to include in the model. Overall, both Models' variables are supported theoretically and empirically to carry out analyses. When testing for normality in the error terms it is found that the errors are not normally distributed<sup>13</sup>. This is only an issue if the severity of non-normality causes for post-estimation tests to fail, or if there is heteroskedasticity among the error terms. As mentioned above, both Model (1) and (2) are specified correctly. In the last row of **Table A2** tests for heteroskedasticity, specifically looking at each Model's error terms, show that there is no heteroskedasticity.

## 6. Limitations and future research

The results of this study should not be considered definitive or conclusive as the models used are probabilistic rather than causal, limiting the ability to infer definitive relationships. Moreover, the fact that mobile money is only subsidized and promoted on a large scale after 2020 suggests that the data used in this study reflects mobile money adoption in its early stages.

As mentioned earlier, remittances are used in this study to proxy for consumption. Alternative proxies for consumption in the literature include forms of consumption, such as durable/non-durable goods consumption in Zhao, Wu & Guo (2023), and reported expenditure. It proved a challenge to source forms of consumption or expenditure from similar surveys that dealt with financial behaviour in Rwanda. For instance, when attempting to find a consumption variable in the Research ICT Africa 2017/18 survey, there is no explicit expenditure variable. Instead, there is only an income and a net income variable, which are then used to calculate

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<sup>13</sup> Skewness-Kurtosis and Shapiro-Wilk Tests for normality are performed to check for normality in the error terms of Models (1) and (2). The coding for these processes is captured in **Appendix B**.

expenditure<sup>14</sup>. Similarly, previous Rwanda FinScope surveys are designed to not include questions on household consumption, but rather types of assets owned by the household.

An alternative approach would involve conducting a natural experiment and employing causal modelling techniques to produce more definitive results. This would involve sourcing panel data, to observe changes in behaviour among the same groups across different time periods. Additionally, exploring how remittances are allocated and whether they function as informal insurance mechanisms would provide a deeper understanding of the effectiveness of mobile money in improving household welfare. Further analysis could explore whether the remittance flows observed are cash-based or cashless. If predominantly cash-based, the findings align with Bongomin et al. (2023), who emphasize the importance of agent liquidity in Sub-Saharan Africa. In such economies, individuals prioritise ease-of-access to cash. This makes mobile money agents, with their proximity and liquidity, more attractive than traditional financial institutions. For instance, the simplistic nature of mobile money enables cash deposits and withdrawals without stringent documentation requirements, common in formal banking systems. This further enhances financial inclusion among rural populations, by reducing barriers to financial transactions and increasing accessibility.

## 7. Conclusion

The financial sector in Africa is less developed compared to more advanced regions. Limited access to financial services poses a significant challenge to rural livelihoods and overall welfare. However, the introduction of mobile money has provided less developed countries with greater inter-household financial flows, more robust informal insurance networks, and elevated levels of consumption. This study empirically examines the impact of mobile money on household consumption in Rwanda, focusing on the determinants of mobile money adoption and using remittances sent and received as proxies for consumption levels in households.

Since its introduction in 2010, mobile money usage has steadily grown, with service providers continually expanding digital wallet services to make them as diverse as possible. Using data from the 2020 FinScope Survey, this study finds that mobile money is inclusive, providing

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<sup>14</sup> See **Appendix C** for details on the coding and definition of the variable *expenditure*.

financial accessibility to households. However, affluent households are more likely to adopt mobile money. These households have better access to mobile phones, higher levels of financial literacy, and are located closer to mobile money agents and banking services.

Empirical results indicate that mobile money increases the likelihood of individuals sending or receiving remittances, making more funds readily available and raising consumption levels. These findings are consistent with the works of Munyegera and Matsumoto (2016) and Bair and Tritah (2019). The evidence suggests that mobile money access is deepening the financial market in Rwanda by bringing more individuals into the financial system and increasing financial flows.

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## Appendix A

**Table A1:** Determinants of mobile money adoption: Results from Probit and Linear Probability Models

Variables		(1) LPM	(2) Probit (marginal effects)
Individual characteristics	Age Group (Ages 16-44 omitted)		
	Middle (45-64)	-0.0425 (0.0509)	-0.0398 (0.0494)
	Old (65 and above)	-0.1508 (0.0981)	-0.1470 (0.0970)
	Gender	-0.0550 (0.0340)	-0.0554 (0.0394)
	Married	-0.0372 (0.04084)	-0.0386 (0.0408)
	Education (No education omitted)		
	Primary	0.1348* (0.0732)	0.1298* (0.0745)
	Secondary	0.2500*** (0.0807)	0.2428*** (0.0829)
	Tertiary	0.2569*** (0.0889)	0.2670*** (0.0960)
Household characteristics	Dwelling Type	-0.0333 (0.0436)	-0.0305 (0.0408)
	Farming	-0.1020** (0.0440)	-0.0977** (0.0407)
Financial/Technology characteristics	Ln Income	0.0333*** (0.0131)	0.0384*** (0.0144)
	Bank account ownership	0.1035** (0.0472)	0.0950** (0.0425)

Notes: The significance levels of 1%, 5%, and 10% are denoted by \*\*\*, \*\*, and \*, respectively. Robust standard errors are reported in parenthesis. For the Probit model the reported estimates are the marginal effects at the mean. Source: RIA 2017-18 Household Survey.

**Table A2:** Robustness checks for Models 1 and 2

Robustness checks		Variables	Model 1	Model 2	
Multicollinearity (VIF)	Individual characteristics	Mobile money		1.27	
		Age group (Ages 16-44 omitted)			
		Middle (45-64)	1.14	1.14	
		Old (65 and above)	1.18	1.19	
		Gender	1.28	1.28	
		Married	1.37	1.37	
		Education (No education omitted)			
		Primary	2.91	2.96	
		Secondary	3.00	3.09	
		Tertiary	2.43	2.45	
		Household characteristics			
		Household size	1.15	1.15	
		Household head gender	1.76	1.76	
		Dwelling Type	1.34	1.35	
		Farming	1.39	2.19	
		Financial/Technology characteristics	Monthly Income (Income bracket of earnings 40 000 Rwf or less omitted)		
		Middle (40 001-100 000 Rwf)	1.33	1.68	
Rich (more than 100 000 Rwf)	2.18	2.19			
Ln Savings	1.67	1.68			
Bank account ownership	1.66	1.67			
Mobile phone access	1.02	1.03			
Wald test (p-value)	Individual characteristics	Mobile money		0.0000	
		Age group (Ages 16-44 omitted)	0.0000	0.7305	
		Gender	0.0000	0.2869	

		Married	0.2204	0.1328
		Education (No education omitted)	0.0000	0.0050
	Household characteristics	Household size	0.2665	0.4710
		Household head gender	0.0555	0.4542
		Dwelling Type	0.0000	0.5476
		Farming	0.0019	0.1180
	Financial/Technology characteristics	Monthly Income (Income bracket of earnings 40 000 or less omitted)	0.0000	0.0000
		Ln Savings	0.0000	0.0000
		Bank account ownership	0.0000	0.0007
		Mobile phone access	0.0000	0.0008
Hosmer-Lemeshow			0.0734	0.0965
(p-value)				
Link test				
( $\hat{p}$ -value)			0.000	0.000
( $\hat{p}^2$ -value)			0.080	0.247

**Table A3:** Robustness checks for Model 3

Robustness checks	Model	Interpretation
	3	
Stock-Yogo values (p-value)	critical 0.0000	Using distance to nearest mobile money agent is an appropriate instrument for mobile money.
Durbin-Wu-Hausman (p-value)	0.0000	Mobile money is indeed endogenous, requiring the use of IV regression.
Sargan statistic (p-value)	0.0903	Instrument used (proximity to mobile money agent) is valid.

Notes: Although an IV Probit model is used post-estimation tests for endogeneity can be carried out using the linear probabilistic form of the model.

## Appendix B

```
1. *Results
2. *Josh Cedras
3. *CDRJOS001
4. *Rwanda FinScope 2020_Final Data
5.
6. clear all
7. set more off
8.
9. cd "C:\*****\Results"
10.
11. use "Rwanda FinScope 2020_Final Data"
12.
13. *****Variables of interest*****
14.
15. gen mobile_money = . // FM4. Statements best describing your experience with mobile money
16. replace mobile_money = 1 if FM4 == 5 | FM4 == 6 // 5.You use mobile money services, but you
are not registered | 6.You are a registered mobile money user
17. replace mobile_money = 0 if FM4 < 5
18.
19. gen mobile_phone = . // FM1. Number of mobile phones owned by HH
20. replace mobile_phone = 1 if C14A1 == 1
21. replace mobile_phone = 0 if C14A1 == 2
22.
23. gen household_size = C0 // C0. Household size
24.
25. gen farming = . // M1. Statements best describing households situation on farming
26. replace farming = 1 if M1 == 1 | M1 == 2 // 1.Your household is only involved in farming
and no-one in the household has any other work | 2.Your household is involved in farming AND
other work
27. replace farming = 0 if M1 == 3 // 3.Your household is NOT involved in farming at all
28.
29. gen age = B1 // B1. Age of respondent
30.
31. gen age2 = age^2 // Age of respondent square
32.
33. gen female = . // B2. Sex of respondent
34. replace female = 1 if B2 == 2 // 2.Female
35. replace female = 0 if B2 == 1 // 1.Male
36.
37. gen education = . // C4A. Education completed
38. replace education = 0 if C4A == 1 // 1.No formal education
39. replace education = 1 if C4A == 2 | C4A == 3 // 2.Primary 1-3 | 3.Primary 4-6 (Primary)
40. replace education = 2 if C4A == 4 | C4A == 5 | C4A == 7 // 4.Secondary 1-3 | 5.Secondary 4-
6 | 7.Vocational training (Secondary)
41. replace education = 3 if C4A == 6 // University or other higher education
42.
43. label define educationlabel 0 "No formal education" 1 "Primary" 2 "Secondary" 3 "Tertiary"
44. label values education educationlabel
45.
46. gen credit_constrained = . // EF1. Over indebtedness - Credit_borrowing commitments are a
heavy burden
47. replace credit_constrained = 1 if EF1_3 == 1
48. replace credit_constrained = 0 if EF1_3 == 2
49.
50. gen monthly_income = . // N4A. Income - Monthly personal income
51. replace monthly_income = 1 if N4A <= 10 // 40 000 Rwf or less (poor)
52. replace monthly_income = 2 if N4A > 10 & N4A <= 12 // 40 001 - 100 000 Rwf (middle)
53. replace monthly_income = 3 if N4A == 13 // more than 100 000 Rwf (rich)
54.
55. label define monthly_incomelabel 1 "Poor" 2 "Middle" 3 "Rich"
56. label values monthly_income monthly_incomelabel
57.
58. gen savings = GS7 // GS7. How much did you save the last time
59.
60. gen bank_acc = . // K1_2_1. Do you have a bank account?
61. replace bank_acc = 1 if K1_2_1 == 1 // 1.Yes
```

```

62. replace bank_acc = 0 if K1_2_1 == 2 // 2.No
63.
64. label define bank_acclabel 0 "Have a bank account" 1 "Do not have a bank account"
65. label values bank_acc bank_acclabel
66.
67. gen rural = . // A3. Urban/Rural
68. replace rural = 1 if A3 == 2 // 2.Rural
69. replace rural = 0 if A3 == 1 // 1.Urban
70.
71. label define rurallabel 0 "Urban" 1 "Rural"
72. label values rural rurallabel
73.
74. gen distance = . // D1. Access to infrastructure - Distance to the nearest Mobile money
agent
75. replace distance = 1 if D1A14 == 1 // 1.Less than 500m
76. replace distance = 2 if D1A14 == 2 // 2.Between 500m and 1Km
77. replace distance = 3 if D1A14 == 3 // 3.Between 1Km and 2Km
78. replace distance = 4 if D1A14 == 4 // 4.Between 3Km and 5Km
79. replace distance = 5 if D1A14 == 5 // 5.More than 5Km
80.
81. label define distancelabel 1 "Less than 500m" 2 "Between 500m and 1Km" 3 "Between 1Km and
2Km" 4 "Between 3Km and 5Km" 5 "More than 5Km"
82. label values distance distancelabel
83.
84. /* Consider deleting the code below...
85. gen remittance = . // Moibile money - Remittances
86. replace remittance = 1 if Mobile_money_Remittances == 1
87. replace remittance = 0 if remittance == .
88. */
89.
90. gen remittance = . // J1A. In the past 6 months have sent money to someone within the
country -or- J1B. In the past 6 months have sent money to someone outside the country -or- J3A.
In the past 6 months have received money from someone within the country -or- J3B. In the past 6
months have received money from someone outside the country
91. replace remittance = 1 if J1A == 1 | J1B == 1 | J3A == 1 | J3B == 1 // 1.Yes
92. replace remittance = 0 if remittance == .
93.
94. label define remittancelabel 0 "Did not use mobile money to send/receive remittance" 1
"Used mobile money to send/receive remittance"
95. label values remittance remittancelabel
96.
97. gen married = . // C4B. Marital Status
98. replace married = 1 if C4B == 2 // 2.married
99. replace married = 0 if C4B != 2
100.
101. gen female_hh = . //B0. Relationship with the Head of HH
102. replace female_hh = 1 if female == 1 & B0 == 1
103. replace female_hh = 0 if female_hh == .
104.
105. *****
106. ***Probit models***
107.
108. gen logsavings = log(savings)
109.
110. gen agegrp = . // Age group variable, where 1 = Young; 2 = Middle; and 3 = Old
111. replace agegrp = 1 if age >= 15 & age <= 44
112. replace agegrp = 2 if age >= 45 & age <= 64
113. replace agegrp = 3 if age >= 65
114. label define agegrplabel 1 "Young" 2 "Middle" 3 "Old"
115. label values agegrp agegrplabel
116.
117. foreach num of numlist 1/5 {
118.     gen distdummy`num' = distance == `num'
119. }
120.
121. foreach num of numlist 1/4 {
122.     gen educdummy`num' = education == `num'
123. }
124.
125. foreach num of numlist 1/3 {

```

```

126.             gen incdummy`num' = monthly_income == `num'
127.         }
128.
129. foreach num of numlist 1/3 {
130.     gen agegrpdummy`num' = agegrp == `num'
131. }
132.
133.
134.
135. *Equation 1
136. *Mmoney_id= $\alpha + \beta X_{ij} + \epsilon_{ij}$ 
137. reg mobile_money i.agegrp female married i.education household_size female_hh rural farming
i.monthly_income logsavings bank_acc mobile_phone, robust // LPM
138. logit mobile_money i.agegrp female married i.education household_size female_hh rural
farming i.monthly_income logsavings bank_acc mobile_phone, robust // Logit
139. margins, dydx(*) // Marginal effects
140. probit mobile_money i.agegrp female married i.education household_size female_hh rural
farming i.monthly_income logsavings bank_acc mobile_phone, robust // Probit
141. margins, dydx(*) // Marginal effects
142.
143. *Robustness tests
144. reg mobile_money i.agegrp female married i.education household_size female_hh rural farming
i.monthly_income logsavings bank_acc mobile_phone, robust // LPM
145. vif // No multicollinearity present
146. probit mobile_money age female married i.education household_size female_hh rural farming
i.monthly_income logsavings bank_acc mobile_phone, robust
147. predict phat // Get predicted probabilities
148. gen res = mobile_money - phat // Compute pseudo-residuals
149. sktest res // Skewness and Kurtosis Test (p-value < 0.05) Non-normal error terms
150. swilk res // Shapiro-Wilk Test (p-value < 0.05) Non-normal error terms
151. probit mobile_money age female married i.education household_size female_hh rural farming
i.monthly_income logsavings bank_acc mobile_phone
152. estat gof, group(10) // Hosmer-Lemeshow test
153. linktest // Link test - _hat significant: Model is capturing relevant information; _hatsq
not significant: No major specification issues detected
154.
155. *Equation 2
156. * $r_{ij} = \theta + \beta_1 Mmoney_{id} + \beta_2 X_{ij} + \epsilon_{ij}$ 
157. reg remittance mobile_money i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone, robust // LPM
158. logit remittance mobile_money i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone // Logit
159. margins, dydx(*) // Marginal effects
160. probit remittance mobile_money i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone, robust // Probit
161. margins, dydx(*) // Marginal effects
162.
163. *Robustness tests
164. reg remittance mobile_money i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone
165. vif
166. probit remittance mobile_money i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone, robust
167. predict phat // Get predicted probabilities
168. gen res = remittance - phat // Compute pseudo-residuals
169. sktest res // Skewness and Kurtosis Test (p-value < 0.05) Non-normal error terms
170. swilk res // Shapiro-Wilk Test (p-value < 0.05) Non-normal error terms
171. probit remittance mobile_money i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone
172. estat gof, group(10) // Hosmer-Lemeshow test
173. linktest // Link test - _hat significant: Model is capturing relevant information; _hatsq
not significant: No major specification issues detected
174.
175.
176. *Equation 3
177. * $r_{ij} = \theta + \delta Z_j + \beta X_{ij} + \epsilon_{ij}$ 
178.
179. ivprobit remittance i.agegrp female married i.education household_size female_hh rural
farming i.monthly_income logsavings bank_acc mobile_phone (mobile_money = distdummy1 distdummy2
distdummy3) // reject null of exogeneity

```

```

180. margins, dydx(mobile_money) predict(pr)
181.
182. *Endogeneity tests
183. ivregress 2sls remittance i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone (mobile_money = distdummy1
distdummy2 distdummy3), first // instrument is distance to nearest mobile money agent less than
2Km
184. estat firststage // distdummy1-3 is not a weak instrument for mobile_money
185. estat endogenous // should use IV instead of LPM
186. estat overid // instruments are exogenous
187.
188. *Ran different combinations of distance dummies to reach most optimal number of dummies to
include
189. *For distdummy4 and distdummy5 the number of observations is much smaller than the previous
distdummies - hence another reason for their exclusion
190.
191.
192. biprobit (remittance = mobile_money i.agegrp female married i.education household_size
female_hh rural farming i.monthly_income logsavings bank_acc mobile_phone) (mobile_money =
distdummy1 distdummy2 distdummy3 i.agegrp female married i.education household_size female_hh
rural farming i.monthly_income logsavings bank_acc mobile_phone)
193.

```

## Appendix C

```

1. *Appendix
2. *Josh Cedras
3. *CDRJOS001
4. *Research ICT Africa (RIA) 2017-18 household survey
5.
6. *Import RIA dataset
7.
8. clear all
9. set more off
10.
11. cd "C:\****\Appendix"
12.
13. use "rias-2017-2018-hhold-v1"
14.
15. keep if A_5 == 5 // This keeps only Rwandan respondents from the dataset
16.
17. ****
18.
19. *Clean data
20.
21. gen age = D_3 // D3. respondent age
22. gen agegrp = . // age group variable
23. replace agegrp = 1 if age > 15 & age < 45
24. replace agegrp = 2 if age > 44 & age < 65
25. replace agegrp = 3 if age > 64
26. label define agegrp_label 1 "Young" 2 "Middle" 3 "Old"
27. label values agegrp agegrp_label
28.
29. gen female = . // D2. respondent gender
30. replace female = 0 if D_2 == 0
31. replace female = 1 if D_2 == 1
32.
33. gen married = . // D5. respondent marital status
34. replace married = 0 if D_5 > 1
35. replace married = 1 if D_5 == 1
36.
37. gen education = D_6 // D6. respondent level of education

```

```

38. replace education = 0 if education == 1 // no education
39. replace education = 1 if education == 2 // primary
40. replace education = 2 if education == 3 // secondary
41. replace education = 3 if education == 4 | education == 5 | education == 6 // tertiary
42. label define educationlabel 0 "No formal education" 1 "Primary" 2 "Secondary" 3 "Tertiary"
43. label values education educationlabel
44.
45. gen rural = . // A6. those staying in rural areas
46. replace rural = 0 if A_6 == 1
47. replace rural = 1 if A_6 == 0
48. label define rurallabel 0 "Urban" 1 "Rural"
49. label values rural rurallabel
50.
51. gen farming = . // IE2. agriculture produce and farming
52. replace farming = 1 if IE_2 > 0
53. replace farming = 0 if IE_2 == 0
54.
55. gen income = IE_12 // IE12. total income of respondent
56. gen Ln_income = log(income)
57.
58. gen consumption = income - IE_17 // consumption = income - (income - expenditure)* ----> *
is what IE_17 is
59. gen Ln_consumption = log(consumption)
60.
61. gen bankacc = . // D14. do you have access to a bank account?
62. replace bankacc = 1 if D_14 == 1
63. replace bankacc = 0 if D_14 == 0
64.
65. gen mobile_phone = . // M1. respondent mobile phone ownership
66. replace mobile_phone = 0 if M_1 == 0
67. replace mobile_phone = 1 if M_1 == 1
68.
69. gen mobile_money = . // MM1. mobile money use
70. replace mobile_money = 0 if MM_1 == 0
71. replace mobile_money = 1 if MM_1 == 1
72.
73. *****
74.
75. *Determinants of mobile money adoption
76.
77. reg mobile_money i.agegrp female married i.education rural farming Ln_income bankacc, robust
78. probit mobile_money i.agegrp female married i.education rural farming Ln_income bankacc,
robust
79. margins, dydx(*)
80.
81. *Mobile money effects on consumption
82.
83. reg consumption mobile_money i.agegrp female married i.education rural farming Ln_income
bankacc
84.
85. gen distance = . // MM43. mobile money agents are located too far away
86. replace distance = 1 if MM_43 == 1 // mobile money agents are nearby
87. replace distance = 0 if MM_43 == 0 // mobile money agents are too far away
88.
89. ivregress 2sls consumption i.agegrp female married i.education rural farming Ln_income
bankacc ( mobile_money = distance)
90.
91.

```