

The impact of private sector projects in Africa

Studies from
the EIB-GDN Programme



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The impact of private sector projects in Africa - Studies from the EIB-GDN Programme

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The mission of the EIB's Economics Department is to provide economic analyses and studies to support the Bank in its operations and in its positioning, strategy and policy. The department, a team of 40, is headed by Debora Revoltella, Director of Economics.

GDN is a public international organisation dedicated to supporting high-quality, policy-oriented research in developing and transition countries. It is headquartered in New Delhi, India and works in close cooperation with national and international development partners.

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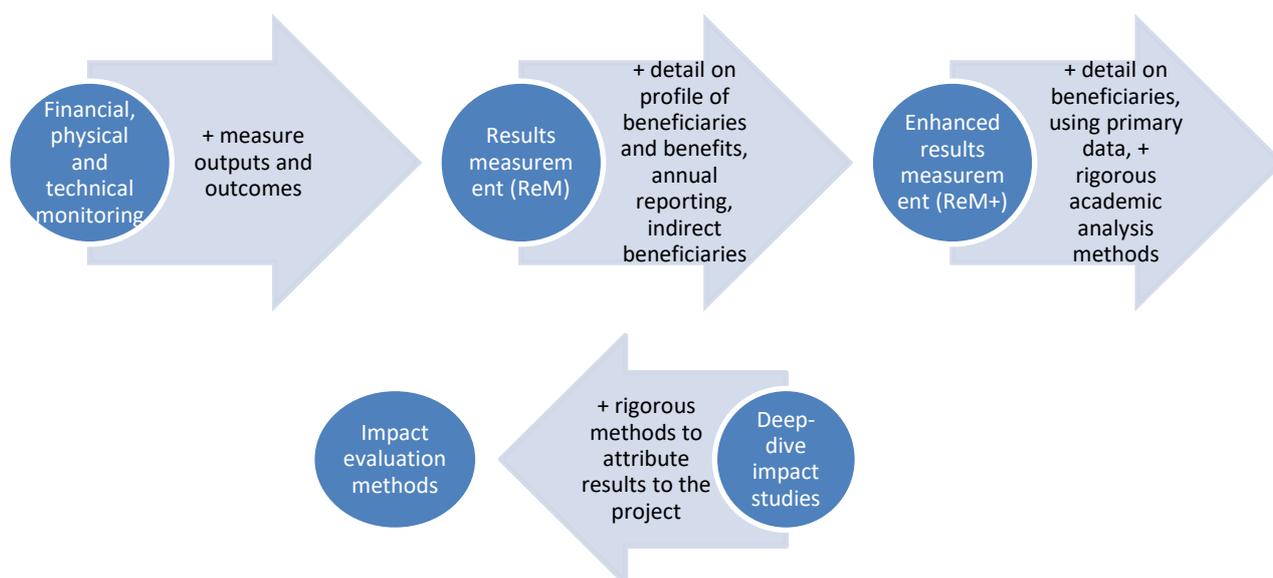
Introduction

Authors: Nina Fenton and Claudio Cali

The EIB, like other International financial institutions, monitors the extent to which its work delivers development impact. Knowing what has worked allows the Bank to enhance its contribution to sustainable and inclusive development. The EIB's objectives go beyond financial return, so the EIB needs to go beyond tracking monetary, physical and capacity-building inputs, to tracking the outputs the operations create, the outcomes they contribute to, and the relation of those outcomes to the Bank's higher-level goals. Insights into results and impact can have strong learning value for the EIB, as it works to enhance its impact and efficiency over time.

The EIB measures development results for all its projects outside the European Union, using the tried and tested Results Measurement (ReM) framework to capture outputs and outcomes at key project milestones. This approach can be placed on a continuum of approaches to capturing results and impact. As Figure 1 shows, for some strategically important projects, including those under the Impact Financing Envelope (IFE) in Africa, Caribbean and Pacific (ACP) countries, the EIB goes even further than the standard ReM monitoring, using the ReM+ framework. This framework follows the ReM structure but collects more in-depth data on the profile of the final beneficiaries and the benefits they experience, with annual monitoring.

Figure 1: Spectrum of approaches to results measurement and impact assessment



Under a pilot programme with the GDN, initiated in 2016, the EIB has been working to get even deeper insights into the profile of end beneficiaries and how they are affected by EIB operations, using primary data, in-depth analysis and academically rigorous methodologies. Some of these studies may also address the question of causality – the extent to which any observed change in outcomes can be attributed to an IFE operation, rather than to any other social or economic changes – via impact evaluation methods. The programme is using and enhancing capacity for impact studies by training a set of talented young researchers from ACP countries.

So far, the programme has supported researchers from Ethiopia, Rwanda, Senegal, Mali, Cameroon, Ghana, Nigeria, Kenya and Gambia. All were selected through a competitive process.

Introduction



Prospective EIB-GDN Fellows with EIB Vice-President Andrew McDowell, Expert Advisors Shahrokh Fardoust (College of William and Mary), Alexandros Sarris (University of Athens), Arianna Legovini (Head of the World Bank's Development Impact Evaluation Group) and Francois Bourguignon (Paris School of Economics), EIB and GDN staff, in October 2018.

We are delighted to share the results from the first cycle of the programme. Here are some of the lessons we have learned:

Investing in local talent pays off. The cooperation with GDN took capacity building as one of its main objectives, working with talented early-career researchers. Not only were these local researchers able to bring new perspectives to the research, drawing on their local knowledge and contacts, but they will create a pool of trained talent for use in the future by the EIB, other institutions and the academic community. They are also proving to be an invaluable resource when it comes to disseminating the findings of the studies within local networks, including contributing to policy debates with public authorities.

Impact studies can help development institutions and private sector companies to boost their impact.

Investors aim for environmental and social impact, as well as a financial return. The EIB-GDN programme has shown that by measuring impact and testing assumptions about investment effectiveness, we can greatly enhance our overall impact. For example, poa! internet provides wireless broadband in low-income communities in Kenya. As part of its business model, poa! provides unlimited free internet access to selected community institutions, including schools, in return for these facilities hosting the infrastructure used to provide its "street" internet service. The EIB-GDN study confirmed poa!'s view that access to unlimited data has changed the way students and teachers use the internet for teaching and learning, but found no evidence that provision of poa! internet had increased the probability that students received educational internet content at school, outside of the ICT (information and communications technology) classes. Nor were they more likely to report improved general ICT-related skills and knowledge. Although more work would be needed to identify the reasons behind these findings, poa!'s management suspects that the full benefit of improved internet access can only be felt if appropriate hardware and capacity to

manage the IT system are in place. Responding to these findings, poa! is seeking ways to continue developing its schools service, potentially involving partnerships with NGOs and others philanthropic organisations. Such partnerships could make it possible, in addition to providing free wi-fi, to cover some of the ICT infrastructure and capacity needs of the schools.

Investing in academic rigour can pay off commercially. Impact evaluation is not purely an academic discipline: private sector firms frequently use impact evaluation techniques, such as experimentation. The EIB-GDN programme has given smaller and early-stage firms the chance to use these techniques – most of these firms had not explored quantitative impact evaluation techniques in the past, due to time as well as budget constraints. The firms are finding that these techniques have the potential to pay off commercially. For example, two researchers worked with M-BIRR to look at willingness to pay for an expansion of services to cover utility bill payments. An experimental technique – randomising hypothetical price offers – allowed the researchers to help M-BIRR understand the demand for this service. The main finding – that the willingness to pay is high and well above the cost – has strengthened M-BIRR’s interest in offering this service, and may help it approach the Government with a view to putting the necessary complementary measures in place.

A strong and independent scientific committee is a useful tool to enhance the quality and credibility of impact studies. Throughout the programme, the researchers have been trained, guided and mentored by a group of renowned academics and practitioners in the fields of impact evaluation and assessment. These experts were recruited by GDN from their international network and are fully independent of the EIB. They are: François Bourguignon (Emeritus Professor of Economics at the Paris School of Economics, Professor of Economics at L’École des hautes études en sciences sociales, Paris, France, and former Chief Economist and Senior Vice President at the World Bank); Emmanuel Jimenez (Executive Director of the International Initiative on Impact Evaluation, 3ie), Arianna Legovini (Head of Development Impact Evaluation at the World Bank); Shahrokh Fardoust (Professor at the Institute of the Theory and Practice of International Relations at the College of William and Mary, Williamsburg, Virginia, USA) and; Alexandros Sarris (Emeritus Professor in the Department of Economics, University of Athens, Greece). At the end of each cycle, these high-level experts verify the quality of the impact studies. These expert advisors have guided the researchers towards the most relevant and rigorous methods and techniques, tailored to their research questions, drawing on their cutting-edge knowledge of the fields of impact evaluation and impact assessment. Because the advisors are independent from the EIB, they also provide a stamp of quality and credibility to the work. Furthermore, the exchange of ideas between the EIB, the experts and the researchers has promoted learning on all sides. The EIB has gained an enhanced understanding of cutting-edge methods and how they can be applied to EIB operations. At the same time, the expert advisors have gained understanding of EIB operations and the expanding field of impact investment. This will lay the ground for their future work and, potentially, for continued cooperation with the EIB.

M-BIRR: Mobile banking in Ethiopia

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Expert Advisors: Arianna Legovini and Emmanuel Jimenez

Headline impacts

- The young, the educated and the better-off have been early adopters of mobile money technology. Nonetheless, the M-BIRR mobile money service is reaching a large number of beneficiaries, including among the poor and underserved population groups.
- There is an enormous market opportunity for further expansion of mobile money use: mobile phone use is widespread. The biggest constraint to increasing take-up is lack of awareness among potential customers.
- Making a mobile money payment option available for utility bills could increase consumer welfare: consumers are willing to pay significantly more than the cost of providing the service for the convenience. This is particularly true in secondary cities, without one-stop payment centres, and among the better-off, the educated and those with experience using technology.
- However, a number of institutional factors, on both the supply and demand sides, would need to be tackled to make it possible for M-BIRR or others to provide this service.

Company overview

MOSS ICT Consultancy is the technology provider for M-BIRR, a mobile money service used by over a million Ethiopians. Around 70% of M-BIRR customers use the service to receive social payments, while the others are members of the country's largest microfinance institutions (MFIs). Services available include person-to-person money transfers, deposits, paying for goods and topping up airtime.

In 2017, MOSS received equity investment from the European Investment Bank, under the IFE in a co-investment operation with DEG, a subsidiary of Germany's KfW. The investment will support further expansion of M-BIRR's services to financially excluded groups and the diversification of its products.

Summary

Mobile banking and mobile payment systems have been rapidly developing in sub-Saharan African (SSA) countries. Nowadays Kenya leads this transformation with almost 50 million mobile accounts opened as of December 2018 (Central Bank of Kenya). This paper aims to demonstrate that there is strong latent demand for mobile payment services in Ethiopia. Thus, addressing supply constraints that are setting back

the introduction of mobile payment services like M-BIRR would have the potential to increase consumer welfare.

In this study, we assess the demand for mobile money (MM) for utility payments and identify factors that affect the adoption of MM in Ethiopia. We randomly offer a range of prices that could be charged for using MM for paying utility bills. Furthermore, we randomly vary additional attributes (receiving a monthly reminder for utility bills and the option of requesting an e-receipt for past and current utility bills) that allow us to test for non-price effects. Using the demand estimates, we find that, on average, households are willing to pay a higher price to use MM for utility payments than the actual price charged by current MM service providers for the payment of goods and services. This finding highlights the strong latent demand for MM for paying utility bills in Ethiopia. However, demand is sensitive to price changes and is influenced by the socio-economic characteristics of households. Further investigation of these estimates revealed a potential welfare gain from using MM for utility bill payments.

The study also discusses the legal, regulatory and structural challenges in offering MM services for utility bill payments. Extending MM for utility payments requires a strong partnership between the public and the private sector; this is particularly important in Ethiopia, where public institutions are the sole providers of utilities such as water and electricity. Part of the National Bank of Ethiopia (NBE)'s role is to develop supportive regulatory frameworks, improve the financial infrastructure and promote financial literacy programmes. For example, the amendment of financial proclamations and directives as well as improvements in interoperability should be explored. On the other hand, MM providers would need to extend efforts to promote the platform for processing payments for goods and services. There is limited information about the necessary infrastructure and capacity required for using MM for processing utility payments. The study finds that utility companies overestimate the infrastructure and human capacity needs.

Introduction

More than 700 million people in Africa were mobile phone subscribers in 2017 (International Telecommunication Union, ITU, 2018). This is around 80% of the continent's population, making it the most widely accessed form of ICT on the continent — compared to fixed phone subscriptions (1.2%), internet use (25%) and households with access to a computer (10.8%). Increased mobile phone usage has created many opportunities for delivering new services and fine-tuning existing ones.

The term “mobile money” (MM) refers to a financial transaction service accessed via a mobile phone device. MM can enable cheaper and more secure transfer of money or remittances between individuals, provides relatively secure saving opportunities in rural areas, and facilitates business transactions through the reduction of transaction costs. It provides opportunities for enhancing access to financial services to individuals and households that are excluded from the formal financial system. Financial exclusion has been identified as one of the factors behind persistent poverty in developing countries (Barrett et al., 2001, 2006) and as a factor in slowing economic growth and increasing inequality (see King and Levine, 1993; Levine, 1997; Demirgüç-Kunt, Honahan and Beck, 2008). As such, the expansion of MM can help reduce poverty (Jack and Suri, 2011; 2014; 2016; Beck et al., 2018) and enhance inclusive economic growth.

The number of MM subscribers in Africa, Asia and Latin America has sharply increased over the last decade, from nearly 7 million users in 2006 to nearly 500 million (GSMA, 2017). The expansion of MM has driven a dramatic improvement in financial inclusion in sub-Saharan Africa, from 23% in 2011 to 43% in 2017

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(Demirgüç-Kunt et al., 2018). In 2016, there were 277 million registered MM accounts; more than the total number of bank accounts in sub-Saharan Africa (GSMA, 2017). On average, across sub-Saharan Africa, 21% of adults use MM (Demirgüç-Kunt et al., 2018).¹

MM usage is heterogeneous across the African continent, ranging from Kenya that has 73% of adult users using MM to 11% of subscribers in Sierra Leone and 6% in Nigeria using MM services (World Bank, 2017). Focusing on Ethiopia, usage remains very limited. Ethiopia is home to over 60 million people aged 18 and above and had nearly 51 million mobile subscribers by 2016 (ITU, 2017) but, according to the Ethiopian Central Statistics Authority (CSA) and the World Bank (2017), about 5.2% of the adult population uses MM. The first MM service in Ethiopia, M-BIRR, launched commercially in 2015. This service offers mainly person-to-person money transfers, deposits and enables social payments to be made by the Government to more than a million customers.² Other services such as HelloCash and CBEBIRR are also available and most banks are either already implementing MM services or are in the process of developing them.

As regards using electronic payments to buy goods or to settle utility bills, the 2014 World Bank Global Financial Inclusion (FinIndex) survey recorded less than 10% of adults in Africa using this service. In Ethiopia, MM is used for money transfers (sending and receiving remittances or social benefits), with very limited use for payments for goods or services.

Against this background, the expansion of MM into other transactions such as utility bill payments, retail payments and other payments such as school fees could support wider adoption and use of MM. Other potential benefits include making it easier for businesses and government offices to collect payments; reducing the risk of cash theft (Jack and Suri, 2011; 2014; Beck et al., 2018), improving safety for consumers and businesses alike; reducing the risk of misappropriation by cashiers (McKay and Pickens, 2010; Donovan, 2012); and helping consumers avoid fines (via quicker transfer of funds and the capacity to send reminders for payments).

While an expanding literature has studied the adoption of MM and its effect on household welfare in developing countries, particularly in Africa (Aker and Mbiti, 2010; Munyegera and Matsumoto, 2014), there is limited evidence of the factors that influence the use of MM for payments, as opposed to transfers between individuals or businesses. In this study, we investigate households' preferences for MM payment systems for utility bills in Ethiopia. Using primary survey data, the study addresses the following research questions:

- What is the average stated willingness to pay for MM use for utility bill payments (UBPs)?
- How sensitive to price is the demand for MM use for UBPs?
- How effective are non-price factors in affecting the demand for MM use for UBPs?

To address the research questions, we randomly apply a range of prices that could be charged for using MM for paying utility bills. Furthermore, we randomly vary additional attributes (receiving a monthly reminder for utility bills and the option of requesting an e-receipt for past and current utility bills) in order to test for non-price effects. These exogenous variations, together with household survey data, enable us to address the questions about demand for MM for UBPs in Ethiopia. Furthermore, to assess the awareness

¹ Individuals may have more than one MM account, so the proportion using MM is lower than the number of accounts divided by total population.

² Around 70% of M-BIRR users are beneficiaries of social payments, while 30% are other members of microfinance institutions.

of, opportunities for and constraints on MM in the country, we conducted a semi-structured interview with utility companies and NBE.

We estimate that customers would be willing to pay, on average, up to 15 Birr per month to use MM services for UBPs. Our results also show that consumer demand is sensitive to price changes and is affected by socio-economic characteristics. The higher the proposed price, the lower the take-up rate for MM services for UBPs. The household head's level of education and previous experience of mobile use correlate significantly with the expressed WTP (willingness to pay) for MM for UBPs. In addition, among respondents not yet using MM services, female-headed and relatively poor households are less likely to express willingness to take up MM services for UBPs. On the other hand, residents of Hawassa (a regional city) and Halaba (a small town in the south of the country) are more likely to take up MM services for UBP compared to households in Addis Ababa (the capital city). In Addis Ababa, households have the option of using one-stop payment centres to settle all their bills, while in the regions (such as in Hawassa and Halaba) customers have to go to each of the different utility companies to make payments, which often involves queuing for a long time.

This result suggests that expanding MM for UBPs requires a fine-tuned product that meets the demands of different customers rather than a one-size-fits-all product; this is particularly important if one of the objectives of MM expansion is financial inclusion. Third, the low penetration of MM in Ethiopia is not only determined by demand and the socio-economic characteristics of customers; institutional factors (legal, regulatory and structural factors) also play a key role.

In conclusion, MM providers should consider extending their payment services to the utility sector. Indeed, market developments present an opportunity for MM service providers to scale up early adoption and reap the benefits of MM that are being achieved in other countries. Given the importance of institutional factors, increasing the penetration of MM in Ethiopia requires collaboration between the relevant utilities, financial technology providers, financial institutions and NBE, a form of public-private partnership arrangement. NBE would need to develop supportive regulatory frameworks, improve the financial infrastructure and promote financial literacy programmes while the private financial sector's role would be to create systems capable of providing good quality services at affordable prices.

Background

Despite rapid economic growth over the last two decades, the financial sector in Ethiopia is underdeveloped and has a more limited outreach than in other developing countries. The financial sector in Ethiopia is highly regulated. As of March 2016, the financial sector comprised 18 banks (of these, 16 were private commercial banks), 17 insurance companies, 35 MFIs and five capital goods leasing companies (NBE, 2017).

Only 35% of Ethiopian adults (aged over 15) have an account with a regulated financial institution, and there is significant variation between urban and rural areas³. The country lags behind its neighbours: in Kenya and Rwanda 82% and 50% of adults respectively have accounts (Demirgüç-Kunt et al., 2017). Progress over time in extending financial inclusion has also been relatively slow. By the end of 2016, 26% of adults in Ethiopia were using financial institutions to save money and 14% to borrow, compared to 11% and 7% in 2011 respectively (Demirgüç-Kunt et al., 2017). As a result, Ethiopian households and businesses rely

³ The percentage of adults with a public bank account stood at 81% and 78% in small and large towns respectively (CSA and World Bank, 2017).

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on a range of basic informal financial services (Azomahou and Yitbarek, 2015; Dercon et al., 2005); 65% of adults used informal means to borrow, save and take out insurance (Demirgüç-Kunt et al., 2017).

Rural communities, micro and small enterprises and women in both urban and rural areas are particularly likely to be marginalised by the limited services delivered by financial institutions. These groups represent a huge potential market for the financial sector, including MM. The rapid penetration of mobile phones creates an inexpensive way of delivering financial services to the unbanked without incurring high operational costs, in a context where public infrastructure for the financial market is largely absent (Bhuiyan, 2004; Mirabaud, 2010).

The size of the customer base for the utility sector is significant; according to the CSA and the World Bank (2017), about 39% of households in small towns and 40% in large cities have their own electricity meter while 37% and 61% in small and large towns respectively have a water meter. Most of these households are required to visit the offices of the various utilities separately to pay their bills.

A unified utility payment system (implemented through a public-private partnership) was introduced in 2013. The partnership arrangement between the Ministry of Communication and Information Technology and a private company (Kifiya Financial plc.) created a unified billing system, '*lehulu*' (meaning "for everyone" and "for all services"), that replaced the independent utility payment centres for Ethiopian Electric Utility (EEU), Ethio Telecom and Addis Ababa Water and Sewerage Authority (AAWSA). *Lehulu* is limited to big cities such as Addis Ababa, Bahir Dar and Mekelle. The single window service enables customers to pay all their utility bills in one place, thereby reducing travel costs. Although *lehulu* announced a plan to introduce an online unified utility payment system and incorporate mobile payment, customers still have to settle their utility payments in person, which often involves lengthy queuing. The one-stop service is only available in three cities, Addis Ababa, Bahir Dar and Mekelle, and thus covers only a relatively small proportion of customers. As a result, it is relatively common for households to pay a "bill messenger" to make their utility payments at the relevant utility office or *lehulu* centre in exchange for a payment of around 10 Birr.

In Ethiopia, financial service provision of any kind is restricted to financial institutions (banks and MFIs) that are owned by Ethiopian nationals. However, according to the National Bank of Ethiopia Directive (FIS/01/2012), financial institutions can outsource technology services to any third party. This has allowed MM providers to enter the market by working in partnership with banks and MFIs.

The first MM service, M-BIRR, was introduced in 2015 by MOSS ICT, a technology provider, in collaboration with six Ethiopian microfinance institutions. The number of MM services is growing (such as M-BIRR, Hellocash, HIBIRR and CBEBIRR), but these services reach fewer than two million users.⁴ The services are used mainly for money transfers (sending and receiving remittances or social benefits) with limited use for payments for goods or services.

M-BIRR is the largest mobile money service and is provided in cooperation with the largest MFIs in Ethiopia; namely, the Amhara Credit and Saving Institution, Dedebit Credit and Saving Institution, Oromia Credit and Saving Cooperative, Omo Microfinance Organization, Addis Credit and Saving Institution and the Poverty Eradication and Community Empowerment Microfinance Institution. Currently, M-BIRR has over a million

⁴ M-BIRR payment services allow cross-bank payments and MFI bank payments.

customers and is used mainly for person-to-person money transfers, deposits and social payments.⁵ Over 5 000 MFI branches and agents support M-BIRR across the country.

The M-BIRR system is designed to be user-friendly and compatible with any type of mobile phone. The platform would be suitable for providing payment services for other types of financial transactions such as UBPs and retail payments.

Methodology

The study uses both quantitative and qualitative research methods. To investigate household preferences for MM payment systems for utility bills, we primarily use a quantitative research design, often referred to as a *stated preference method*. To assess the awareness of, opportunities for and constraints on MM in the country, we use qualitative data collected from utility companies and NBE.⁶

Analytical framework

The economics literature identifies various ways to elicit consumer preferences. One of the most common is to determine the WTP for a given product, estimating the maximum price a buyer is willing to pay (Miller et al., 2011; Wertenbroch and Skiera, 2002; Welsh and Poe, 1998; Kalish and Nelson, 1991). Estimates of WTP are crucial for forecasting the expected profitability of a new product (Grunert et al., 2009), designing optimal pricing policies (Wertenbroch and Skiera, 2002) and for shaping competitive strategies for products (Anderson et al., 1993; Miller et al., 2011). Previous research has extensively developed and tested various techniques that can be used to estimate WTP by eliciting consumer preferences for new products and services including public goods (Jedidi and Zhang, 2000). While the choice of method for measuring WTP is an ongoing topic of debate (Petraakis, 2002; Voelckner, 2006), eliciting true WTP or preference by offering different prices to randomly assigned customers for the actual purchase of goods and services dominates the other methods.

There are two major WTP methods: a real WTP or a hypothetical one (Louviere et al., 2000). In hypothetical WTP methods, consumers state their preference for non-existent products/services, whereas real WTP methods require an economic commitment from the consumer — i.e. after stating her/his preference a respondent has to purchase the product/service. Data on hypothetical WTP is gathered through surveys, while collecting data on real WTP requires a sophisticated research design, such as incentive-aligned mechanisms (Miller et al., 2011; Ding, Grewal and Lietchy, 2005), auctions (Vickrey, 1961), lotteries (e.g. the Becker–DeGroot–Marschak (BDM) method, 1964) and revealed preference data (e.g. Ben-Akiva et al., 1994).

Widely applied methodologies for measuring hypothetical WTP include contingent valuation (CV) (e.g. Mitchell and Carson, 1989) and conjoint analysis (e.g. Kohli and Mahajan, 1991). CV is designed to obtain value estimates of WTP in the absence of a market (for instance for public goods) or before the introduction of a product into the market, either by asking consumers to directly state the maximum price they are willing to pay for a given product or to decide whether they would buy a product at a specific price

⁵ Social payments are provided by the Government of Ethiopia with support from international development organisations under the Productive Safety Net Programme (PSNP). The PSNP is the largest social security scheme in Africa. It aims to improve the well-being of poor rural households that are facing chronic food insecurity and uninsured shocks. Development organisations involved in the PSNP include the Canadian International Development Agency, the Danish International Development Agency, the European Union, Irish Aid, the Netherlands Development Organization, the Swedish International Development Agency, the United Kingdom's Department for International Development, the United States Agency for International Development, the World Food Programme and the World Bank (Wiseman et al., 2010).

⁶ The National Bank of Ethiopia is the regulatory body of the financial sector, including microfinance institutions.

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(Kalish and Nelson, 1991; Wertenbroch and Skiera, 2002). Conjoint analysis is used mainly to determine trade-offs among product attributes, including price. According to this method, a customer is provided with a profile of different attributes of a product and asked to rank or rate the profiles according to his/her preferences. Both methods (CV and conjoint analysis) have the advantage of being able to assess the WTP and estimate the demand curve for products before introduction to the market (Louviere et al., 2000). However, hypothetical WTP methods are subject to hypothetical bias; consumers usually tend to give a higher WTP than their true WTP because of a lack of real economic commitment during the study (Hensher, 2010; Hoffman et al., 1993).

None of the providers in Ethiopia were providing MM services for UBPs at the time of our study, therefore our study looks at a hypothetical situation in anticipation of the introduction of this service. The simplicity of the method — it demands less knowledge from the respondent than other methods such as conjoint analysis and discrete choice experiments — makes CV our preferred hypothetical method, particularly given the relatively low educational level of many of the respondents.

CV draws on the microeconomic theory of utility maximisation and uses a survey to obtain individual WTP. Hanemann (1984) provides a random utility model (RUM) framework for analysing closed-ended and single-bounded responses. In this framework, the indirect utility is composed of a deterministic and stochastic component. The deterministic component represents the observable element of the consumer's preference, while the stochastic component represents the unobservable element of the consumer's preference (from the researcher's perspective). This is due to the fact that the researcher may not observe some of the preferences due to a lack of information, though the individual knows his utility function with certainty.

Formally, the indirect utility function for consumer i in the state j of the change to be valued (from $j = 0$, the *status quo* and $j = 1$, the final state with the new commodity) can be given as follows.

$$u_{ij} = v_{ij}(m, y, X) + \varepsilon_{ij} \quad (1)$$

where $u_{ij}(\cdot)$ is a function of the new commodity to be valued, m , household income, y , and household characteristics, X , suppressing the prices and quantities of other commodities. $v_{ij}(\cdot)$ is the deterministic part, while ε_{ij} is the random component with mean zero.

We are interested in the WTP of individuals for a new commodity (not yet available in the market, $j = 1$). We present the respondents with two options:

Option 1: whether they are willing to use the new service (MMUBP), with a reduction in his/her income by the amount of the bid price, B ; and

Option 2: remain with the status quo, without using the new commodity and no reduction in his/her income.

According to utility maximisation, the individual prefers the new commodity (or responds 'yes') if his utility with the new commodity that costs the bid price (B) is at least the same as his utility with the *status quo* (without the new commodity).

$$u_{i1}(m, y - B, X, \varepsilon) \geq u_{i0}(y, X, \varepsilon) \quad (2)$$

Formally, the probability that the consumer responds 'yes' is:

$$\Pr(\text{yes}) = \Pr(u_{i1}(m, y - B, X, \varepsilon_{i1}) \geq u_{i0}(y, X, \varepsilon_{i0})) \quad (3a)$$

$$\Pr(\text{yes}) = \Pr(v_{i1}(m, y - B, X) + \varepsilon_{i1} \geq v_{i0}(m, y, X) + \varepsilon_{i0}) \quad (3b)$$

$$\Pr(\text{yes}) = \Pr(\Delta v + \varepsilon \geq 0) \equiv F_{\varepsilon}(\Delta v) \quad (3c)$$

We define the WTP as the bid price (B) that turns the inequality in Eq. (2) into equality as below:

$$u_{i1}(m, y - WTP, X, \varepsilon) = u_{i0}(y, X, \varepsilon) \quad (4)$$

$WTP = w(m, X, \varepsilon)$ is the maximum WTP that shifts the consumer from the *status quo* into consuming the new commodity, m . In a RUM framework, the WTP is also a random variable since the researcher does not know it and treats it as a random variable even if the individual knows his WTP with certainty.

Alternatively, given our CV question, “would you be WTP \$ x , the bid price (B), for the new commodity?” the individual consumer answers ‘yes’ if the bid price (B) is less than his WTP ($WTP \geq B$) and ‘no’ otherwise. So, the probability of ‘yes’ $\Pr(\text{yes})$ could be written as in Eq. (5):

$$\Pr(\text{yes}) = \Pr(WTP = w(m, X, \varepsilon) \geq B) \quad (5)$$

Let $F_w(\cdot)$ be the cumulative density function (CDF) of WTP and $f_w(\cdot)$ the corresponding probability density function (pdf). So, the probability of ‘yes’ $\Pr(\text{yes})$

$$\Pr(\text{yes}) = 1 - F_w(B) \quad (6)$$

From Eqs. (3c) and (6), the probability of ‘yes’ can be summarised as in Eq. (7) below, which ties the probability defined over utility space with a probability defined over WTP space:

$$\Pr(\text{yes}) = F_{\varepsilon}(\Delta v) \equiv 1 - F_w(B) \quad (7)$$

Estimation of Eq. (7) requires in the former case assumptions about the utility function and distribution function for F_{ε} , while the latter requires an assumption about the distribution function for F_w . We follow the approach in Cameron (1988) and directly specify a particular CDF for the individual random WTP, F_w , avoiding assumptions about the utility function.

Let the expected value of WTP be $E(WTP) = \mu$; the variance of WTP, $var(WTP) = \sigma^2$ and $F_w(\cdot)$ a CDF of standardised variate $\omega = \frac{WTP - \mu}{\sigma}$; then the probability of ‘yes’ can be written as:

$$\Pr(\text{yes}) = 1 - F_w(B) = 1 - F_w\left(\frac{B - \mu}{\sigma}\right) \quad (8)$$

Assuming a standard normal CDF (Φ), Eq. (8) is a probit model, where $\alpha = \frac{\mu}{\sigma}$ and $\beta = \frac{1}{\sigma}$, rewritten as in Eq. (9):

$$\Pr(\text{yes}) = \Phi\left(\frac{\mu - B}{\sigma}\right) = \Phi(\alpha - \beta B) \quad (9)$$

From the above probit model, we can estimate the expected value of WTP as in Eq. (10) using coefficients from the probit regression:

$$E(WTP) = \frac{\alpha}{\beta} \quad (10)$$

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In Appendix 2, we show how the expected value of WTP is derived following Hanemann (1984) based on a RUM framework and assumptions about the utility function.

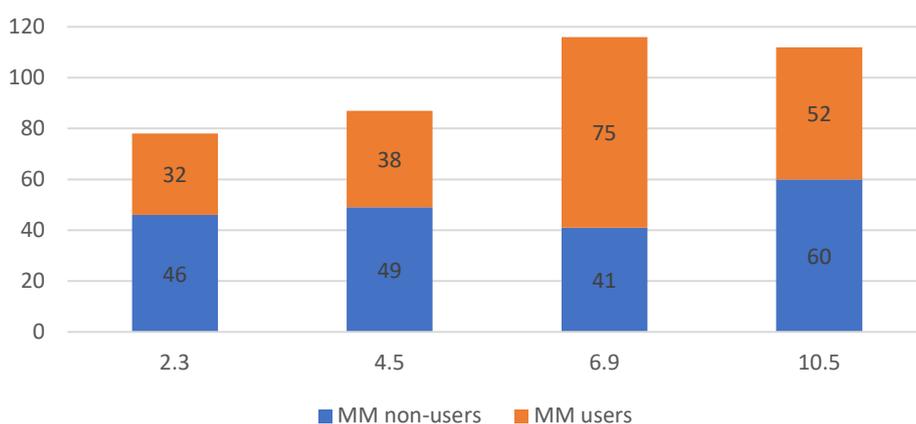
Sampling, instrument design and data collection

The required sample size was set at 400 households, including 10% of missing households and non-responses. We collected cross-sectional data from 393 households (197 users and 196 non-users) living in Addis Ababa, Hawassa and Halaba. The selection of cities was based on the existing distribution of MM users, geographic size and existing utility payment arrangements. Whilst in Addis Ababa, the capital city, there are large numbers of MM users and one-stop payment centres for processing UBPs, in Hawassa and Halaba utility users have to travel to each utility provider (electricity, telecoms and water) to make their monthly payments.

We followed a stratified random sampling procedure. We stratify the households in each district into households that have an M-BIRR account (either through MFIs or individual agents), and households without an M-BIRR account. The sample frame for MM users is largely based on the list of current M-BIRR customers obtained from MFIs with the generous support of MOSS ICT Consultancy. About 10% of MM users in the sample use another MM provider such as CBEBIRR. The sample frame for non-users is based on the list of households in the administrative records of each *kebele*, excluding households on the M-BIRR customer lists. Enumerators administered the interviews face-to-face or via telephone.

The interviews began with a short socio-economic questionnaire. Then, they explained the MM procedure for UBPs and asked households whether or not they would be willing to take it up. In order to elicit the willingness to use MM for UBPs, we randomly assign households to one of the four different price categories (2.3, 4.5, 6.9 and 10.5 Birr for each utility bill per month). Figure 1 shows the sample size for different price categories. Furthermore, we randomly assigned additional marketing or value propositions.

Figure 1: Sample size by price categories (number of households)



All six enumerators received one day of training, and a pilot test of the survey instrument was carried out in Addis Ababa. The results of the pilot tests were used to refine our survey questionnaire. Both researchers were present during the interviews and also supervised the data collection.⁷ The data were collected between 3 May and 23 May 2018, achieving a 98% response rate.

⁷ The researchers also conducted the key informant interviews.

Table 1: Sampled households by city and MM use status*

City	MM users	MM non-users	Total
Addis Ababa	105	98	203
Hawassa	68	76	144
Halaba	24	22	46
Total	197	196	393

*The MM users are randomly drawn from the client base of M-BIRR. However, we have included other MM users (such as CBEBIRR), who account for less than 10% of the interviewed MM users.

The sample is representative of the M-BIRR clients in each city but not the total number of MM users in the country. Regarding non-users, the sample also provides a good representation of the non-users in each city. Overall, given the representative characteristics of the sampled cities and the existing utility payment arrangements, our results are highly likely to be replicated in other cities in Ethiopia.

We collected both qualitative and quantitative data. The quantitative data are based on a field survey approach, where enumerators collected the information primarily from face-to-face interviews using a survey questionnaire.

The survey questionnaire was prepared in consultation with different stakeholders and fine-tuned after the results of the pilot tests were received. The household survey questionnaire included the following major components (full questionnaire available from the authors on request):

- Household composition and socio-demographic characteristics
- Education and occupation of household head
- Household livelihoods: simple poverty scorecard
- Details of utility bill payments
- Financial access and use
- Awareness and use of mobile money and MM usage-related questions
- Financial literacy and trust
- WTP module.

To elicit the willingness to use MM for UBPs, we randomly assigned households to one of the four different price categories (2.3, 4.5, 6.9 and 10.5 Birr for each utility bill per month). Our reference price was Birr 4.5, which is M-Birr's current market price for processing payments for goods and services.

The qualitative data are from semi-structured key informant interviews that we conducted during the last week of May 2018 with relevant stakeholders, namely, NBE, Ethiopian Electric Utility, Ethio Telecom, and the Addis Ababa Water and Sewage Authority.

Econometric approach

One of the objectives of this study is to estimate the mean WTP for the new MM service that is to be introduced in the market. The probability that the respondents answer 'yes' to the CV question, stating their willingness to accept the offer at the bid price, B , can be approximated by a probit model given in Eq.

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(9). Using the take-up of MM for UBP by household i , MM_i , and the randomly assigned prices, B_i , we estimate the following probit model:

$$\Pr(MM_i = 1) = \Phi\left(\frac{\mu - B}{\sigma}\right) = \Phi(\alpha - \beta B) \quad (11)$$

By estimating the probit model, we can compute the mean WTP as shown in Eq. (10), above. Another objective of this study is to examine the factors that affect individuals' WTP. To this end, we can easily extend the above probit equation to include additional factors, X , that may affect the WTP, as follows:

$$\Pr(MM_i = 1) = \Phi\left(\frac{\mu - B}{\sigma}\right) = \Phi(\alpha - \beta B + \gamma X) \quad (12)$$

The dependent variable (MM_i) is a binary variable, whether the household is willing to take up the offer for using MM for UBP (=1) or not (=0). (B_i) is the proposed monthly fee (bid price) per transaction and X_i is the vector of household characteristics (age, gender, education, poverty status, mobile use, financial literacy, trust), a marketing feature proposed to household i (the option to request an e-receipt for current and past utility bills) and location indicators. α is the constant, β is the coefficient for the bid price, and γ is the vector of the coefficient for X_i .

Results

This section presents both the quantitative and qualitative results. First, it describes the characteristics of sampled households and presents the potential demand for MM services for UBPs. Then, it provides the probit estimates of the WTP model and the mean WTP. It also discusses the potential welfare effects of the new MM service. Lastly, it highlights the challenges in providing MM services for UBPs in Ethiopia.

Descriptive results

Socio-economic characteristics

Table 2 summarises the characteristics of the respondents in the sample by MM usage. We define MM users as those households with at least one registered MM customer or a member who is not registered but has used MM.

Table 2: Socio-economic characteristics, sampled households

	MM non-users	MM users	Difference
Age of the household head	40.421	36.066	4.355***
Female-headed households	0.272	0.193	0.079*
Education level of household head			
Illiterate	0.056	0.056	0.000
Primary	0.112	0.061	0.051*
Secondary	0.490	0.244	0.246***
Diploma	0.143	0.203	-0.060
Degree and above	0.199	0.437	-0.238***
Household size	4.489	3.791	0.698**
Proportion below the national poverty line [§]	20.683	14.941	5.742***
Observations	197	196	393

*, ** and *** denote statistically significant at 10, 5 and 1 percent level respectively.

[§] based on Poverty Probability Index (PPI) using the national poverty line (3 774 Birr or USD 229 per year) in December 2010 (Schreiner, 2016).

MM non-users are older than MM users (average age of 36, compared to 40 for non-users) and about 23% of the households in the sample are female-headed, in line with the urban population's demographic structure in which nearly 30% of households are female-headed (Central Statistics Authority, 2018).

Using MM to make a payment requires a basic level of literacy and numeracy (e.g. reading and following the instructions and inputting the numbers), and MM users are indeed more likely to be highly educated than non-users (Table 2). Almost 44% are educated to degree level or above, compared to 20% of non-users. However, the fact that 12% of MM users are educated to primary level or below suggests that the minimum level of literacy required is not an insurmountable constraint to the adoption of MM for UBPs. On the other hand, the MM providers should be aware of the need to cater to less educated or illiterate groups, which make up almost 17% of non-users, particularly as they expand to more remote areas and more disadvantaged groups.

MM users live in smaller households than non-users and enjoy a higher standard of living across most of the eight indicators of the Poverty Probability Index (PPI) Scorecard. On average, about 15% of users and 21% of non-users are estimated to live below the national poverty line based on the PPI, indicating that the early adopters of MM are relatively wealthier. The poverty data closely mimic poverty estimates for urban areas in Ethiopia, which stood at 14.8% in 2016.⁸

Utility use and bill payment

Most of the sample households have both electricity and water meters and pay their bills monthly. Table 3 shows the difference between users and non-users by utility use and bill payment. Overall, about 63% and 62% of households have electricity and water meters, respectively. About 17% of the households reported having a fixed telephone line, the same proportion for both users and non-users. About 70% of non-users have their own electricity and water meters, in contrast to 56% and 54% of MM users, respectively.

Table 3: Utility use and bill payment

	MM non-users	MM users	Difference
Household has electricity meter	0.696	0.561	0.135***
Household has water meter	0.703	0.541	0.162***
Household has fixed telephone	0.177	0.167	0.010
Pays electricity bill monthly (1=yes)	0.859	0.927	-0.068*
Pays water bill monthly (1=yes)	0.876	0.943	-0.067*
Pays fixed telephone bill monthly (1=yes)	1.000	0.903	0.097*
Travel time from home to the electricity payment centre (in minutes)	30.175	22.272	7.902***
Travel time from home to the water payment centre (in minutes)	27.180	20.819	6.361**
Travel time from home to the fixed telephone payment centre (in minutes)	17.730	18.829	-1.100
Processing time at 'Lehulu' centre	30.232	25.468	4.764
Processing time at utility branch office (in minutes)	31.145	26.188	4.957
Observations	197	196	393

*, ** and *** denote statistically significant at 10, 5 and 1 percent level respectively.

⁸ National Planning Commission, interim poverty analysis report for 2015/16

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Most of the sampled households report paying their bills monthly (electricity bill: 89%; water bill: 91%; and telephone bill: 95%), with monthly payments slightly more common among non-users. Among those with their own electricity meters, about 44% pay their bills at a 'Lehulu' centre, 45% pay at the utility branch office and 10% use a bill messenger.⁹ Of those with a water meter, 48% pay their bills at a 'Lehulu' centre, 42% pay at the utility branch office and 10% use a bill messenger.¹⁰ Of those with a fixed telephone line, about 60% pay at a 'Lehulu' centre, 36% pay at the utility branch office branch and about 4% use a bill messenger.

Table 3 shows that the average travel time to the bill payment centre is 26 minutes for electricity, 24 minutes for water and 18 minutes for telephones. The average travel time is just under half an hour (23 minutes). The difference between travel times for users and non-users is statistically significant: users reported relatively shorter travelling times than non-users. However, there is no significant difference between processing times at the 'Lehulu' centres and the utility branch offices: an average of 28 minutes and 29 minutes, respectively. In most cases, household heads or their spouses are responsible for making the payments at the bill centres. They spend, on average, nearly an hour (51 to 52 minutes) processing utility payments (travelling to the payment centre and queuing to make the payment). Those in Hawassa and Halaba have to process payments at each utility company, which requires triple the effort. If valued at the average unskilled labour wage, the time spent paying utility bills every month represents twice the current cost of MM services for processing payments for goods and services (4.5 Birr).¹¹

The cost of mobile money payments compared to the average utility bill is significant: about 21%, 26% and 24% of electricity, water and fixed phone bills, respectively. The percentage is high because utilities (electricity and water) are subsidised by the Government whereas the cost of MM use is not.

Mobile phone use

About 99% of the sampled households own a mobile phone, and 88% of mobile phone users have been using a mobile device for over five years. In 87% of the sampled households, at least two members have phones. This indicates that there is an enormous opportunity for MM adoption.

Households use their phones for making or receiving calls (100%), sending (88%) or receiving texts (100%), internet browsing or Facebook use (66%), listening to FM radio (70%), and transferring money or making payments (44.6%).

Financial access; awareness and use of MM

Financial inclusion is relatively high within the sample: 89% of households have a bank account, nearly 54% of households have an ATM card; 33% have accounts with an MFI; and 58% and 56% are members of 'iddir' and 'equb', respectively.¹² These levels are much higher than for the country as a whole. The results are broadly consistent with estimates for urban areas: 2016 estimates show that the percentage of adults with

⁹ The distribution of households' payment centres is influenced by our sample selection of cities. In Addis Ababa, households have the option of making payments at the 'Lehulu' center; while those in Hawassa and Halaba have to pay at the utility branch office because there are no one-stop window payment services in their area.

¹⁰ In Addis Ababa, there are individuals who provide a service to pay utility bills; on average they charge Birr 10 per bill. However, there seems to be a lack of trust in them; most of the messengers often wait until they have collected money from several customers before making the payment, which raises concerns about the timely settling of the utility bill payment and the risk of being cut off.

¹¹ The minimum wage for unskilled labour in the public sector is around 420 Birr (USD 22) per month or around 3 Birr per hour.

¹² 'Iddir' is a voluntary association, usually formed among friends, colleagues and neighbours, to provide the resources for carrying out funeral rituals; while 'Equb' is a voluntary association that regularly pools funds and rotates them among members.

a public bank account stood at 81% and 78% in small and large towns respectively (CSA and World Bank, 2017).

A large proportion of the sampled households (82%) are aware of MM or mobile banking services in their city. The rate of awareness in the sample exceeds rates for the country as a whole even for non-users. 63% of non-users are aware of MM, whereas the national level of awareness of mobile banking is about 15% (World Bank, 2017). This reflects the level of use of an urban sample, drawn in areas where MM providers are active. World Bank data (World Bank, 2017) show that the proportion of individuals aged 18 and above who are familiar with mobile banking in Addis Ababa, large towns and small towns, is 65.4%, 52.8% and 27.1%, respectively.

MM is used for transferring money, receiving money, paying for goods and topping up/purchasing airtime. The reasons for not using MM are a lack of awareness or knowledge of the service (68%), a lack of information on the availability of services in their city (6%) and other reasons (26%) such as not having a mobile phone, lack of trust or not considering it important.

Financial literacy and trust

Using mobile money requires an element of trust. For the purpose of this study, we asked respondents whether they would trust an MM service to transfer money to a relative — on a scale of 1 to 5 (distrust a lot, distrust, not sure, trust and trust a lot). Trust in the use of MM is high, with 88% of users and 76% of non-users reporting that they would trust MM to transfer remittances (Table 4). Both groups are more likely to trust MM than a stranger or their relatives. However, trust in banks is almost universal in both groups.

Table 4: Financial access and mobile phone use

	MM non-users	MM users	Difference
Financial use, literacy and trust:			
Household has a bank account	0.821	0.964	-0.143***
Household has an ATM card	0.428	0.648	-0.220***
Household has an MFI account	0.135	0.513	-0.378***
Household member of ' <i>Iddir</i> '	0.653	0.503	0.151***
Household member of ' <i>Equb</i> '	0.508	0.604	-0.096*
Financial literacy score (<i>Maximum score=4</i>)	2.495	2.873	-0.378***
Trust MM (1= trust)	0.760	0.883	-0.123***
Mobile phone ownership:			
Respondent owns mobile phone	0.974	0.995	-0.020*
Any household member owns mobile phone (1=yes)	0.856	0.827	0.029
Mobile phone usage:			
Mobile phone used for making calls	0.979	1.000	-0.021**
Mobile phone used for sending texts	0.781	0.979	-0.199***
Mobile phone used for receiving texts	0.989	1.000	-0.011
Mobile phone used for internet browsing/Facebook use	0.482	0.827	-0.346***
Mobile phone used for listening to FM radio	0.628	0.772	-0.143***
Mobile phone used for transferring money or making payments	0.136	0.746	-0.610***
Observations	197	196	393

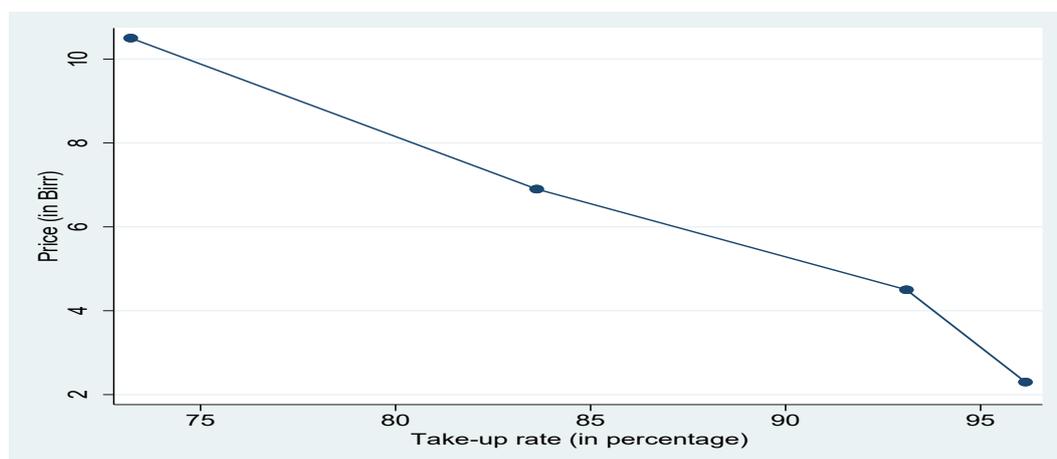
Financial literacy was assessed via four short questions. The revealed level of financial literacy is high, with respondents correctly answering 2.68 questions on average. Financial literacy was higher among MM users than non-users. The figures are roughly in line with national data, which show that the level of financial knowledge in small towns ranges between 18 and 42%, while in large urban towns it ranges between 26 and 64% (CSA and World Bank, 2017).

Estimation of WTP and demand analysis

Potential demand for MM services

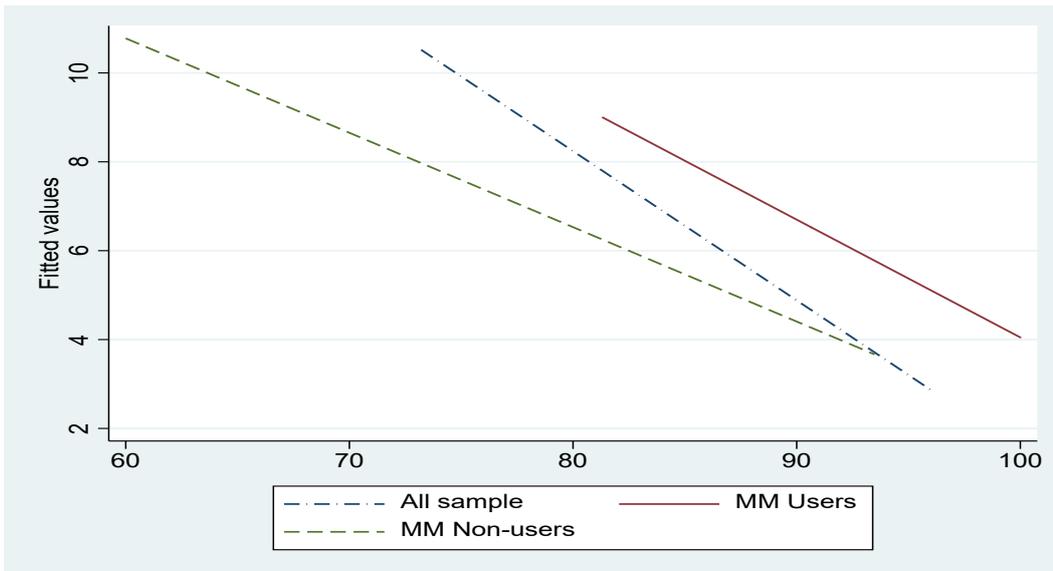
We use the results of our survey question, “would you be willing to pay birr x to pay your utility bill using MM?”, to infer the potential demand for MM services for UBPs. Figure 2 shows the relationship between price and quantity (proportion of households that are willing to use the service at different prices) for the whole sample.

Figure 2: Potential take-up rate at different prices, full sample



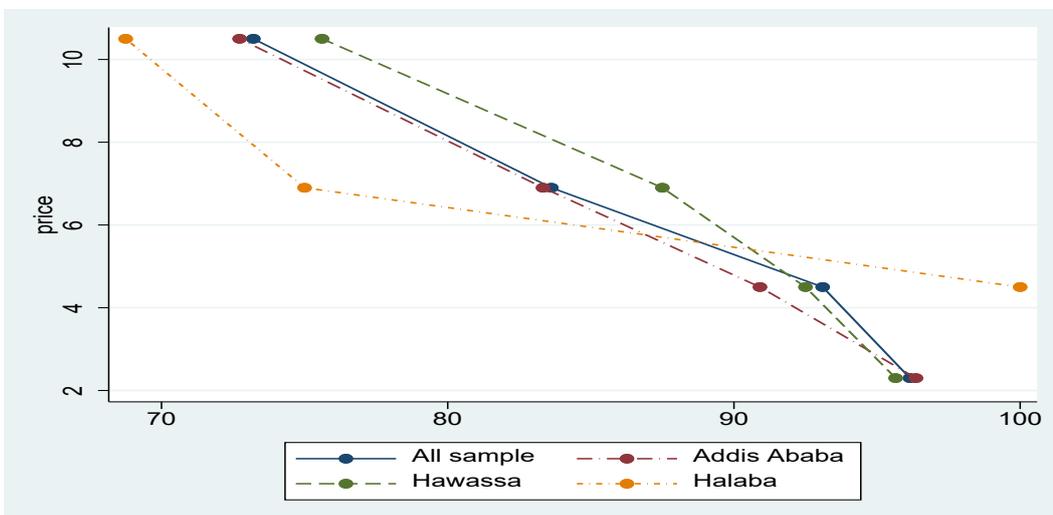
The figure shows that about 96.5% of the respondents are willing to use the service at 2.3 Birr per month, while 93.1% are willing to pay 4.5 Birr (the reference price that is charged by MM providers for processing payments for goods and services). Tripling the price leads to a decline in willingness (83.62%); likewise, further increasing the price to 10.5 Birr reduces the WTP to 73.21%. Overall, the graph shows a negative relationship between price and quantity. As expected, MM users have relatively higher demand at each price point than MM non-users (Figure 3).

Figure 1: Potential take-up rate disaggregated by MM users



Potential demand is relatively higher in Hawassa, followed by Addis Ababa and Halaba (Figure 4). This might reflect the utility payment options that are available for households in different regions. In Addis Ababa, households have the option of using one-stop payment centres to settle all their bills, while in Hawassa and Halaba customers still have to go to each of the different utility companies to make payments. This involves lengthy queuing. Non-poor households exhibit a higher potential demand than poor households for MM use for UBPs (Figure 5).

Figure 2: Potential take-up rate disaggregated by location



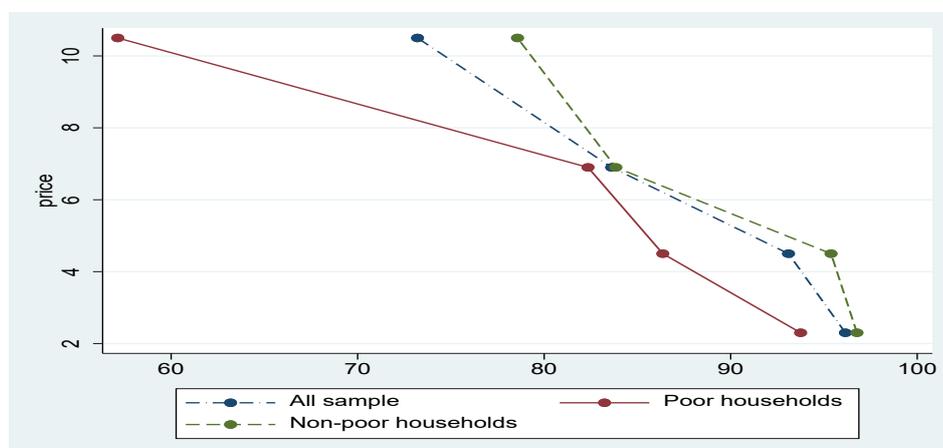
The figures reveal two interesting findings for MM service providers. First, there is significant potential demand for using MM services for UBPs across metropolitan, regional and small cities. Second, the potential demand is sensitive to price. For instance, if we set the price of MM for UBPs at 4.5 Birr¹³ — the current market price for paying for goods or services using mobile money — the potential take-up rate would be 93.1%. Providing a 50% subsidy (reducing the price from 4.5 to 2.3 Birr) would only slightly raise the potential take-up (to 96.5%). A 50% increase in the current market price (raising the price from 4.5 to 6.9 Birr) or a 133% increase (raising the price from 4.5 to 10.5 Birr) would significantly reduce the potential

¹³ The price according to M-BIRR

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take-up. However, the majority of consumers would still take up the service: 83.62% and 73.21%, respectively.

Figure 3: Potential take-up rate disaggregated by poverty status



Determinants of WTP for MM services

In Table 5, Columns 1-3 provide the baseline regression results from a probit regression model used to identify significant correlates of demand for MM. As expected, price negatively and significantly affects take-up of MM use for UBPs (column 1). There is no significant effect of including marketing (column 2), and neither the sign nor the significance of the coefficient for price are affected by including location.

Table 5: Baseline regression of Willingness to Pay model: Probit estimates

	(1)	(2)	(3)	(4)
Price	-0.138*** (-4.84)	-0.138*** (-4.80)	-0.137*** (-4.75)	-0.143*** (-4.88)
Marketing		0.007 (0.04)	0.010 (0.06)	0.050 (0.30)
Halaba [‡]			-0.063 (-0.26)	-0.044 (-0.18)
Hawassa [‡]			0.101 (0.57)	0.148 (0.81)
MM user				0.474*** (2.82)
Intercept	2.029*** (8.88)	2.027*** (8.67)	1.994*** (8.18)	1.778*** (7.03)
Pseudo R-square	0.077	0.077	0.079	0.104
LR chi2	25.45***	25.45***	25.97***	34.12***
N	393	393	393	393

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[‡]Addis Ababa is the reference city

Based on the baseline regression results, we estimate the mean WTP to be about 15 Birr per transaction. This is more than twice the actual market price charged by MM service providers for processing payments for goods and services. The WTP estimate of 15 Birr is equivalent to 0.3% of urban households' average monthly consumption expenditure (4 986 Birr), based on the 2015/16 Household Consumption Expenditure Survey (Central Statistical Agency, 2018). The estimate confirms the potential profitability for financial institutions of providing MM services.

We relied on the baseline regression in estimating the mean WTP, since our interest is to provide the average WTP for the service in the whole sample. However, if one is interested in estimating the average

WTP for a particular group (for instance, poor or female-headed households only), then the estimation of WTP relies on the extended regression provided in Table 6. For instance, we estimated the mean WTP for MM users and non-users using results in Table 6, Column 4. Average WTP among MM users (15.8 Birr) is significantly higher than among non-users (12.5 Birr).

Table 6: Extended regression of Willingness to Pay correlates: Probit estimates

	(1)	(2)	(3)	(4)	(5)
Price	-0.154*** (-5.02)	-0.154*** (-5.01)	-0.158*** (-4.80)	-0.162*** (-4.83)	-0.162*** (-4.83)
Marketing	-0.006 (-0.03)	-0.021 (-0.12)	0.012 (0.07)	0.021 (0.11)	0.026 (0.14)
Age	-0.001 (-0.15)	0.001 (0.07)	0.005 (0.63)	0.007 (0.94)	0.007 (0.94)
Female household head	-0.282 (-1.42)	-0.280 (-1.40)	-0.316 (-1.54)	-0.253 (-1.17)	-0.244 (-1.12)
Illiterate	0.024 (0.07)	0.050 (0.14)	0.136 (0.35)	0.118 (0.30)	0.095 (0.24)
Primary education	-0.078 (-0.27)	-0.054 (-0.18)	-0.105 (-0.34)	-0.118 (-0.39)	-0.128 (-0.42)
Diploma	0.868*** (2.98)	0.843*** (2.88)	0.769** (2.55)	0.747** (2.48)	0.734** (2.42)
Degree and above	0.863*** (3.86)	0.839*** (3.71)	0.789*** (3.28)	0.781*** (3.17)	0.767*** (3.07)
Poverty status		-0.005 (-0.72)	-0.006 (-0.90)	-0.008 (-1.19)	-0.008 (-1.14)
Used mobile for sending texts			0.215 (0.75)	0.266 (0.91)	0.255 (0.86)
Used mobile for internet browsing/Facebook			-0.024 (-0.11)	0.016 (0.07)	-0.005 (-0.02)
Financial literacy			0.070 (0.61)	0.084 (0.72)	0.079 (0.68)
Trust in MM			0.560*** (2.63)	0.549** (2.55)	0.541** (2.51)
Halaba [‡]				0.160 (0.53)	0.154 (0.51)
Hawassa [‡]				0.301 (1.38)	0.304 (1.39)
MM user					0.076 (0.37)
Intercept	1.922*** (5.45)	1.963*** (5.47)	1.097** (2.17)	0.838 (1.53)	0.839 (1.53)
Pseudo R-square	0.165	0.166	0.199	0.205	0.206
LR chi2	54.19***	54.70***	63.34***	65.28***	65.42***
N	391	391	381	381	381

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[‡]Addis Ababa is the reference city

While we are aware that the estimated WTP (based on stated preference) could differ from revealed preference or actual market behaviour due to possible hypothetical bias, Cameron et al. (2002) show that predictions from hypothetical stated preference are comparable to actual market behaviour. Furthermore, we have attempted to minimise the bias by providing a dichotomous choice of a carefully set range of prices that enable us to assess the potential demand.

The regression results in Table 6 include additional covariates to control for the effect of household characteristics. The results (column 1) show that the age and gender of the household head have no

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significant effect on take-up, while education positively and significantly correlates with a willingness to use MM for UBPs. Household heads with a diploma and above are more likely to take up the service compared to those with a secondary level of education. Household poverty status has no significant effect on WTP (column 2), although this could reflect the high correlation of poverty status with education levels. Mobile use and financial literacy have no statistically significant effect on WTP, while trust in MM transfers positively and significantly correlates with take-up (column 3). Household location does not have a significant effect on take-up, and the higher WTP among MM users is revealed not to be significant, controlling for the various observed differences between the two groups (columns 4 and 5).

Disaggregating between existing MM users and potential clients brings some additional insights (Table 7). Both groups are sensitive to price, and more educated household heads are consistently more likely to take up the service. But it is only among non-users that the gender of the household head, poverty status, trust in MM and location significantly affect the WTP. Those residing in Hawassa and Halaba are more likely to take up the proposed MM service for UBPs compared to households in the capital city, Addis Ababa. This might be because there are no one-stop utility payment centres in the regional cities.

Welfare analysis of MM for UBPs

In this section, we highlight the costs and benefits of MM services for UBPs, comparing the costs of providing the service with the estimated benefits to the sampled households based on the elicited WTP estimates.

By welfare, we mean the net benefits to consumers from using the new service (MM for UBPs), which is measured using a consumer surplus (CS) approach. CS is the difference between what consumers are willing to pay and what they actually pay for the transaction. If the introduction of MM for UBPs increases welfare (a positive CS), it can be considered welfare-enhancing.

The consumer WTP is based on the stated average WTP estimated above, which is 15 Birr per transaction. To approximate what consumers would actually pay per transaction, we use the current market price (4.5 Birr per transaction for M-BIRR)¹⁴ which represents the acceptable supply-side cost. The CS is therefore 10.5 Birr per transaction. The average WTP shows how consumers, on average, value the new commodity; this represents the value of the benefits they expect to derive from the commodity. MM for UBPs is a hypothetical market commodity, as these services are currently not available. However, the price of similar market commodities could be a good proxy for the cost of providing MM for UBPs.

Table 7: Probit estimates of Willingness to Pay correlates: disaggregated by MM use

	(1) MM users	(2) MM non-users
Price	-0.129** (-2.14)	-0.223*** (-4.62)
Marketing	-0.058 (-0.19)	-0.081 (-0.32)
Age of the household head	-0.003 (-0.29)	0.016 (1.40)
Female household head	0.237 (0.61)	-0.497* (-1.75)
Illiterate	0.345 (0.57)	-0.242 (-0.39)

¹⁴ This is the amount the M-BIRR service charges per transaction (See <http://www.m-birr.com/pricing.html>).

Primary education	0.241 (0.43)	-0.367 (-0.92)
Diploma	1.036** (2.03)	0.322 (0.79)
Degree and above	0.910** (2.33)	0.840** (2.09)
Poverty status	0.003 (0.26)	-0.021** (-2.05)
Used mobile for sending texts	1.549** (2.01)	-0.033 (-0.09)
Used mobile for internet browsing/Facebook	-0.468 (-0.93)	0.314 (1.03)
Financial literacy	-0.140 (-0.70)	0.209 (1.25)
Trust in MM	0.317 (0.75)	0.754*** (2.66)
Halaba [‡]	-0.083 (-0.18)	0.778 (1.63)
Hawassa [‡]	0.420 (1.16)	0.548* (1.74)
Intercept	0.665 (0.61)	0.880 (1.21)
Pseudo R-square	0.202	0.277
LR chi2	26.01**	50.63***
N	195	186

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[‡]Addis Ababa is the reference city

At an aggregate level, the net benefit could be 352.8 million Birr (12.6 million US dollars)¹⁵ per year. This is based on the 14% of households that have their own electric meter (CSA and WB, 2016) and the average number of 20 million households in Ethiopia. This is a lower bound estimate of the benefit since it does not include the producers' benefit.

Implementation challenges

This section is based on qualitative data obtained from semi-structured interviews with key informants: staff and experts from NBE and the utility providers (EEU and AAWSA). The discussion focuses on the challenges in implementing the new mode of payment for UBPs. The discussions revealed that, while increased use of MM could be an effective way to promote financial inclusion in Ethiopia, there are key challenges on the supply side, both in terms of the policy environment, the capacity of other stakeholders (such as the utility service providers) and the mechanisms for cooperation between various players in the system. Addressing the various challenges will require actions both from the Government and the private sector. Staff supervising microfinance at NBE identified the following bottlenecks to the development of MM services in Ethiopia:

- 1. Interoperability between systems such as ATMs, points of sale and mobile money systems:** NBE created in 2011 the Ethiopia Automated Transfer System, which does not support MFIs due to their limited technological capacities. Respondents expected the new national payment switch (EthSwitch) to address this issue.
- 2. Integration of technological service providers in the national payment system:** at the time of the study, no directive existed to regulate technology providers in the national payment system. As a

¹⁵ The current exchange rate is 1USD equals to 28.05 on January 02, 2019.

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result, there is uncertainty on whether or not technology providers can provide MM or can support MFIs in clearing and settling transactions. Currently, NBE is in the process of revising existing directives (Directive No. FIS /01/2012) and is reviewing the role, regulation and oversight of technological service providers in the financial sector.

3. **Reliability of electricity and mobile network:** despite the recent improvement in mobile penetration and rural electrification, unreliable mobile networks and electricity supply are seen as major bottlenecks in expanding MM services, particularly in rural parts of the country.
4. **Capacity:** NBE's supervisory departments (banks and microfinance) have limited capacity to design new directives and approve new financial products.

Staff of utility providers (EEU, AAWSA and Ethio Telecom) reported that there is demand from all the utility companies to adopt digital payment systems, including the use of MM to collect payments from customers. For instance, EEU is assessing its clients' access to bank accounts in order to use a debit order payment system, in collaboration with the Commercial Bank of Ethiopia. However, no concrete steps have been taken towards incorporating mobile money in the utility payment systems in any of the companies. Moreover, there is no clear procedure for engaging payment technology providers and financial institutions. According to our interviews, the main reasons for this are:

1. **Coordination and cooperation:** a lack of coordination and cooperation among financial institutions such as banks and MFIs reportedly hampers the development and adoption of digital payment systems for bill collection.
2. **Capacity:** EEU and AAWSA stated that they currently lack the human resources and the ICT infrastructure to integrate digital payments into their utility payment systems.
3. **Cost:** procuring, installing and maintaining digital payment systems is perceived as entailing a high cost, whether they are hosted in-house or outsourced.
4. **Regulation:** all the staff we interviewed stated that NBE's strict regulatory requirements for banks and MFIs make collaboration between companies to incorporate digital payment challenging. The lack of clear and well-defined regulations on digital payment systems was mentioned as a major challenge. Issuing an electronic receipt for clients as evidence of payment was also reported as a challenge.
5. **Threshold amounts for mobile money:** the current threshold of 6 000 Birr for daily transactions excludes utility company customers from using mobile money to settle their payments.¹⁶
6. **Internet and electricity network:** There is a fear that during electricity and internet outages, the utility providers will be unable to collect payments from customers (both pre-paid and post-paid service users) and that this will lead to loss of revenues.

Discussions of the findings with MOSS ICT revealed that utility companies tend to overestimate the requirements, in terms of infrastructure and human capital, for using mobile money. In the view of MOSS

¹⁶According to the Regulation of Mobile and Agent Banking Service Directive (Directive No FIS/01/2012), the total balance in a mobile account shall not exceed Birr 25 000 and daily mobile banking transactions shall not exceed Birr 6 000.

ICT, a number of the concerns raised by the utility companies either do not apply or could be easily overcome. This apparent knowledge gap could be addressed by financial institutions reaching out to utility providers and other companies to provide information on the underlying requirements.

Expanding MM requires actions from the relevant authorities, specifically NBE, regulatory reforms and a revision of the current directives, to allow for new financial products. The timely amendment of financial proclamations and directives, as well improvements in interoperability, should be key priorities. The provision of an effective and efficient MM payment system also requires reliable interbank and telecommunications infrastructure. Thus, Ethio Telecom and NBE should work towards ensuring that payment systems are interoperable. This also requires close coordination among the financial institutions.

Conclusions

This study presents evidence of the potential demand for using MM for utility bill payments in urban areas of Ethiopia. The evidence highlights the significant potential take-up (about 93.1%) at the current market price of 4.5 Birr, suggesting the viability of an alternative payment method for settling utility bills. We estimate that households are willing to pay up to 15 Birr per month, on average, to use MM for paying for their utilities. This amount is higher than the market price charged by MM services such as M-BIRR for processing payments for goods and services. The positive difference between the average willingness to pay and the market price highlights the potential profitability for financial institutions of providing MM services for UBPs. Our results also show that the demand is highly sensitive to price changes. Similarly, the potential take-up of the new payment method is influenced by the socio-economic characteristics of households.

Comparing the average WTP estimate and the current cost, our findings show a welfare gain from using MM for UBPs. This suggests that it would be viable to use MM in processing payments for utilities. Hence, both MM service and utility providers should take steps to meet the potential demand and benefit from the opportunities. A comprehensive cost-benefit analysis requires a more in-depth study. We would suggest a randomised control trial study of the WTP, against an actual offer to receive the service. A randomised control trial study could also look at the impact of MM services on household welfare.

Finally, there are legal, regulatory and structural challenges to the development of MM in Ethiopia. These challenges relate both to the policy environment and to the capacity of other stakeholders (such as the utility service providers). Addressing these challenges would require action from the public and private sectors. Partnership between the public and private sectors is particularly important in Ethiopia, where public institutions are the sole providers of utilities such as water and electricity.

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Appendices

Appendix 1: Summary statistics of key variables by MM use

	MM non-user	MM user	Total
Socio-demographic characteristics			
Age of the household head	40.42 (14.09)	36.07 (14.08)	38.23 (14.23)
Female-headed household	0.272 (0.446)	0.193 (0.396)	0.232 (0.423)
Illiterate	0.0561 (0.231)	0.0558 (0.230)	0.0560 (0.230)
Primary	0.112 (0.316)	0.0609 (0.240)	0.0865 (0.281)
Secondary	0.490 (0.501)	0.244 (0.430)	0.366 (0.482)
Diploma	0.143 (0.351)	0.203 (0.403)	0.173 (0.379)
Degree and above	0.199 (0.400)	0.437 (0.497)	0.318 (0.466)
Household size	3.806 (1.941)	4.345 (1.957)	4.076 (1.965)
Proportion of poor households	20.68 (15.32)	14.94 (12.15)	17.80 (14.10)
Utility use			
Household has electricity meter	0.696 (0.461)	0.561 (0.498)	0.628 (0.484)
Household has water meter	0.703 (0.458)	0.541 (0.500)	0.621 (0.486)
Household has fixed telephone	0.177 (0.383)	0.167 (0.374)	0.171 (0.377)
Travel time from home to the electricity payment centre	30.17 (31.75)	22.27 (17.29)	25.92 (25.28)
Travel time from home to the water payment centre	27.18 (24.63)	20.82 (16.69)	23.76 (20.94)
Travel time from home to the fixed telephone payment centre	17.73 (9.62)	18.83 (11.46)	18.49 (10.89)
Processing time at 'Lehulu' centre	30.23 (22.91)	25.47 (17.51)	27.91 (20.51)
Processing time at utility branch office	31.15 (21.20)	26.19 (19.47)	28.80 (20.48)
Pays electricity bill monthly (1=yes)	0.859 (0.349)	0.927 (0.261)	0.890 (0.314)
Pays water bill monthly (1=yes)	0.876 (0.331)	0.943 (0.232)	0.905 (0.293)
Pays fixed telephone bill monthly (1=yes)	1 (0)	0.903 (0.301)	0.950 (0.220)
Financial access, awareness and literacy			
Household has a bank account	0.821 (0.384)	0.964 (0.186)	0.893 (0.309)
Household has an MFI account	0.135 (0.342)	0.513 (0.501)	0.326 (0.469)
Household member of 'Iddir'	0.653 (0.477)	0.503 (0.501)	0.578 (0.495)
Household member of 'Equb'	0.508 (0.501)	0.604 (0.490)	0.556 (0.497)
Household knows MM service available in the city	0.632 (0.484)	0.995 (0.0716)	0.820 (0.385)
Financial literacy score (Maximum score=4)	2.495	2.873	2.684

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	(0.826)	(0.808)	(0.837)
Trust MM for remittances	0.760	0.883	0.822
	(0.428)	(0.322)	(0.383)
Trust a stranger for remittances	0.215	0.137	0.175
	(0.412)	(0.345)	(0.381)
Trust a friend for remittances	0.528	0.523	0.526
	(0.500)	(0.501)	(0.499)
Trust banks for remittances	1	0.995	0.997
	(0)	(0.071)	(0.050)
Mobile phone ownership and use			
Household has mobile phone	0.974	0.995	0.985
	(0.158)	(0.0712)	(0.123)
At least one other household member owns a mobile phone	0.856	0.827	0.842
	(0.352)	(0.379)	(0.365)
Used the mobile phone for:			
Making calls	0.979	1	0.990
	(0.144)	(0)	(0.101)
Receiving calls	1	1	1
	(0)	(0)	(0)
Sending texts	0.781	0.979	0.882
	(0.415)	(0.142)	(0.323)
Receiving texts	0.989	1	0.995
	(0.102)	(0)	(0.0719)
Internet browsing/Facebook use	0.482	0.827	0.657
	(0.501)	(0.379)	(0.475)
Listening to FM radio	0.628	0.772	0.701
	(0.485)	(0.421)	(0.458)
Transferring money or making payments	0.136	0.746	0.446
	(0.344)	(0.436)	(0.498)
Location			
Addis Ababa	.5	.53	.52
	(.50)	(.50)	(.50)
Halaba	.11	.12	.12
	(.32)	(.33)	(.32)
Hawassa	.39	.35	.36
	(.49)	(.48)	(.48)
Number of observations	196	197	393

Mean values; standard deviation in parentheses

Appendix 2: Estimating WTP based on RUM framework

The following shows the computation of expected WTP based on the RUM framework, as in Hanemann (1984). Given our CV question, “*Would you be WTP \$x, B, for the new commodity?*”, the individual answers ‘yes’ if:

$$u_{i1}(m, y - B, X, \varepsilon) \geq u_{i0}(y, X, \varepsilon) \quad (\text{a1})$$

Formally, the probability that the consumer responds ‘yes’ is:

$$\Pr(\text{yes}) = \Pr(u_{i1}(m, y - B, X, \varepsilon) \geq u_{i0}(y, X, \varepsilon)) \quad (\text{a2})$$

$$\Pr(\text{yes}) = \Pr(v_{i1}(m, y - B, X) + \varepsilon_{i1} \geq v_{i2}(m, y, X) + \varepsilon_{i2}) \quad (\text{a3})$$

$$\Pr(\text{yes}) = \Pr(\Delta v + \varepsilon \geq 0) \equiv F_{\varepsilon}(\Delta v) \quad (\text{a4})$$

Let $F_{\varepsilon}(\cdot)$ be the CDF of $\varepsilon = \varepsilon_{i1} - \varepsilon_{i0}$ and $\Delta v = v_{i1}(\cdot) - v_{i0}(\cdot)$. The expected value of WTP can be computed as follows:

$$E(WTP) = \int_0^{\infty} F_{\varepsilon}(\Delta v(B)) dB - \int_{-\infty}^0 1 - F_{\varepsilon}(\Delta v(B)) dB \quad (\text{a5})$$

Assuming a linear income utility function (constant income elasticity):

$$v_{ij} = a_j + \beta y \quad (\text{a6})$$

Where a_j is the intercept and β is the marginal utility of income. Hence, the change in utility denoted as θ :

$$\theta = \Delta v = \alpha - \beta B \quad (\text{a7})$$

Where $\alpha = \alpha_1 - \alpha_0$ and choosing an F_{ε} to be a normal distribution with mean zero. The expected value of WTP can be computed as follows:

$$\begin{aligned} E(WTP) &= \int_{-\infty}^{\infty} B f_{\varepsilon}(\Delta v(B)) \frac{\partial v}{\partial y} dB \quad (\text{a8}) \\ &= \int_{-\infty}^{\infty} B f_{\varepsilon}(\Delta v(B)) dB = \int_{-\infty}^{\infty} \left(\frac{\theta - \alpha}{-\beta} \right) f_{\varepsilon}(\theta) d\theta \\ &= -\frac{1}{\beta} \int_{-\infty}^{\infty} (\theta - \alpha) f_{\varepsilon}(\theta) d\theta = \frac{\alpha}{\beta} \int_{-\infty}^{\infty} f_{\varepsilon}(\theta) d\theta - \int_{-\infty}^{\infty} (\theta) f_{\varepsilon}(\theta) d\theta \\ &= \frac{\alpha}{\beta} \end{aligned}$$

poa! Internet: Community internet in low-income areas of Kenya

Expert Advisors: Arianna Legovini and Alexandros Sarris

Headline impacts

- Improved access to unlimited data has changed the way students and teachers use the internet for teaching and learning.
- Students using poa! Internet at school are more likely to benefit from ICT training during school hours and made more use of the internet for private purposes, including accessing educational content.
- However, there was no evidence that the internet was being used to enhance learning outside of ICT training. Improvements in school ICT infrastructure may be needed to translate better internet access into enhanced student achievement.

Company overview

poa! internet provides wireless broadband in low-income communities in Kenya. The service is delivered through a Wi-Fi network, and this technology has allowed *poa!* to bring more affordable internet access to underserved individuals and small businesses. *poa!* offers both public “street” internet access and internet in the home. Customers receive unlimited data packages, free content and access to online services such as job boards and marketplaces. *poa!* also provides free internet access to selected community institutions, including schools, in return for these facilities hosting the infrastructure used to provide the street service.

Poa International Limited is a portfolio company of Novastar, a venture catalyst firm that has received investment from CDC’s Impact Fund and the European Investment Bank’s Impact Financing Envelope.

Summary

poa! internet is a low-cost internet service provider serving individuals, households and small businesses in poor and underserved communities in Kenya. *poa!* provides its services via Wi-Fi, which reduces the cost of providing mobile data coverage. This allows *poa!* to offer internet packages at lower prices than leading mobile operators and to make its service available in places that other technologies can’t reach or which operators have chosen not to serve. In order to provide its public “street” internet service to customers out and about in their communities, *poa!* uses large-scale Wi-Fi infrastructure, which must be installed on top of relatively high buildings. In return for hosting this infrastructure, *poa!* provides free internet to the

Community internet in low-income areas of Kenya

“social hosts” that own these buildings, many of which are schools. By 2018, the company was providing services to 23 partner schools in Kibera, Nairobi.

The main findings of the qualitative and quantitative research underlying this deep dive are:

- Improved access to unlimited data has changed the way students and teachers use the internet for teaching and learning.
- Students in poa!’s partner schools are more likely than their peers in comparable schools to benefit from ICT training during school hours, and made more use of internet for private purposes, including accessing educational content.
- There is considerable enthusiasm for greater use of the internet to deliver and access educational content. Students are most interested in scientific and numeracy/mathematical content.
- However, there was little evidence that the internet was, in practice, being used to enhance learning in a classroom context, outside of formal ICT training. The study found no evidence that provision of poa! internet had increased the probability that students received educational internet content at school. Nor were they more likely to report improved general ICT-related skills and knowledge.

Because poa! did not select its partner schools randomly, it is difficult to make causal inferences about the impacts of *poa!’s* schools service. However, the analysis does control for observable student characteristics, and the results have provided useful lessons for *poa!* to follow up as it expands. First, the results suggest that there are limitations in translating the provision of *poa!* internet into improved use of internet for educational purposes, and thus into improved student outcomes. Discussions with poa! staff and school management indicate that this reflects a lack of complementary capacity and infrastructure in the schools. Schools need a sufficient number of computers or other devices if students are to access the internet as a learning tool – currently many can access only for a few minutes at break times or after class. Teachers also need to be trained in how to bring the internet into their teaching in an effective way. Furthermore, school management needs the appropriate capacity to keep an ICT system functioning well.

poa! is expanding and adapting its services. It is currently expanding the number of Wi-Fi hotspots to improve coverage of the poa! street service. This will reduce their need for partners to host their infrastructure. However, this study has demonstrated that schools and students appreciate and are benefiting from poa!’s free service. This contributes to raising the company’s profile and reputation in the communities, which will remain important as it expands to new areas in Kenya. Responding to these findings, poa!’s management is seeking ways to continue developing its schools service. They are considering partnerships with NGOs and other philanthropic organisations: these could help to cover some of the ICT infrastructure and capacity needs of the schools. This could catalyse an even greater impact for schools and students in these underserved communities.

Introduction

The 2030 Agenda for Sustainable Development recognises the central importance of access to ICT for development with a specific target, 9.C: “Significantly increase access to information and communications technology and strive to provide universal and affordable access to the internet in least developed countries by 2020.” The importance of education for development is also recognised, in particular under Sustainable Development Goal (SDG) 4: *Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities for All*. In this context many developing countries, including Kenya, are

looking not only to expand access to ICT, but also to use the increased internet access to catalyse increased access to information for the education sector and improve the achievement of Kenya's children.

poa! internet provides low-cost and unlimited internet services to individuals, households and small businesses in relatively poor and underserved communities in Kenya. In 2016, *poa!* internet began providing free and unlimited internet access to a number of partner schools in Kibera, a large informal settlement in Nairobi. A *poa!* router is placed on the roof of the schools and is then used to provide wireless internet services – *poa!*'s "street" service – to paying customers in the surrounding community. *poa!* is expanding to other parts of the country and is considering providing similar internet services to schools in Kiambu County. This study investigates whether providing free and unlimited internet access to schools in Nairobi has changed the use of related ICT services, leading to higher ICT use and improved educational outcomes among students.

This study was carried out in May/June 2018 in seven public and private schools in Nairobi County that have been partnering with *poa!* internet since May/June 2016. In addition, 13 private and public schools in Kiambu and Nairobi that have not received support but are potential partners for *poa!* in the near future were selected to serve as a comparison group.

The research seeks to deepen understanding of the impacts of the uptake and use of *poa!* internet on: (1) children's educational practice outcomes such as internet skills and knowledge; (2) school attendance and participation in education; (3) children's ICT skills and knowledge. The results from the study will provide information to *poa!* internet and other stakeholders that will enable them to plan for improved services and respond to the needs of the ICT sector in Kenya.

The Link between Internet Use and Socio-economic Development

Understanding the link between ICT use and educational outcomes in a developing country context is important for two main reasons. Firstly, use of ICT can directly contribute to improving teaching and learning. For instance, teachers and school authorities can use the internet as a resource to find teaching and learning materials for use in and out of the classroom. This may be particularly relevant in developing countries where the quality of teaching is often poor and access to pedagogical materials is limited. Secondly, access to ICT could support student outcomes indirectly, for example by making schools more appealing to students and thus increasing enrolment and attendance (see Banerjee et al., (2007)).

Evidence on the impact of ICT use on educational outcomes is mixed. Using a randomised evaluation, Banerjee et al., (2007) found that "computer-assisted learning programs focusing on math increased math test scores in India". Attewell and Battle (1999) found that student use of computers at home is associated with higher test scores in mathematics and literacy. However, other studies have found no positive impacts of investment in educational technology on test scores. According to Angrist and Lavy (2002), there is limited evidence (based on short-term effects) that higher investment in education technology (including internet access) in the US in the 1990s led to improvements in the academic performance of students. Using both ordinary least squares (OLS) and instrumental variable (IV) methods they also found that while the introduction of computers in schools in Israel increased the use of computer-aided instruction by teachers, this did not translate into better educational outcomes.

One of the reasons that the findings are mixed is due to the lack of an adequate ICT environment, including suitable devices (e.g. smartphones, computers and tablets) and educational contents. Lu et al. (2015) found that the use of ICT-supported courses and multimedia classrooms in primary and middle schools in rural

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China depends on the availability of an effective ICT infrastructure. In other words, internet provision is unlikely to achieve its maximum impact unless it is part of a larger investment in education technology.

The availability of *poa!* internet in schools could impact on students indirectly through other changes in socio-economic development indicators. A survey of the literature by Castellacci and Tveito (2018) finds evidence that, among the positive benefits of internet use are more efficient use of time, increased access to information on labour market participation, consumption of new products, and greater knowledge on health and education. The possible negative impacts include addiction, and an increase in gambling and pornography. Research indicates that internet use can also influence health outcomes, including mental health, and can cause psychosocial problems (see Işık and Alkaya (2017) and Choi et al., (2017)). All of these factors could influence student outcomes.

Other indirect linkages may influence education at the level of schools or local government. For example, access to ICT and internet in particular may also influence political engagement. Tolbert and McNeal (2003), using a multivariate analysis, found that access to the internet and online election news coverage increases the probability of voting in presidential elections in the US. On the other hand, Falck et al. (2014) found that access to high-speed internet services is positively associated with entertainment consumption in Germany; using an instrumental variable approach, they found that internet availability is negatively associated with voter turnout. Finally, there is some evidence of the potential for ICT use to help address the challenge of corruption: Kanyam et al. (2017), using panel data analysis techniques, found that internet and mobile phone penetration have reduced corruption in sub-Saharan Africa.

This study focuses on short-term student outcomes, mainly related to educational practice, that are measurable and achievable within the timeframe of the study. Longer-term outcomes and impacts (for example, improved test scores among students) are left for future research. In this light, the study examines whether, relative to the students in the comparison group, students in *poa!*'s partner schools for internet use will:

1. Demonstrate superior internet skills and knowledge;
2. Miss fewer days of school;
3. Report better access to online teaching and learning materials;
4. Demonstrate superior computer and other ICT-related skills and knowledge.

These are the variables that this study has in mind when “student outcomes” are mentioned.

Methodology

Analytical framework

poa! internet has installed Wi-Fi routers in selected schools in low-income areas of Nairobi and has been providing unlimited data to them since May 2016. Because *poa!* partners only with selected schools, differences in levels of internet access and usage across schools within similar areas enable us to identify the effects of internet provision on various measures of student outcomes such as internet skills. This is done by comparing outcomes for students studying in a selection of *poa!*'s partner schools (the “treatment” group) and students in other schools (the “comparison” group). The study controls for observable differences between the two groups using Inverse Probability Weighting (IPW).

Because *poa!* did not select its partner schools randomly, it is impossible to rule out bias in the results caused by unobserved differences between the treatment and comparison groups. However, under plausible assumptions, the quasi-experimental cluster design used in this study would control also for unobservable differences between the groups. The comparison schools were selected from among a set of “pipeline” schools that *poa!* had already identified as potential future partners, and which might be expected to be similar to the existing partners. Under certain assumptions about the way that *poa!* selects its partners and the nature of the pipeline (described below), the situation is similar to a “natural experiment”. However, there are a number of reasons why these assumptions may fail, so the results cannot be given a causal interpretation.

The basic empirical specification for estimating the effects of internet provision on student outcomes is as follows:

$$E_{ij} = \beta_0 + \beta_1 P_j + \beta_2 X_i^C + \beta_3 X_i^{HH} + \beta_4 X_i^S + \varepsilon_{ij} \quad (1)$$

where E_{ij} denotes a student outcome of interest, mainly related to educational practice, of child i in school j , and P_j is a dummy variable which denotes the provision of the *poa!* internet service in school j . X_i^C are student-specific indicators (age, gender, academic performance, etc.), X_i^{HH} are household level characteristics (location of household, access to ICT, etc.), X_i^S are school-specific characteristics (age and gender of school respondent, etc.) and ε_{ij} is the error term. Robust standard errors are reported throughout. The parameter of interest is β_1 , which, under certain assumptions, would represent the impact of *poa!* internet provision on student outcomes.

However, because *poa!* did not select its partner schools randomly, there may be differences between the two groups which are related to the outcomes of interest. Failure to take these differences into account would lead to biased estimates of β_1 relative to the “true” impact of internet provision. The study therefore uses a variety of variables, represented in equation (1) by X_i^C , X_i^{HH} and X_i^S , to isolate β_1 from other characteristics which may also affect E_{ij} . The estimation is implemented via IPW. As a robustness check, Propensity Score Matching (PSM) is also used to ensure that the average characteristics of the treatment and comparison groups are similar. PSM also relies on observable characteristics to generate a propensity score, which is used to match treatment students with similar comparison students.¹ The study also undertakes a heterogeneous treatment effect analysis of the outcome measures, testing for differing effects depending on the gender of students.

Unobserved differences between the two groups could include, for example, the motivation levels of the students or teachers. Such unobserved differences, if they are correlated with student outcomes, could lead to endogeneity bias: the estimated parameter β_1 would either understate or overstate the “true impact” of internet provision. In equation (1), the unobserved characteristics would be captured in the error term, ε_{ij} , biasing the parameter β_1 upwards or downwards depending on the direction of the correlation with the dummy variable P_j .

The way in which *poa!* selected its partner schools and the use of “pipeline” schools as a comparison group could be argued to eliminate this endogeneity bias. The main criterion used by *poa!* to select partner schools was geographic location (within the neighbourhood of Kibera), which had to be suitable for hosting

¹ Two schools which could be expected to differ significantly from the treatment group (a vocational school and a school for students with disabilities) were excluded from the main sample for the estimates.

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of Wi-Fi infrastructure. If i) this was the only criterion for school selection and ii) location is not correlated with unobservable variables such as student or teacher motivation, then we could consider the provision of *poa!* internet to have been “as good as randomly assigned”, making this case akin to a “natural experiment”.² Under these assumptions, β_1 would provide an unbiased estimate of *poa!*’s impact. Discussions with *poa!* confirmed that they made the initial selection of potential partners based purely on geography, identifying schools from a map of the area, that all the schools contacted were willing to take up the partnership opportunity, and that there was no attrition of schools from the partnership once accepted. In addition, the study uses “pipeline” schools as the comparison groups. These were schools that *poa!* had identified as potential partners. These potential partners may be expected to be very similar to the first wave of *poa!* partner schools, including on relevant unobservables.

All of these factors make it more likely that the assumptions described above hold. However, we cannot conclusively rule out the influence of unobservables on the estimates. In particular, *poa!* confirmed that school partnerships were only initiated if *poa!* representatives were able to find an appropriate school leader on the premises at the time of their visit. In cases where no senior member of staff could be found, the schools usually missed the chance to participate – some of these schools may be among the pipeline comparison schools. It is possible that there are unobservable differences between those schools and the schools that did partner with *poa!* in the first wave, for example that the leaders of the *poa!* partner schools had higher levels of motivation, which is why they were found on campus at the time of the initial visit. Furthermore, the decision of students to sign up for and attend particular schools is not exogenous. It is possible that, for example, more motivated or able students signed up to attend schools that receive free internet from *poa!*, either as a result of the service provision, or because of unobserved characteristics of the schools. Overall, we cannot conclude that the parameter β_1 will provide an unbiased estimate of *poa!*’s causal impact.

Sampling, instrument design and data collection

The sample frame consisted of seven *poa!* partners and 13 comparison schools located in Kawangware and Kibera in Nairobi, and in Kiambu County. These included both primary and secondary schools, one vocational school and one special-needs school. At the time of the survey, *poa!* partner schools had been accessing and using *poa!* internet services for between two years and six months, and six out of seven had no internet connection prior to this partnership. The comparison schools selected for the sample were schools that *poa!* internet plans to partner with in the near future. This approach was taken in order to justify the quasi-experimental design. In addition, because those schools had already established a relationship with *poa!* internet staff, this made it easier to organise the structured interviews.

The standard data collection was carried out in 18 schools. In the selected primary schools, students from standards six to eight were targeted for interviews, while in the secondary schools the study targeted all the students in form one to four. In each selected school and grade, a near equal sample of boys and girls was randomly selected for the structured interviews, through a ballot process. In each school, a total of 20 students were selected.

The student survey covered 404 students: 183 boys and 221 girls. Table 1 presents the sample frames and observational counts for the school authority and student surveys. As indicated earlier, data collection was

² https://dimewiki.worldbank.org/wiki/Quasi-Experimental_Methods

undertaken in 20 educational institutions in Nairobi and Kiambu: 12 private and eight public. However, one school was too busy with other activities to participate in the school-level survey.

Table 1: Sample Frames and Numbers of Observations

Sample Frame			
	Educational institutions	Students	
<i>poa!</i> partner schools	7	144	
Comparison schools	13	260	
Total	20	404	
Numbers of observations			
	<i>poa!</i> partner schools	Comparison schools	Total
Boys	54	129	183
Girls	90	131	221
Total	144	260	404
Private	103	140	243
Public	41	120	161
Total	144	260	404

Source: Author's computations from *poa!* internet data.

The study relies on self-reported measures of internet-related activities and other variables collected via structured interviews using two instruments: (1) student questionnaires and (2) school authority questionnaires.

Student questionnaires were designed to collect information on children's socio-economic characteristics and ICT-related activities, including questions about access to ICT services at home. The study used internationally standardised questions on internet activities including those from questionnaires generated by the International Telecommunication Union (ITU) and other published studies (for example, van Deursen et al., 2015). The instrument also included a series of real and hypothetical questions on the types and dissemination of educational content. For instance, respondents were asked to select the types of educational content they would be interested in, including questions on scientific, technological, literacy/reading, numeracy/mathematical and social content, among others.

The school authority questionnaire was designed to solicit information on school demographics and ICT-related activities. Data on ICT-related activities were collected through a series of internationally standardised questions generated by the ITU and other published studies. The school-level interviews were directed at the vice-principal and/or ICT manager, as these are in charge of dealing with institutions providing educational support to the schools. The ICT managers are responsible for computer labs and internet services at the schools.

The survey team consisted of 11 enumerators (seven female and four male) from a local university and from the team of Acumen Lean Data (a private research firm) in Kenya. A training workshop, lasting around four hours, was conducted in Nairobi on 23 May 2018. Enumerators studied the questionnaires section-by-section and took part in a role play to demonstrate how to administer the survey instruments.

The survey instruments were pre-tested in a primary school in Kawangware on 25 May 2018. Issues identified during the training and pre-testing were used to refine the survey instruments. The number of questions was cut to reduce the burden for the respondents and minimise disruption to academic activities.

Data collection commenced on 28 May 2018 and ended on 6 June 2018, over a total of six school days. The structured interviews were conducted in Swahili or English, depending on the language the student was

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most comfortable with. The responses were recorded in English on the paper questionnaires administered to the respondents. The data enumerators were supported by *poa!* internet staff who liaised with the school authorities. While school authorities were given advanced warning about the exercise, the survey instruments were not shared with them beforehand to maintain the authenticity of their responses.

Econometric approach

The study uses the IPW method to estimate the effects of uptake and use of *poa!* internet on students' internet use and training, controlling for student and school characteristics. Both average treatment effect on the treated (ATET) and average treatment effect (ATE) are estimated. The preferred estimator is the ATE, which is the mean difference of the outcome measures between the treatment students and that of the comparison students.

In addition, a robustness check using PSM with nearest neighbour of four (NN4) was undertaken to check the stability of the estimated results for the IPW method. The study uses a probit regression for the treatment assignment equation and reports independent and identically distributed Abadie-Imbens standard errors. The same controls as in the IPW method were included in the PSM method. The study finds that the regression results from the IPW method do not differ significantly from the estimates from the PSM method.

Results

Knowledge and Use

Based on Table 2, 73% of students in *poa!* partner schools were aware of the *poa!* brand, compared to 45% of their counterparts in the comparison schools. However, only around 41% of students in the partner schools were aware that *poa!* internet had been installed in their schools (9.3% of the students in comparison schools mistakenly believed the same). There is evidence that the schools service may be helping *poa!* to raise its profile, but the limited awareness of students in partner schools of the role of *poa!* in providing free internet indicates a possible missed opportunity for *poa!* to earn goodwill in the communities where it operates.

Table 2: Knowledge and sources of knowledge of *poa!* internet

Items	Frequency	Percent	Frequency	Percent	Frequency	Percent
Has heard of <i>poa!</i> internet						
Response	All		Poa! partner schools		Comparison schools	
Yes	223	55.20	105	72.92	118	45.38
No	181	44.80	39	27.08	142	54.62
Total	404	100.00	144	100.00	260	100.00
Knows that <i>poa!</i> internet has been provided in the school						
Yes	54	24.22	43	40.95	11	9.32
No	169	75.78	62	59.05	107	90.68
Total	223	100.00	105	100.00	118	100.00

Source: *poa!* internet student survey, 2018. The indicator "sources of knowledge of *poa!* internet" has multiple responses so percentage responses are reported.

The extent to which students in *poa!* partner schools access the service will be affected by a variety of socio-economic and environmental factors, including school ICT infrastructure, and household and individual characteristics. An in-depth interview during the field trip to Nairobi provided this response:

“Due to time and resource constraints, students mainly download articles and print from the computer labs. In future, the school needs more computers for teachers to undertake research” (Vice-principal, Olympic High School, Nairobi).

The survey revealed that about 26% of the 223 students who had heard of *poa!* internet had used the service themselves. In the *poa!* partner schools, about 41% of the students had used *poa!* internet, while in the comparison schools only 12.7% had used it. The usage among comparison schools shows the possibility of contamination of the treatment assignment and therefore the estimated treatment effects are in the lower bound.

Table 3: Usage of *poa!* internet

Had used <i>poa!</i> internet	Frequency	Percent	Frequency	Percent	Frequency	Percent
Response	All		<i>Poa!</i> partner schools		Comparison schools	
Yes	58	26.01	43	40.95	15	12.71
No	165	73.99	62	59.05	103	87.29
Total	223	100.00	105	100.00	118	100.00

Source: *poa!* internet student survey, 2018.

Perceived Benefits

The benefit most commonly reported by school authorities was improved internet availability (all schools) followed by improved access to information (six out of seven schools). Improved availability of teaching and learning materials, and the uptake of online resources for teaching and learning were reported by four schools. Improved communication between students and teachers was reported by only one school.

School authorities were also asked their opinions on the benefits of *poa!* internet providing unlimited data, rather than the limited internet “bundles” available from alternative providers, using an open-ended question. The observations included: *“freedom to search for anything without limitation”*; *“gives access to more information”*; *“gives room to use it for a long period of time”*; *“one can access any site without restriction”*; and *“unlimited access to the internet”*.

Box 1: Use of *poa!* internet in Olympic High School

*The school, before receiving *poa!* internet, used to rely on a modem from other internet service providers. *poa!* internet is used at one of the school blocks whilst the other block uses internet from other service providers (e.g. Safaricom). Internet is used in the computer labs but not in the classrooms.*

**poa!* internet is used to undertake research in all subjects. *poa!* internet provided consultancy on how to install anti-virus and updating software for the computer labs. Currently, 18 out of the 26 computers are fully operational. *poa!* internet is cheap and fast. ICT including internet is used by students to undertake project work. Students use internet in order to get high scores/marks during examinations both at school and national levels.*

(Vice-Principal, Olympic High School, Nairobi)

Box 2: Use of poa! internet in Kibera Girls Soccer Academy

Currently, poa! internet provides unlimited data bundle. Moving to unlimited data has led to behavioural change, particularly on how the internet is used for teaching and learning. The school uses the internet for a number of teaching and learning activities. For instance, it is a hosting centre for Nairobi (a course undertaken in Kenya). The internet is used for graphic design. In the evening, the internet is used to access revision questions for KCC [national exams]. The internet is also used to stream online videos on how to learn photography. There are plans to use the internet to access the online syllabus developed by a local company called ELEWA. Internet usage during school hours is regulated by blocking non-academic sites. In addition, students are advised on moral issues, including not using the internet for entertainment during school hours.

(Key informant, Kibera Girls Soccer Academy, Nairobi)

From the perspective of the students, Table 4 indicates that the main benefit of poa! internet in schools is improved (i) internet accessibility (60.5%), (ii) access to information (51.2%), (iii) availability of teaching and learning materials (44.2%), and (iv) communication between teachers and students (23.3%). Around 21% of the students reported no effect on internet access in their schools.

Table 4: Benefits of poa! internet on school internet access

How poa! internet in schools has affected school internet access	Frequency	Percent
Has improved internet accessibility	26	60.47
Has encouraged the introduction of online courses	4	9.30
Has improved the availability of teaching and learning materials	19	44.19
Has improved communication between teachers and students	10	23.26
Has encouraged the use of the internet for teaching and learning	9	20.93
Has improved access to information	22	51.16
Other	2	4.65
No effect/impact	9	20.93
Total	101	234.88

Source: poa! internet student survey, 2018. This indicator has multiple responses, so the percentages will not sum to 100%.

Customer satisfaction

poa!’s school service was provided for free and the majority of school authorities reported that they would recommend partnering with poa! to other schools. On a 10-point scale, with 10 being extremely likely, five out of the seven schools gave a score of seven or above. Two respondents gave a score of five. However, satisfaction levels among school authorities were not high. Two out of the seven poa! partner schools rated their experience of using poa! internet as 7 (on a scale of 1-10), three schools gave a score of 5 and two schools a score of 4.

Reported sources of dissatisfaction were the speed of *poa!* internet, the reliability of the service and the equipment provided. In each case, four of the seven schools reported being either dissatisfied or very dissatisfied. Problems were also reported with the installation process, with two schools reporting that the installation process had been difficult, while the other schools were either neutral or positive about the installation process.

Five out of the seven *poa!* partner schools had experienced challenges using *poa!* internet, including in the weeks before the survey was implemented. The challenges reported included: *“does not open some sites”*; *“lengthy authentication process”*; *“low speed”*; *“slow”*; *“sometimes it disappeared completely”*; and *“the internet was too slow”*. One of the schools that experienced challenges was satisfied with the support received from *poa!* internet in addressing them, whereas one was dissatisfied and the other did not answer. Four out of the five *poa!* partner schools that had experienced challenges had received some training on how to resolve them.

The in-depth interviews during the field trip to Nairobi provided the following insights on the challenges with *poa!* internet:

“The main challenge for using poa! internet is limited access in some parts of the school [i.e. the signal gets lost in some of the rooms]. For instance, teachers in their office are not able to access the internet. This is based on the fact that the routers provide internet access to a particular point but not to the entire school compound.” (Key Informant, Kibera Girls Soccer Academy, Nairobi)

“Major challenges with poa! internet include weak signal in some of the blocks/classrooms. It is difficult for paid individuals/customers to access the internet in some parts of the compound during school hours.” (Vice-principal, Olympic High School, Nairobi).

When asked about things that *poa!* internet could do to improve its services, the respondents provided some of the following suggestions: *“check on the speed of the internet”*; *“encourage them to use fibre [optic cables]”*; *“have monthly visit to the clients to solve technical issues”*; *“improve on speed”*; *“increase bandwidth”*; *“increase coverage”*; *“increase router size [coverage]”*; *“provide routers”*; *“shorten access procedures”*; and *“sponsor some needy students”*.

Impacts on student outcomes

Summary Statistics

The treatment and control groups differ significantly in a number of ways (Table 5). The students in *poa!* schools are older, on average, than the comparison group, and slightly worse off, as reflected by lower ownership of key household assets. They also live in larger households. They report higher expenditure on education. This may be related to their age, as the cost of schooling tends to increase as students progress through the grades. They travel slightly further to school. The students in *poa!* partner schools are less confident of their own academic ability than the comparison students, although this may also be correlated with their age.

The students in the *poa!* partner schools performed better against most of the indicators of access to information, ICT and internet skills, and knowledge than their counterparts in the comparison schools.

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Internet use and training

Uptake and use of *poa!* internet improves internet use among students in the *poa!* partner schools by 28.8 percentage points (standard error (s.e.) 12.2 percentage points, relative to the average value of 46.6% for the comparison students, Table 6, Panel B, Column 1). This result is robust to using PSM as the estimation strategy (Panel B, Column 2).

Table 5: Summary Statistics

Variable	Treatment students	Comparison students	Treatment – Comparison	Observations
	Mean (SD)	Mean (SD)	(SE)	
Household has a radio	0.708 (0.456)	0.796 (0.404)	-0.088 (0.044)**	404
Household has a television	0.757 (0.430)	0.888 (0.315)	-0.132 (0.037)***	404
Household has a mobile telephone	0.951 (0.216)	0.985 (0.123)	-0.033 (0.017)**	404
Household has a computer	0.201 (0.402)	0.373 (0.485)	-0.172 (0.047)***	404
Household has internet	0.549 (0.499)	0.600 (0.491)	-0.051 (0.051)	404
Student is male	0.375 (0.486)	0.496 (0.501)	-0.121 (0.051)**	404
Age of student	16.563 (3.802)	11.891 (2.011)	4.671(0.290)***	402
Student's self-reported academic performance is excellent or above average	0.444 (0.499)	0.608 (0.489)	-0.163 (0.051)***	404
Average daily school expenses (Kenya shillings)	44.206 (51.424)	15.366 (17.426)	28.840 (3.542)***	395
Minutes taken from home to reach school	24.014 (15.559)	18.542 (11.824)	5.472 (1.384)***	402
Student resides in Nairobi County	1.000 (0.000)	0.535 (0.500)	0.465 (0.042)***	403
Number of years in the school	2.923 (2.729)	3.622 (2.477)	-0.699 (0.268)***	397
Student stays with both mother and father in the same house	0.448 (0.499)	0.589 (0.493)	-0.142 (0.052)***	401
Number of household members	5.222 (2.967)	4.829 (1.729)	0.393 (0.234)*	402
Internet use in the past three months	0.688 (0.465)	0.442 (0.498)	0.245 (0.051)***	404
Number of internet activities in the last three months	3.455 (2.067)	2.191 (1.290)	1.263 (0.232)***	214
Internet knowledge is high (if percentile 50-100 of internet activities in the last three months)	0.879 (0.328)	0.670 (0.472)	0.209 (0.056)***	214
Student uses internet daily	0.242 (0.431)	0.130 (0.338)	0.112 (0.053)**	214
Student has received training on internet use during school hours	0.361 (0.482)	0.131 (0.338)	0.230 (0.041)***	404
Student has a social media account	0.451 (0.499)	0.127 (0.334)	0.324 (0.042)***	404
Number of years of internet use	2.589 (1.840)	1.997 (1.403)	0.592 (0.223)	213
Student has been absent from school during the past academic term	0.368 (0.484)	0.354 (0.479)	0.014 (0.050)	404
Student has been absent from school during the current academic term	0.285 (0.453)	0.242 (0.429)	0.042 (0.045)	404
Student has used internet for educational purposes	0.909 (0.289)	0.800 (0.402)	0.109 (0.049)**	214
Number of educational purposes student has used internet for	1.411 (0.701)	1.315 (0.645)	0.096 (0.100)	182
Internet use for educational purposes is high (if percentile 50-100 of number of educational purposes)	0.300 (0.461)	0.239 (0.429)	0.061 (0.066)	182
Student has received online educational content	0.403 (0.492)	0.185 (0.389)	0.218 (0.045)***	404
Student would like to receive online educational content	0.972 (0.165)	0.954 (0.210)	0.018 (0.020)	404
Student has used computer in the last three months	0.694 (0.462)	0.462 (0.499)	0.233 (0.051)***	404

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Number of computer-related activities in the past three months	2.390 (1.853)	1.358 (0.951)	1.032 (0.194)	220
Computer knowledge is high (if 50-100 percentile of computer-related activities)	0.550 (0.500)	0.225 (0.419)	0.325 (0.062)***	220
Student has participated in ICT education programme	0.688 (0.465)	0.477 (0.500)	0.211 (0.051)***	404
Student is either very satisfied or satisfied with current ICT use at school	0.538 (0.500)	0.436 (0.497)	0.103 (0.052)**	400

Notes. SD represents standard deviation. SE indicates standard error. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The data are unweighted. Summary statistics of each variable will be affected by missing data.

The number of students receiving internet training during school hours is 39 percentage points higher for those in *poa!* partner schools (s.e. 9.4 percentage points, relative to the average value of 10.3% for students in the comparison schools, Table 6, Panel B, Column 3). This result is also robust to using PSM as the estimation strategy (Table 6, Panel B, Column 4).

Table 6: Treatment effects of uptake and use of *poa!* internet on internet use and training

Estimation strategy	Internet use		Internet training	
	IPW (1)	PSM (2)	IPW (3)	PSM (4)
Panel A: Average treatment effect on the treated (ATET)				
Treatment students vs comparison students	0.107 (0.282)	0.110 (0.145)	0.282*** (0.054)	0.264** (0.121)
Potential outcome means				
Comparison students/Average for comparison students	0.549* (0.283)	0.442 (0.031)	0.029 (0.031)	0.131 (0.021)
Number of observations (N)	352	357	352	357
Panel B: Average treatment effect (ATE)				
Treatment students vs comparison students	0.288** (0.122)	0.343*** (0.118)	0.390*** (0.094)	0.513*** (0.105)
Potential outcome means				
Comparison students/Average for comparison students	0.466*** (0.105)	0.442 (0.031)	0.103*** (0.029)	0.131 (0.021)
Number of observations (N)	336	316	336	316

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, + $p < 0.15$. Robust standard errors reported in parentheses for IPW. Independent and identically distributed Abadie-Imbens standard errors reported in parentheses for PSM. Student controls include: student is a male, student's age, student's self-reported academic performance is excellent or above average, minutes student takes from home to reach school, student stays with both mother and father in the same dwelling, number of years the student has spent in the school, county of residence is Nairobi County, household size, household has a television, household has a mobile telephone, and household has internet at home. School controls include: school has a library, type of educational institution is a primary school, and age of respondent for school authority questionnaire.

Access to information for educational purposes

In the school authority survey, 11 out of 19 schools reported using online educational content during school hours. However, only 26.2% of the students reported using educational content as part of their school internet use. This was more common in the *poa!* partner schools, where 40% of students reported using online educational content, compared to 19% of their counterparts in comparison schools (Table 5). However, once controls for observable characteristics are included, the study finds no effect of uptake and use of *poa!* internet on students' use of educational content as part of internet use in schools (Table 7). The results are similar if the question is about future aspirations for using educational content. Based on the PSM estimation strategy, students in *poa!* partner schools receive more educational content as part of internet use during school hours (Table 7, Panel B, Column 2).

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General ICT-related skills and knowledge

Students in *poa!* partner schools are 20.6 percentage points more likely to report participating in an ICT education programme (Table 8, s.e. 11.3 percentage points, relative to average value of 56.1% for students in the comparison schools, Panel B, Column 3). The result is stable to using PSM (Table 8, Panel B, Column 4). On the other hand, uptake and use of *poa!* internet does not improve satisfaction among students with current use of ICT in school (Table 8, Panel B, Column 5).

Table 7: Treatment effects of uptake and use of *poa!* internet on access to information

Estimation strategy	Student has received educational content		Student would like to receive educational content	
	IPW (1)	PSM (2)	IPW (3)	PSM (4)
Panel A: Average treatment effect on the treated (ATET)				
Treatment students vs comparison students	-0.170 (0.293)	0.173 (0.137)	-0.019 (0.021)	-0.030 (0.041)
Potential outcome means				
Comparison students/Average for comparison students	0.523* (0.293)	0.185 (0.024)	0.986*** (0.014)	0.954 (0.013)
Number of observations (N)	352	357	352	357
Panel B: Average treatment effect (ATE)				
Treatment students vs comparison students	0.044 (0.159)	0.246** (0.116)	0.010 (0.017)	0.013 (0.038)
Potential outcome means				
Comparison students/average for comparison students	0.296** (0.138)	0.185 (0.024)	0.970*** (0.012)	0.954 (0.013)
Number of observations (N)	336	316	336	316

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, < 0.15 . Robust standard errors reported in parentheses for IPW. Independent and identically distributed Abadie-Imbens standard errors reported in parentheses for PSM. Refer to Table 6 for information on controls included in the estimation of the results.

Table 8: Treatment effects of uptake and Use of *poa!* internet on general ICT-related skills and knowledge

	Student has used computer in the last three months		Student has participated in ICT education programme		Student is either very satisfied or satisfied with current ICT use in school	
	IPW (1)	PSM (2)	IPW (3)	PSM (4)	IPW (5)	PSM (6)
Panel A: Average treatment effect on the treated (ATET)						
Treatment students vs comparison students	0.008 (0.248)	-0.018 (0.149)	-0.076 (0.185)	-0.022 (0.152)	-0.275+ (0.170)	-0.242+ (0.150)
Potential outcome means						
Comparison students/Average for comparison students	0.631** (0.247)	0.462 (0.031)	0.731*** (0.182)	0.477 (0.031)	0.762*** (0.165)	0.436 (0.031)
Number of observations (N)	352	357	352	357	348	353
Panel B: Average treatment effect (ATE)						
Treatment students vs comparison students	0.040 (0.135)	0.040 (0.130)	0.206* (0.113)	0.244** (0.124)	0.089 (0.132)	0.042 (0.134)
Potential outcome means						
Comparison students/Average for comparison students	0.527 (0.100)	0.462 (0.031)	0.561*** (0.093)	0.477 (0.031)	0.537*** (0.094)	0.436 (0.031)
Number of observations (N)	336	316	336	316	334	314

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, + < 0.15 . Robust standard errors reported in parentheses for IPW. Independent and identically distributed Abadie-Imbens standard errors reported in parentheses for PSM. Refer to Table 6 for information on controls included in the estimation of the results.

School attendance

The preferred estimator of ATE (Panel B) found no statistically significant additional effect of uptake and use of *poa!* internet on students' school attendance (Table 9, Panel B, Columns 1 and 3). The results are similar using the PSM estimation strategy (Table 9, Panel B, Columns 2 and 4).

Table 9: Treatment Effects of Uptake and Use of *poa!* internet on School Attendance

Estimation strategy	Student absent from school during the past academic term		Student absent from school during the current academic term	
	IPW (1)	PSM (2)	IPW (3)	PSM (4)
Panel A: Average treatment effect on the treated (ATET)				
Treatment students vs comparison students	0.216** (0.109)	0.238* (0.132)	0.105 (0.114)	0.108 (0.135)
Potential outcome means				
Comparison students/Average for comparison students	0.136 (0.100)	0.354 (0.030)	0.149 (0.110)	0.242 (0.027)
Number of observations (N)	352	357	352	357
Panel B: Average treatment effect (ATE)				
Treatment students vs comparison students	-0.022 (0.089)	0.056 (0.119)	0.145 (0.117)	0.124 (0.117)
Potential outcome means				
Comparison students/Average for comparison students	0.269*** (0.062)	0.354 (0.030)	0.208*** (0.050)	0.242 (0.027)
Number of observations (N)	336	316	336	316

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, + < 0.15 . Robust standard errors reported in parentheses for IPW. Independent and identically distributed Abadie-Imbens standard errors reported in parentheses for PSM. Refer to Table 6 for information on controls included in the estimation of the results.

Gender and internet use

The results in Tables 10 and 11 compare student outcomes between boys and girls within *poa!* partner schools. The results indicate that boys are more likely than girls to benefit from the *poa!* schools service. Within *poa!* partner schools, boys are 31 percentage points more likely than girls to have used the internet within the last three months, and 17 percentage points more likely to have used a computer. They are slightly less likely to report having attended internet training, but the effect is not significant. There was no significant difference between boys and girls in *poa!* schools in terms of likelihood of receipt of or wish to receive educational content, satisfaction with ICT in school, or participation in ICT training.

Table 10: Gender Differential for Internet Use and Receipt of Internet Training and Educational Content

	Internet use (1)	Internet training (2)	Student has received educational content (3)	Student would like to receive educational content (4)
Panel A: Average treatment effect on the treated (ATET)				

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Male student in poa! school compared to female student in poa! school	0.297*** (0.081)	-0.102 (0.092)	0.097 (0.094)	-0.029 (0.026)
Potential outcome means				
Comparison students	0.609*** (0.074)	0.385*** (0.075)	0.375*** (0.074)	0.991*** (0.007)
Number of observations (N)	141	141	141	141
Panel B: Average treatment effect (ATE)				
Male student in poa! school compared to female student in poa! school	0.313*** (0.065)	-0.118* (0.077)	0.127* (0.078)	-0.026 (0.033)
Potential outcome means				
Comparison students	0.570*** (0.052)	0.386*** (0.053)	0.354*** (0.053)	0.983 (0.012)
Number of observations (N)	141	141	141	141

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, + $p < 0.15$. Refer to Table 6 for information on controls included in the estimation of the results.

Table 11: Gender differential for general ICT-related skills and knowledge

	Student has used computer in the last three months (1)	Student has participated in ICT education programme (2)	Student is either very satisfied or satisfied with current ICT use in school (3)
Panel A: Average treatment effect on the treated (ATET)			
Male student in poa! school compared to female student in poa! school	0.173** (0.082)	0.000 (0.079)	0.011 (0.098)
Potential outcome means			
Comparison students	0.676*** (0.063)	0.736*** (0.058)	0.528*** (0.075)
Number of observations (N)	141	141	140
Panel B: Average treatment effect (ATE)			
Male student in poa! school compared to female student in poa! school	0.224*** (0.068)	0.024 (0.077)	0.035 (0.082)
Potential outcome means			
Comparison students	0.624*** (0.048)	0.682*** (0.047)	0.525 (0.054)
Number of observations (N)	141	141	140

Notes: Refer to Table 10.

The robustness check for the gendered treatment effects for the IPW estimates was undertaken using PSM (results presented in the Appendix). The results proved to be robust to this check.

Conclusions

The provision of free and unlimited internet services by poa! has led to improved internet availability for schools and, in turn, increased the availability of teaching and learning materials. poa!'s partner schools expressed their appreciation for the provision of free and unlimited internet services to schools. Some noted that this has transformed the way they use the internet as an educational resource.

The service has had a positive effect on internet use by students. Students in poa! partner schools are 28.8% more likely than students in comparison schools to have used the internet in the past three months. The service has also had a strong positive effect on student participation in internet training during school hours and on their participation in ICT education programmes. However, the service has had little effect, on average, on the uptake of online courses: whether students have used educational content as part of their internet use at school (despite a high level of enthusiasm among students for ICT-supported education including internet use), or whether the students had used a computer in the past three months. Students in

poa! partner schools were no more likely to report being satisfied with the current ICT use in school than their peers in the comparison group. There was no evidence of an effect on absenteeism, in either the current or the previous term.

There is some evidence that the impacts of the poa! service vary by gender, as boys are significantly more likely than girls to be accessing the internet or using computers, therefore benefiting more from the poa! service. However, the results suggest that boys and girls receive roughly equal access to the poa! service within a classroom setting. It appears to be outside of the classroom that a differentiation in access or usage applies.

The study has several limitations. First it is impossible to rule out the influence of unobserved characteristics on the estimates, so the results cannot be given a casual interpretation. Second, the findings are based on a limited sample of schools and students. Thirdly, the study only examines short-term benefits; a complete analysis of the long-term effects would be an important avenue for future research. Finally, the study relies on subjective measures of self-reported internet skills and knowledge, among other indicators. These indicators are widely used internationally, but objective measures that evaluate actual skills through performance tests and games could shed more light on the effects of internet services on educational institutions.

Notwithstanding the limitations of the study, the results have provided useful lessons for *poa!* to follow up as it expands. It appears from the findings that there are limitations in translating the provision of *poa!* internet into improved use of internet for educational purposes, and thus into improved student outcomes. Addressing this would involve tackling both supply and demand-side factors affecting internet access and use in schools. The supply-side factors include internet speed and coverage of the Wi-Fi routers. On the demand side there is a lack of hardware to support the use of internet services. For instance, in Kibera Girls Soccer Academy, the school had 15 computers serving over 130 students. Similarly, in Olympic High School, there were 18 operational computers serving more than 200 students. Teachers also need to be trained in how to bring the internet into their teaching in an effective way, school management needs the appropriate capacity to keep an ICT system functioning well. Tackling these challenges goes beyond the capacity of *poa!* internet, and beyond its core role as a private business. Closing the gap would thus require further support from government and/or non-governmental organisations.

poa! is expanding and adapting its services. It is currently expanding the number of Wi-Fi hotspots to improve coverage of the *poa!* street service. This will reduce their need for partners to host their infrastructure. However, this study has demonstrated that schools and students appreciate and are benefiting from *poa!*'s free service. This contributes to raising the company's profile and reputation in the communities, which will remain important as it expands to new areas in Kenya. Responding to these findings, *poa!*'s management is seeking ways to continue developing its schools service. They are considering partnerships with NGOs and others philanthropic organisations: these could make it possible to cover some of the ICT infrastructure and capacity needs of the schools. This could catalyse an even greater impact for schools and students in these underserved communities. As they work on this, *poa!* and their partners may wish to pay attention to gender equality: the results suggest that without special measures to include girls, the benefits of internet provision in school will be unequally distributed by gender.

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Appendix

Table 12: Gendered treatment effects of uptake and use of *poa!* internet on Internet Skills

Students in <i>poa!</i> partner schools versus comparison students	Internet use		Internet training	
	All	<i>Poa!</i> partner schools only	All	<i>Poa!</i> partner schools only
	(1)	(2)	(3)	(4)
Panel A: Average treatment effect on the treated (ATET)				
Male treatment students vs comparison students	0.297*** (0.068)	0.335*** (0.070)	-0.042 (0.088)	-0.071 (0.085)
Average for comparison students	0.471 (0.027)	0.556 (0.053)	0.200 (0.021)	0.400 (0.052)
Number of observations (N)	371	141	371	141
Panel B: Average treatment effect (ATE)				
Male treatment students vs comparison students	0.369*** (0.115)	0.356*** (0.081)	0.071 (0.115)	-0.082 (0.095)
Average for comparison students	0.471 (0.027)	0.556 (0.053)	0.200 (0.021)	0.400 (0.052)
Number of observations (N)	371	141	371	141

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, + < 0.15 . Independent and identically distributed Abadie-Imbens standard errors reported in parentheses. Refer to Table 6 for information on controls included in the estimation of the results.

Table 13: Gendered treatment effects of uptake and Use of *poa!* internet on school attendance

Students in <i>poa!</i> partner schools versus comparison students	Student absent from school during the past academic term		Student absent from school during the current academic term	
	All	<i>Poa!</i> partner schools only	All	<i>Poa!</i> partner schools only
	(1)	(2)	(3)	(4)
Panel A: Average treatment effect on the treated (ATET)				
Male treatment students vs comparison students	-0.014 (0.094)	-0.047 (0.089)	0.028 (0.080)	0.151* (0.086)
Average for comparison students	0.357 (0.026)	0.367 (0.051)	0.249 (0.023)	0.267 (0.047)
Number of observations (N)	371	141	371	141
Panel B: Average treatment effect (ATE)				
Male treatment students vs comparison students	-0.043 (0.127)	-0.053 (0.096)	-0.062 (0.107)	0.165* (0.091)
Average for comparison students	0.357 (0.026)	0.367 (0.051)	0.249 (0.023)	0.267 (0.047)
Number of observations (N)	371	141	371	141

Table 14: Gendered treatment effects of uptake and use of *poa!* internet on access to information

Students in <i>poa!</i> partner schools versus comparison students	Student has received educational content		Student would like to receive educational content	
	All	<i>Poa!</i> partner schools only	All	<i>Poa!</i> partner schools only
	(1)	(2)	(3)	(4)
Panel A: Average treatment effect on the treated (ATET)				
Male treatment students vs comparison students	0.104 (0.099)	0.066 (0.095)	-0.028 (0.032)	-0.019 (0.032)
Average for comparison students	0.229 (0.022)	0.356 (0.051)	0.960 (0.010)	0.978 (0.016)
Number of observations (N)	371	141	371	141
Panel B: Average treatment effect (ATE)				
Male treatment students vs comparison students	0.440*** (0.124)	0.167* (0.099)	0.018 (0.045)	-0.069* (0.044)
Average for comparison students	0.229 (0.022)	0.356 (0.051)	0.960 (0.010)	0.978 (0.016)
Number of observations (N)	371	141	371	141

Table 15: Gendered treatment effects of uptake and Use of *poa!* internet on general ICT-related skills and knowledge

Students in <i>poa!</i> partner schools versus comparison students	Student has used computer in the last three months		Student has participated in ICT education programme		Student is either very satisfied or satisfied with current ICT use in school	
	All	<i>Poa!</i> partner schools only	All	<i>Poa!</i> partner schools only	All	<i>Poa!</i> partner schools only
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Average treatment effect on the treated (ATET)						
Male treatment students vs comparison students	0.278*** (0.079)	0.222*** (0.082)	0.170* (0.089)	0.024 (0.088)	-0.024 (0.100)	0.034 (0.107)
Average for comparison students	0.497 (0.027)	0.600 (0.052)	0.523 (0.027)	0.656 (0.050)	0.461 (0.027)	0.533 (0.053)
Number of observations (N)	371	141	371	141	367	140
Panel B: Average treatment effect (ATE)						
Male treatment students vs comparison students	0.192+ (0.128)	0.268*** (0.086)	0.261** (0.123)	0.043 (0.093)	0.162 (0.133)	0.055 (0.106)
Average for comparison students	0.497 (0.027)	0.600 (0.052)	0.523 (0.027)	0.656 (0.050)	0.461 (0.027)	0.533 (0.053)
Number of observations (N)	371	141	371	141	367	140

Première Agence de Microfinance (PAMF): Promoting financial inclusion in Côte d'Ivoire

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Expert Advisors: François Bourguignon and Shahrokh Fardoust

Headline impacts

- PAMF Côte d'Ivoire (PAMF-CI) is contributing to financial inclusion in some of the poorest areas of Côte d'Ivoire. More than 94% of their clients had been financially excluded prior to gaining access to a PAMF-CI solidarity group loan.
- Clients are highly satisfied with PAMF-CI products and services.
- Most PAMF-CI loans are invested in business activities.
- Successive borrowing has positive impacts on the economic and financial performance of microenterprises.
- Customers also perceive positive impacts on their economic well-being, but no evidence could be found of an impact on longer-term fixed asset accumulation.
- PAMF-CI is successfully addressing financial exclusion among women, who make up over half of the client sample. However, the impact of PAMF-CI lending on business outcomes is less pronounced for women entrepreneurs.

Company overview

Première Agence de Microfinance provides financial services to more than 17 000 micro entrepreneurs and small-scale farmers in northern and central Côte d'Ivoire who are excluded from commercial banking services. PAMF-CI was created in 2008 and has received funding under the Luxembourg Microfinance and Development Fund (LMDF), a microfinance investment vehicle that received funding from the European Investment Bank under the Impact Financing Envelope (IFE).

Summary

This Deep Dive Report (DDR) examines the effect of microcredit on the financial profitability of microenterprises and subjective well-being of business owners in Côte d'Ivoire. The study collected and analysed primary data on 303 solidarity group borrowers from PAMF-CI in the regions of Bouaké and Boundiali. It employs a non-experimental approach to compare more senior clients (e.g. borrowers who have been with PAMF-CI for more than one year and who have received at least two loans) with new clients (borrowers who have been with PAMF-CI for less than one year and who have been through one loan cycle at most).

After controlling for individual background characteristics (e.g. location, firm and loan size), the study shows that borrowing positively impacts the financial performance of microenterprises. These results imply that the number of loan cycles undertaken by microbusinesses in support of their activities (including expansion) is an important determinant of business performance and business profitability. The results indicate that men benefit more than women. The analysis also shows that borrowers perceive an increased economic well-being from participating in the microfinance programme. No significant effect is found, however, on asset accumulation.

The relatively high gains in revenues and net profit, and the absence of any significant effect on the accumulation of assets, suggest that profits may have been reinvested back into working capital for businesses, allowing owners to grow their companies and generate additional profits. It is worth noting that small-scale traders usually require very few productive assets to operate, and data confirm that borrowers have increased their working capital and sales capacity.

The researchers conducted a customer satisfaction survey, measuring different dimensions of customer perceptions and expectations. New and more senior clients, and even former clients, shared positive views of PAMF-CI's services and products. Overall, although this study did not detect any solid evidence of the impact of PAMF-CI funding on asset accumulation, it does highlight meaningful positive consequences of participation in the lending scheme.

Introduction

The international development community has long recognised the role of SMEs (small and medium-sized enterprises) in the fight against financial exclusion, poverty and unemployment. According to the AFDB (2013), the SME sector including microenterprises contributes about 33% of gross GDP and up to 45% of total employment in Africa – thus playing a major role in alleviating poverty.¹

The present study analyses the marginal effects of successive borrowing from PAMF-CI on SMEs in the solidarity group programme. PAMF-CI is one of the microfinance institutions that have received funding under the LMDF, a microfinance investment vehicle supported under the EIB's Impact Financing Envelope for Africa, the Caribbean and the Pacific.

¹ This paper uses the SME definition according to Law 2014.140 in Côte d'Ivoire: SMEs are sub-divided into three groups: (i) microenterprises, which permanently employ fewer than 10 people or have an annual turnover of less than or equal to XOF 30 million excluding tax; (ii) small businesses, defined as companies that permanently employ fewer than 50 people or have an annual turnover of no more than XOF 30 million; (iii) medium-sized enterprises, defined as companies that permanently employ fewer than 200 people, or achieve an annual turnover of more than XOF 150 million and less than XOF 1 billion excluding tax.

Most of the PAMF-CI solidarity group borrowers are microbusinesses operating in the informal economy. Recent evidence suggests that these microbusinesses may have a notable positive effect on poverty alleviation and household livelihoods (ILO, 2015; Duflo, 2012).

The contribution of microfinance to SME development, poverty alleviation and financial inclusion has attracted a significant amount of research interest over the last decade, but the empirical evidence on the impact of microfinance programmes on socio-economic outcomes remains mixed. There is evidence that microfinance schemes have enhanced social inclusion (Maldonado and Gonzales-Vega, 2008) and increased entrepreneurial activities among marginalised populations (Mutisya and Yarime, 2014). However, studies such as Barnes et al. (2001b) and Khandker (2005) found little or negative change for the extremely poor. Mixed results across studies could be due to various assessment methodologies as well as to lending decisions made by MFIs – for example, because concern with financial sustainability led institutions to reduce focus on social objectives (Onyina and Turnell, 2013, p.3).

Some studies have cited the costs of microcredit as a major obstacle to the profitability and long-term survival of businesses (Onyina and Turnell, 2013). However, as suggested by a small number of empirical studies, these costs may not be insurmountable, and microcredit can have a significant positive impact on clients in the lowest income bracket. In fact, the repayment rate for microfinance loans has turned out to be high and positive, with default rates as low as 2-3% (McKinsey, 2013).² Furthermore, evidence from various sub-Saharan African firms has shown that credit-constrained SMEs grow more rapidly (Fafchamps et al., 2011)³ when granted funding, with an average increase in turnover of as much as 80% per year (Udry and Anagol, 2006).⁴ Finally, the use of solidarity groups, along with progressive lending and social peer pressure, have provided convenient ways to mitigate risks in lending to the poorest strata of society (D'Espallier et al., 2011).

The purpose of the study is fourfold: (i) to understand the profile of PAMF-CI beneficiaries and former beneficiaries; (ii) to assess whether they have benefited, and if so how, from borrowing; (iii) to measure customer satisfaction and; (iv) to draw strategic and operational lessons to inform the design and implementation of PAMF-CI operations going forward. We address these questions through a deep dive assessment of the economic impact of PAMF-CI lending operations on the performance of clients' and former clients' businesses, subjective well-being and customer satisfaction.

We use an approach suited to PAMF-CI's size, constraints and operations, and commensurate with the likely depth of impact. The proposed design uses a non-experimental cohort approach with a dataset spanning PAMF-CI borrowers who joined the institution between 2013 and 2017. The data were collected through a cross-sectional survey of 303 micro and small enterprises (MSEs) of current and former PAMF-CI borrowers from two different regions of Côte d'Ivoire. Senior clients are defined as clients who have borrowed from PAMF-CI for more than one year with at least two loan cycles, whereas new clients have been members for less than one year with only one loan cycle, which is being disbursed or has recently been serviced. PAMF-CI does have individual borrowers but we did not interview them because they were much fewer in number (less than 1%) and group-based lending is the focus of PAMF-CI.

² Source: <https://www.mckinsey.com/business-functions/risk/our-insights/new-credit-risk-models-for-the-unbanked>

³ Cited by Araar et al. (2018)

⁴ Cited by Grim et al. (2011)

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This study is aimed at better understanding the value added by PAMF-CI's on-lending activities, such as improving access to finance for underserved segments of the market, and at shedding light on how the institution can further improve its activities to better suit customer needs.

Literature review

The effectiveness of microlending in reducing poverty remains unproven, due to the challenges associated with producing robust evidence (Banerjee et al., 2009). These challenges come in two major forms: attempting to generalise effects when microlending is highly context-specific and, dealing with statistical biases. Recent studies have used various techniques to address these challenges.

One important bias has to do with self-selection of microborrowers. Attempts to control for this have often led to inconsistent estimates and even to conflicting results regarding their sign (Skoufias et al., 2004). Randomised Controlled Trials (RCTs) are one of the most effective tools to control for self-selection bias. However, this methodology is difficult to implement, particularly if a microcredit program has been in operation for a long time. Therefore, many studies rely on non-experimental or quasi-experimental approaches, which construct the counterfactual from observational data. Results drawn from observational data seem to be sensitive to the method used.

Pitt and Khandker (1998) serves as an excellent example of a quasi-experimental survey design and illustrates the sensitivity of the findings. The study aimed to isolate the causal effects of three Grameen Bank microfinance programmes in Bangladesh. Using an instrumental variable (IV) to address the self-selection issue for microfinance participation, they found positive significant effects of the programme. The estimation approach and related assumptions were later challenged by Morduch (1998); using a differences-in-differences approach, he found that microfinance had little to no impact. The same data were then analysed by Khandker (2005) using panel data with a slightly enhanced methodology; this study found a high and positive impact, albeit lower in magnitude than the original study. Finally, Roodman and Morduch (2009) reanalysed the earlier data, finding negative estimates, at odds with Pitt and Khandker's (1998) and Khandker's (2005) results, bringing into question the findings from the previous set of studies (Karlan and Goldberg, 2011).

Several other studies found that the effects of microlending vary by context, beneficiaries and settings (for example, Nguyen, 2018). Studies using non-experimental and quasi-experimental approaches have provided evidence of positive impacts of microfinance on firm performance and business expansion (Gubert et al., 2004; Onyina and Turnell, 2013; Banerjee et al., 2015); asset accumulation (Onyina and Turnell, 2013; Barnes et al., 2001a), and economic well-being and welfare (Duvendack, 2011; Onyina and Turnell, 2013).

Becho (2017) used PSM to assess the effect of microcredit on the performance of informal enterprises in Côte d'Ivoire. She found a positive and significant impact of microfinance on sales and net profit with a gain of 72% in turnover and 34% in net profit respectively. The effect was even stronger using a kernel matching procedure, with an average increase of 84% in turnover and 38% in net profit. In order to avoid a self-selection bias, Becho paired the beneficiary group with a group of non-beneficiary companies with similar observable characteristics. The study found a positive impact of the operations of MFIs on firm performance and sales capacity but a mixed effect on employment.

Koloma (2016) used PSM to evaluate the gender effect of microfinance programmes on beneficiaries in Mali. Using a dataset from a survey by the Malian Observatory of Sustainable Human Development which covered various types of microfinance programmes, Koloma and Alia (2014) found a statistically significant effect on beneficiaries versus non-beneficiaries with the same propensity score based on a kernel matching procedure. The data also show that women were willing to spend close to 73% of their loans on entrepreneurial activities as opposed to 44% for men, and that the average effect on poverty reduction was higher for women than men. The disparity in generated profit was mixed and conditional upon the method used. Koloma concluded that, while the PSM methodology serves to control for observable covariates, it does not control for potential selection biases based on unobserved variables.

Diallo and Goyette (2016) used a Regression Discontinuity Design to assess the effect of microcredit on entrepreneurial activities in Panama. The researchers used entrepreneur eligibility cut-offs and compared MFI clients to non-clients to isolate the causal effects of microcredit. They found limited impact on revenues and positive, high impacts on investment and assets. Furthermore, they attempted to control for self-selection by examining non-funded eligible entrepreneurs in the sample; they showed that the differences between being eligible and being treated can lead to overestimates of effectiveness. The results also showed that the effect of microcredit on economic activity was correlated with loan size, with a positive effect on revenues for smaller loans and greater effects on equipment and fixed assets for larger loans.

Other non-experimental approaches (e.g. Khandker, 1998; Koloma and Hayyan, 2014) posited that the microfinance effects are larger for repeated borrowers, who can usually borrow larger amounts (following a progressive lending approach) and achieve better performance.

On the other hand, studies such as Karlan and Zinman (2010) and Crépon et al. (2011) questioned the validity of the positive results summarised above. Some studies showed that the performance of clients' businesses was worse than that of the control group (Gubert and Roubaud, 2005). Barnes et al. (2001b), conducted a controlled trial in Zimbabwe on a sample of clients and non-clients, matched by gender and business sector, from three different villages. The authors found no evidence of a significant impact on either the value of clients' businesses or employment levels. In addition, their findings showed that, after considering the length of involvement in the microfinance programme, the longer a client stayed in a credit scheme, the less profit their business made. An additional leavers' survey showed that, over the two years following their departure from a microcredit programme, dropouts had diversified their income sources resulting in an overall increase in income.

Where the matching of a treatment and control group was not feasible, some researchers have used 'cohort studies' to control for self-selection. For instance, Adjei (2009) examined the impact of the Sinapi Aba Trust in Ghana by comparing new, intermediate and mature clients. By comparing new and mature clients, researchers sought to make use of two groups, both of whom self-select into the programme, with a view to cancelling out the self-selection bias. The study failed to show an impact on average monthly profits, but identified a positive impact on clients' businesses, asset purchases and the economic conditions of their households. A significant challenge in this study involved the demographic differences between new and mature clients, suggesting that the beneficiaries may be more successful for reasons that have nothing to do with benefiting from the microfinance services. Senior clients were, on average, five years older than new clients when they started the programme and were much more likely to live in urban areas. Some experts, notably Karlan (2001), discussed the advantages and disadvantages of this cohort-based

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approach, urging researchers to check whether comparing baseline data between incoming and existing clients is likely to cancel out the selection bias.

Based upon the arguments put forward by Karlan, and after considering the likely breadth and depth of data available, we decided to apply the cohort approach, trying to control for some of the common pitfalls mentioned above. The study relies on cross-sectional data. However, we argue that panel data would also suffer from challenges, particularly the potential dilution of the microfinance effects of small loans in a relatively long panel data survey (Bhuiya et al., 2015).

Background

Microfinance in Côte d'Ivoire began in the early 1990s and Côte d'Ivoire now has the second largest microfinance sector in the West Africa Economic and Monetary Union (WAEMU) region. However, its share in the overall financial system has remained marginal. In contrast to the banking sector, which manages a little over 80% of the financial sector's assets (i.e. total outstanding credits), microfinance covers only 2% (EIB, 2018), with the remaining assets being controlled by other financial service providers, particularly insurance companies.

According to the Association of Decentralized Financial Systems (APSF) — the professional body tasked with enforcing the regulatory and prudential rules at the national level — there were 51 accredited MFIs in Côte d'Ivoire in Q3 2017, with as many as 309 microfinance branches across the country.

MFIs in Côte d'Ivoire predominantly serve informal microentrepreneurs (90% of clients) and around 40% of clients are women. Microfinance loans have average maturities of 3-12 months, with interest rates of around 19-24% p.a. The average loan size is around XOF 2.1 million (EUR 3 200), with some MFIs lending as much as EUR 9 400.

Ivorian MFIs have always been focused on urban areas, but there has been a recent shift towards rural areas. In 2016, around 50% of access points were still in Abidjan and neighbouring districts, but the remaining 50% were scattered across the rest of the country. The uneven penetration of financial services across different regions of the country has left large segments of the population, mostly in rural areas, unserved or underserved. The Consultative Group to Assist the Poor (CGAP)⁵ (2018) estimates that 44% of Ivorian adults have never used formal or informal financial services, with these numbers being substantially higher among rural populations and other vulnerable groups, including women.

Established in 2006 by the Aga Khan Agency for Microfinance, PAMF is an emerging MFI dedicated to the development of small businesses in disadvantaged rural and peri-urban communities.

The institution ranks among the ten largest MFIs in Côte d'Ivoire in terms of outreach. As of October 2017, PAMF-CI reported a total of 17 706 active clients, 96% of whom were located in rural areas. The volume of outstanding credits was nearly XOF 6.78 billion (EUR 10.33 million). Since its inception, PAMF-CI has cumulatively disbursed over 2.7 million loans. PAMF-CI is among the top performers in the country in terms of the quality of its portfolio.

⁵ Source: <http://www.cgap.org/blog/cote-divoire-financial-inclusion-crossroads>

Table 1: PAMF-CI's outreach

	PAMF data as of October 2017
<i>Number of branches (including satellite branches, points of sale and sub-branches)</i>	6
<i>No. of (active) clients</i>	17 702
<i>No. of staff</i>	56
<i>Total assets (USD thousands)</i>	10 108
<i>Total credit disbursed (USD cumulative in millions)</i>	6 775
<i>No. of solidarity loans outstanding</i>	5 449
<i>Outstanding loan volume for solidarity loans (in millions)</i>	1 319

The MFI offers loans to microentrepreneurs for expansion, working capital and/or fixed asset needs, and to new customers with promising activities and strong potential. One of their main products is solidarity group lending (the focus of the DDR). These are collateral-free loans to groups of borrowers (with 3-15 members) that pledge cross-guarantee repayment of the loans. Solidarity loans are typically lent over 3-24 months with an interest rate of 24% on average per annum. The first loan can range between XOF 25 000 (EUR 38) and XOF 500 001 (EUR 763); following a progressive lending approach, each team member can borrow up to XOF 30 000 000 (EUR 45 735) from the fourth lending cycle.

As of November 2018, solidarity loans represented around 37% of PAMF-CI clients, of which the majority are informal microbusinesses. The rest of the portfolio is composed of loans for groups⁶ of farmers, individual loans for microbusinesses and for SMEs.

Methodology

Analytical framework

This study measures the impact of the MFI on economic and social indicators to provide a reliable and tangible evidence base for assessing the social effects of the programme. We also assess the impact of the MFI in terms of the perceived quality of products and services and clients' advocacy behaviour.

We employ non-experimental design using a cross-sectional survey. The estimation technique uses seniority, measured by length of time in the programme, to assess the impact of PAMF-CI lending. We apply parametric estimation techniques for our estimates with OLS for continuous dependent variables, and logit regressions for dichotomous outcome variables. Consistency of the results was double-checked using alternative approaches such as the Linear Probability Model (LPM) for dichotomous dependent variables and non-parametric approaches for continuous variables.

'Senior clients' are defined as clients that have borrowed from PAMF-CI for more than one year and have progressed through at least two loan cycles, whereas 'new clients' are defined as individuals who have been members for less than one year and have undertaken only one loan cycle, which is being disbursed or has recently been serviced. In addition, data were collected on clients who had dropped out.

Drawing on Karlan's (2005) contention, the 'fitness' of this estimation strategy hinges on the presumed comparability between senior and new clients. The self-selection of clients does not influence the results of the study because all respondents are members of the same microfinance programme; after controlling for

⁶ Credit groups are solidarity groups for farmers. In their credit policy and operational reports, PAMF-CI clearly distinguishes between classic solidarity groups and credit groups for farmers, which operate under different rules.

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a range of background characteristics, we may be able to generate unbiased estimates. In order to further protect against potential differences, outcomes should have been evaluated at the same 'time since joining'. However, due to scarce data, individual and loan characteristics were observed at the time the survey was administered, and a balance test was carried out on the overall sample to probe any similarities between groups.

Other intrinsic characteristics, which cannot be accounted for with this approach, may affect the results (Karlan, 2001). For instance, borrowers join the programme at different points in time. As a result, changes in economic conditions can affect the difference between groups. The analysis of secondary documents did not reveal any major changes or notable external shocks in the region at the time of study that might have significantly influenced the programme. This provided an acceptable check for the validity of comparisons between treatment and control groups, but we still cannot rule out the heterogeneity of underlying individual reasons for adhering to the programme at a specific time.

PAMF-CI practices continuous lending cycles with borrowers taking on a new loan as soon as the last one is repaid. A borrower who fails to take up a successive loan is characterised as a passive borrower, and after three months they are considered a 'dropout'⁷ as the majority of all credits are normally renewed within this period. Indeed, there are reasons to believe that former customers differ from new customers in the presence of massive client exits throughout the period under review, and this can overestimate the true impact of the programme. We dealt with potential dropout bias by replicating the regression analyses on a sample of dropouts — the size of the sample corresponded roughly to the attrition rate.

The choice of location of the MFI means that unobservable characteristics of the target area could influence the effects of the programme (Maldonado and Gonzales-Vega, 2008). We attempt to overcome this by examining programmes in two separate geographical regions with different infrastructure and intervention schedules. PAMF-CI opened its first branches in rural areas before branching out to Bouaké (a peri-urban area). Therefore, we controlled for branch fixed effects to capture differences in the outcome variable.

Findings were complemented by information collected through: (i) individual interviews with PAMF-CI managers and a staff focus group discussion; (ii) analysis of the TOC (Theory Of Change); (iii) post-survey interviews with key informants (PAMF-CI credit agents, risk managers and solidarity group coordinators) to help interpret the findings; and (iv) unstructured conversations (open-ended questions to gauge respondents' perceptions). To enrich the findings from the survey, enumerators were required to ask open-ended questions to elicit responses about the main benefits and/or problems associated with PAMF-CI's credit operations. Combining these diverse sources of data allowed for the triangulation of results and provided a better understanding of the different perspectives of the PAMF-CI loan scheme and its impact on borrowers.

Econometric approach

The general specification of the model is:

$$\ln(Y_i) = \beta_0 + \beta_1 \text{SEN}_i + \beta_2 L_i + \beta_3 V_i + X_i' \delta + F_i' \lambda + u_i \quad (1)$$

⁷ According to CGAP, a 'dropout' is a client who has not taken up a follow-up loan within a specified number of days. Drawing upon this definition and that of PAMF-CI, we define dropouts, for the purpose of this study, as borrowers who joined the MFI between 2013 and 2017 and whose last transaction with PAMF-CI was more than three months ago.

Where (β_0) is the intercept, and (u) is the error term representing unobservable/unobserved characteristics. The coefficient of interest is (β_1) which measures the impact of the loan on the outcome. The dependent variable (Y) is one of the four different outcomes of interest:

- (i) **Revenue:** the net sales generated by a business during a particular period. Revenue is one of the key measures of a business's performance.
- (ii) **Net profit:** revenue minus the cost of goods sold, business operating expenses, loan interest and taxes. Net profit is the bottom line of the income statement and an important measure of firm profitability.
- (iii) **Asset stock accumulation:** the accumulation of both household and productive assets. As the literature considers asset ownership to be negatively correlated with poverty, we asked questions about some of the common household assets in Côte d'Ivoire such as houses, land, means of transportation (i.e. vehicles) and productive assets (i.e. machinery, equipment, land to be leased, etc.). Asset accumulation equals 1 if the respondent has purchased at least three assets and 0 otherwise.
- (iv) **(Subjective) Economic well-being** is a composite index which equals 1 if a client reported having increased his overall earnings and seen an improvement in overall living standards as a result of the loan, and 0 otherwise.

The dependent variable Y is regressed on the explanatory variable of interest SEN (seniority of the borrower) and inherent covariates X (respondent's background characteristics); L (loan size); F (firm size) and V (Branch location):

- (v) The variable **(SEN)** is binary and its value (0 or 1) is determined by the entrepreneur's seniority within the lending programme. This is coded as 1 if the borrower has been affiliated with the microfinance institution for at least one year and has been through at least two loan cycles (*senior*); and 0 otherwise (*new*).
- (vi) The matrix (X'_i) controls for observable individual characteristics of the borrower, such as age, gender, marital status, education and household size, and is the vector of coefficients associated with these characteristics. The variable (V) captures the MFI branch fixed effects, and (F'_i) is a vector of firm characteristics such as business size and firm activity. Finally, loan characteristics (L) are proxied by the average loan received by the borrower to date.

The estimation technique for dichotomous dependent variables is undertaken using the logit regression model. The function can be linearised into the logit transformation:

$$\Pr(Y_i=1) = \frac{e^{\beta_0 + \beta_1 SEN_i + \beta_2 L_i + \beta_3 V_i + X'_i \delta + F'_i \lambda + u_i}}{1 + e^{\beta_0 + \beta_1 SEN_i + \beta_2 L_i + \beta_3 V_i + X'_i \delta + F'_i \lambda + u_i}} \quad (2)$$

In addition to the overall impacts of the microfinance lending operation, differential impacts are investigated: lending in a peri-urban area (*Bouaké*) versus a rural area (*Boundiali*); on-lending to women versus to men; and lending to educated versus uneducated borrowers. Importantly, we also investigated the interaction effects of key components of the X variables (gender, education) with SEN . This is in case the beta coefficients associated with the X variables are orthogonal to the main explanatory variable (SEN), in which case the variance in X would not be correlated to SEN .

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We tested the robustness of our results in three ways. First, we redefined seniority to increase the gap between senior and new clients in order to see how this effect behaves. Secondly, we devised an alternative estimation technique that separates out the number of loans and the duration of the programme to isolate the effect of the funding. Finally, we calculated the NPS (Net Promoter Score) to validate our results in terms of clients' feelings towards PAMF-CI.

Sampling, instrument design and data collection

A phone-based survey was carried out with PAMF-CI borrowers in April 2018. The questionnaire is divided into four sections: socio-demographic characteristics, business characteristics, impact on business and welfare, and level of satisfaction.⁸ The majority of questions come directly from the 2015 Household Survey conducted by the Ivorian Government and other neighbouring West African countries.

Power analysis estimations were performed using Stata, a statistical software for data science. The sample size required in order to get a 0.80 statistical power at a 5% level of significance is 291. Assuming a 15% non-response rate, the required sample size was set at 334 borrowers and the ratio between the treatment group size and the control group was set to two.

Survey questions were evaluated prior to survey implementation by a staff focus group; the questionnaire was then piloted on 5% of the calculated sample, and credit officers were briefed. The questionnaire was prepared in English and French and translated into the two main local dialects, Dioula and Baoule. The survey was administered by telephone by a team of enumerators and a research assistant who conducted phone interviews for over a month in both Bouaké and Boundiali.

Clients were selected using a multi-stage sampling method. PAMF-CI has six branches in two regions; therefore, one branch was selected from each region: one in Bouaké (central region) and one in Boundiali (northern region). Together, these two branches represent around 50% of the client portfolio.

Then, borrowers were grouped by gender and classified by loan purpose (excluding agriculture and related activities). We compiled separate lists of senior and new clients, and a stratified random sample of clients was selected to ensure that groups were represented in terms of branch and gender.

Although the database contained data on demographic characteristics, business type and household data, historical information on loan features was not available. Furthermore, there were no available data on the size of the first loan received by borrowers or any prior loan cycle, except for the most recent intake.

The sampling frame for borrowers who have received at least one microcredit solidarity loan over the period under review (2014-2017) was made up of 518 clients (outside of the agriculture sector), from whom a sample of 330 was drawn, representing 64.5% of the sampling frame.

The survey was carried out over a four-week period from early April to May 2018. Only seven borrowers refused to participate in the survey, while ten respondents claimed they had never taken out a microcredit loan with PAMF-CI. Up to 98.8% of respondents had received a group liability loan and only four reported having taken out a non-solidarity loan. The non-solidarity group borrowers were removed from the final sample.

⁸ Survey instrument available from the authors on request.

To address bias arising from the omission of clients who have dropped out of the programme, we also surveyed 22 former PAMF-CI clients (so-called 'dropouts').

Results

Descriptive statistics

Business and demographic characteristics

Profiling active clients is an important step in evaluating the socio-economic impact of a microfinance institution.

Table 2: Descriptive statistics

	Sample	PAMF-CI branch		T-test	Gender		T-test	Seniority		T-test
		Bouaké	Boundiali		Male	Female		Senior	New	
<i>N</i>	281	210	71		121	160		184	97	
Business characteristics										
Sector (%)				36.94**			52.52**			4.97
Sale of agricultural products	34.88	25.71	61.97	-	49.59	23.75		32.61	39.18	-
Sale of processed products	32.38	39.52	11.27	-	14.05	46.25		34.24	28.87	-
Sale of textiles and cosmetics	17.79	20.48	9.86	-	13.22	21.25		18.48	16.49	-
Services	7.12	7.14	7.04	-	14.05	1.88		5.43	10.31	-
Others	7.83	7.14	9.86	-	9.09	6.88		9.24	5.15	-
Average number of employees prior to joining PAMF-CI	2	2	1	1.56	2	1	-4.15***	2	2	-0.09
Branch										3.51*
Annual revenues (millions, XOF)	8 506	8 976	7 119	1	11 200	6 453	-2.97***	8 813	7 925	-0.52
Annual net profit (millions, XOF)	2 583.6	2 501.5	2 822.5	-1	3 398	1 966		2 524	1 876	-
Purchased at least one productive asset between 2014-2017 (%)	60.85	48.57	97.18	52.63***	82.64	44.38	42.36***	59.78	62.89	3.10
Purchased at least two productive assets between 2014-2017 (%)	22.78	18.10	36.26	10.35***	34.71	13.75	17.21***	27.84	20.11	2.15
Purchased at least three productive assets between 2014-2017 (%)	14.23	3.33	46.48	80.90***	24.79	6.25	19.40***	13.59	15.46	0.18
Invested in housing between 2014-2017 (%)	61.57	56.67	76.06	8.43***	71.90	53.75	9.59***	63.04	58.76	6.39
Invested in another income-generating activity between 2014-2017 (%)	30.96	32.38	26.76	0.78	39.67	24.38	7.54***	30.43	31.96	0.07
Demographic characteristics										
Average age (years)	41	40	43	12.80**	42	40	16.07***	42	40	4.44
Education (%)				35.53***			9.14*			1.13
No education	46.3	37.14	73.24	-	51.24	42.50	-	44.57	49.48	-

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Primary	22.4	26.19	11.27	-	18.18	25.63	-	23.91	19.59	-
Secondary	24.6	30.48	7.04	-	20.66	27.50	-	25.00	23.71	-
Vocational	2.5	2.38	2.82	-	2.48	2.50	-	2.17	3.09	-
Graduate	4.2	3.81	5.63	-	7.44	1.88	-	4.35	4.12	-
Average number of household members	8	7	9	-4.35***	8	7	-0.95	8	7	-
Gender										2.75***
Statistics on loans										
Average amount of credit received per cycle up to 2017 (XOF)	421 754	349 342	644 326	-3.86	591 464	297 924	-4.42***	430 055	413 453	-0.23
Total amount of loan received up to 2017 (XOF)	992 597.2	899 619	1 267 603	-1.96**	1 376 031	702 625	-4.18***	1 297 907	413 453	-
Repayment frequency (%)				3.37			3.08			26.30**
Less than 6 months	13.52	13.81	12.68		16.53	11.25		5.98	27.84	-
6-12 months	82.92	83.81	80.28		78.51	86.25		89.67	70.10	-
Over 12 months	3.56	2.38	7.04		4.96	2.50		4.35	2.06	-
Dropouts										
N	22									
Average age (years)	42	43	38		45.5	54.5		100	0	
Education (%)										
No education	45.4	46.1	44.4		40.0	50.0		45.4	-	
Primary	31.8	30.8	33.3		50.0	16.67		31.8	-	
Secondary	18.2	23.1	11.1		10.0	25.0		18.2	-	
University	4.6	0.0	11.1		0.0	8.33		4.6	-	
Average number of household members	10	9	11		11	9		10	-	

The majority of respondents are married (80.07%) (Table 2), with the rest being either single (13.88%) or widowed (4.27%); the difference between the two groups is not significant. The median age of respondents is 40.5 years, and the majority are married (80%). Borrowers live in families of eight individuals on average. Household sizes across the sample are larger than the national average of 5.4⁹ individuals, with new and senior clients recording 8 and 7 individuals per household. This difference is statistically significant.

Around 37% of respondents have taken up one loan, and among these, 94% are first-time borrowers; 38% have taken out two to three loans; and close to a quarter of sampled clients have taken out more than four loans.

Six out of ten clients (61%) reported purchasing at least one asset over the period 2014-2017. Asset ownership varies between Bouaké and Boundiali: almost all borrowers in Boundiali (97%) own at least one asset, while fewer than half of those located in Bouaké (49%) have purchased an asset. On average, 25% of senior clients purchased at least three assets during their loan period, compared with 15% of new clients. Housing stock, specifically house repairs, did not differ between the two groups: 63% of senior clients had made at least one house improvement compared to 59% of new clients.

The study highlights high levels of illiteracy among PAMF-CI clients, with four out of ten clients having no education at all. However, 48.71% of PAMF-CI clients have completed secondary education, 2.5% vocational

⁹ 2015 Household Survey

education and 4.2% have studied to university level. Borrowers affiliated with the Boundiali branch tend to be less educated than those affiliated with the Bouaké branch, with three out of four borrowers living in Boundiali being uneducated. These results are consistent with public data from the Ivorian National Institute of Statistics and the economic status of the two cities. While Bouaké has a very dense and diversified economy with a poverty rate of 54.9%, Boundiali is one of the poorest regions in the country with a poverty rate of 68.5%. According to the latest household survey (ENV 2015), the risk of poverty is lower when individuals can read and write or have reached at least a secondary level of education or equivalent.

Poverty rates among customers are estimated using consumption expenditures divided by the square root of the number of household members, combined with regional poverty lines from the 2015 national household survey. The estimates find a 49% poverty rate for Boundiali and a 10% poverty rate for Bouaké. New clients are more likely to be poor: just over 61% and 14% of new clients in Boundiali and Bouaké live below the regional poverty lines. Combined with other indicators — for example, on education and household size — the evidence suggests that PAMF-CI is successful in its objective of reaching vulnerable entrepreneurs, with poverty rates close to the average regional poverty incidence, except in Bouaké where PAMF's portfolio is concentrated in peri-urban and urban areas.

As discussed in more detail in Appendix 7, relying on consumption expenditures fails to account for consumption of own produced goods (or goods purchased for business use). To investigate in more detail whether a secondary agricultural activity introduces a bias into the poverty effect, we regressed consumption expenditures on household characteristics including the secondary activity of the PAMF-CI client. There is no significant difference in consumption expenditures between households with secondary agricultural activities and those without. Although not conclusive, this suggests that the effect of consumption of own produce is likely to be marginal. In addition, the consumption expenditure-based estimates are roughly consistent with the data from PAMF-CI's own monitoring of poverty rates using the Progress out of Poverty Index (PPI).

On average, senior and new clients recorded an annual revenue of XOF 8.81 and XOF 7.92 million and annual net profits of XOF 2.52 million and XOF 1.87 million respectively. This suggests that a higher number of loan cycles may be associated with higher average net profit. On average, yearly revenues stand at XOF 8.97 million in Bouaké and XOF 7.11 million in Boundiali. Male borrowers generated an average annual revenue of XOF 4.23 million: up to 1.6 times the amount generated by women.

Our findings also show that women tend to operate within less productive sectors such as textiles and cosmetics, and are usually retailers, whereas their male counterparts are more likely to invest in high-yield activities and more productive businesses such as the sale of agricultural products. In addition, women tend to operate in similar sectors to each other.

Eight out of ten clients reported having a loan tenure of between 6 and 12 months, a distribution which does not change across the two branches. However, loan tenors seem to be slightly lower for new clients, resulting in shortened repayment frequencies: 33.82% of new clients have a repayment frequency of fewer than 6 months compared to 5.98% of senior clients.

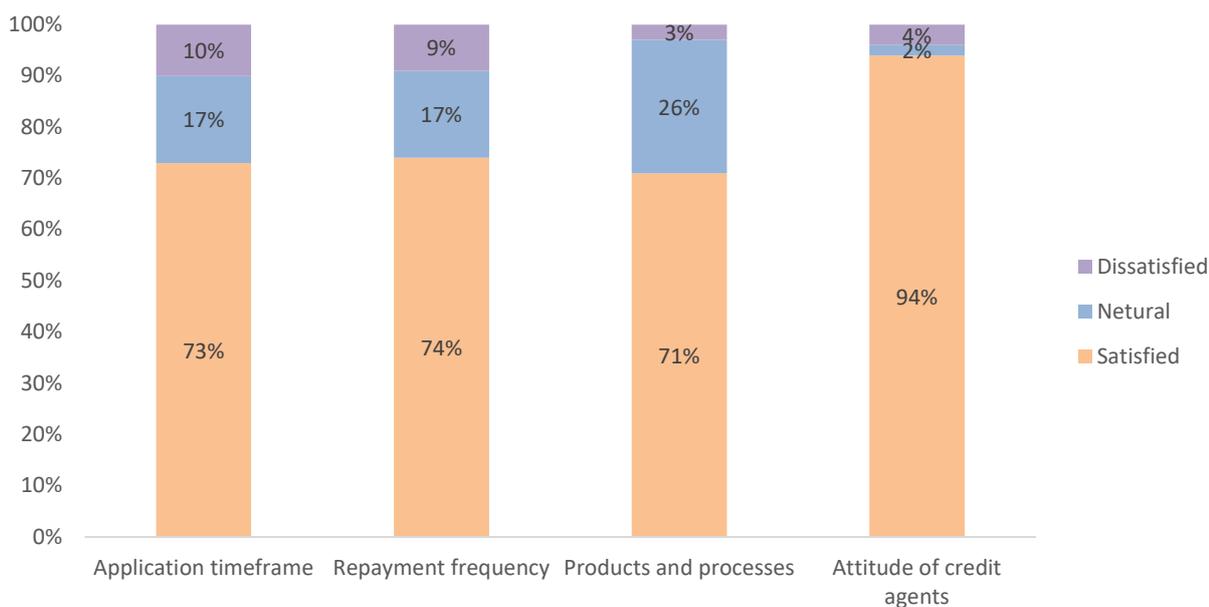
This study includes 22 former clients who decided to drop out of the PAMF-CI lending scheme. They are mostly women (54.5%) and approximately six out of ten were registered with the Bouaké branch. There is no statistically significant difference between clients and dropouts in terms of age, education, sectors of

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operation and gender. However, the average family size for dropouts is significantly larger than for current clients. Furthermore, the dropouts' businesses before their association with PAMF-CI were smaller than those of the current clients at entry into the portfolio.

Survey respondents were asked to rank their level of satisfaction with PAMF-CI's products and services using a 3-point Likert-type scale, ranging from 1 (disagree) to 3 (agree). They responded to a range of specific and general questions. As shown in Figure 1, overall customer satisfaction is very high for all PAMF-CI's key attributes.

Figure 1: PAMF-CI clients' satisfaction with four loan dimensions



Some 94% of clients reported high levels of satisfaction with the professional conduct of credit officers. Satisfaction with PAMF-CI products was 65% for new clients and 74.4%. Fewer than 80% of clients were satisfied with repayment frequency: 68% of new clients and 77.17% of senior clients. Senior clients are more likely to recommend the MFI system (90%) than new clients (79%), which suggests that the overall levels of satisfaction with PAMF-CI increase with seniority. Dropouts also reported high levels of satisfaction with PAMF-CI products and services (see Appendix 4). Fewer than 10% have switched to a different provider, while the rest have dropped out of the MFI system, suggesting that they may have faced constraints that prevented them benefiting from microfinance, rather than dropping out as a result of dissatisfaction with the service offered.

The unstructured conversations with clients provided additional insights into the different causes of satisfaction and dissatisfaction. In line with the quantitative findings, most clients are satisfied with PAMF-CI. Most are convinced that the loans have enabled them to improve their financial performance, with a large majority reporting that the loan was very effective in helping their businesses and families. Examples of the impacts include doubling business revenues and building family homes. Clients are broadly satisfied with the cost of the loans, which they find affordable. However, a number of respondents raised concerns about the mutual cross-guarantee loans. They noted that rogue clients pose a serious threat to the cohesion of solidarity groups and the sustainability of other clients' businesses. Some clients drop out of the programme as soon as they identify a risky group member.

The majority of clients are satisfied with the attitude of PAMF-CI agents, with few respondents reporting pressure from loan officers. Loan officers confirmed that, in some cases, they need to put pressure on borrowers to repay on time, in particular with uneducated clients that tend to forget periodic repayments. Some customers would like the reimbursement period (loan tenor) to be longer to allow them to cope with unexpected economic shocks in their sector of activity.

With regard to repayment frequencies, the most dissatisfied respondents are new clients; this is in line with our other results, which show that repayment frequencies are shorter for newer clients.

There is also some dissatisfaction with the amount of credit provided, which is sometimes deemed insufficient to cover all the needs of their businesses, and usually lower than the requested amount.

Regression results

Profitability and performance

We constructed an OLS multilinear regression model to assess the relationship between revenues, profits and borrowing from PAMF-CI (Table 3). The reference group for the regression is 'new clients', who have been borrowing for less than one year with only one loan cycle. In columns 1, 3 and 5 these new clients are compared with 'senior clients', who have been borrowing from PAMF-CI for at least two loan cycles. In columns 2, 4 and 6, a group of 'intermediate' clients is introduced. These have been members of PAMF-CI for between six months and three years with two to four loan cycles completed. In these columns 'senior' clients are those who have been through at least four loan cycles and have been members for more than three years.

Table 3: Revenues and net profit¹⁰

	Log of revenues		Log net profit		Log net profit (with interactions)	Log net profit with dropouts
	(1)	(2)	(3)	(4)	(5)	(6)
Seniority (Ref. = New)						
Intermediate	-	0.18 (0.09)**	-	0.17 (0.08)**		-
Senior	0.37 (0.08)***	0.63 (0.10)***	0.27 (0.07)***	0.48 (0.09)***	0.03(0.14)	0.23 (0.07)***
Adjusted R-square	0.34	0.38	0.31	0.35	0.25	0.29
AIC	554.16	531.88	462.25	454	551	521.46

Note: Z in parentheses * p<0.1, ** p<0.05, *** p<0.01

When controlling for borrowers' demographic, business and loan characteristics, the results indicate that the effect of being a senior client is strongly positive in all specifications (Table 3; models 1 to 6), except for model 4. Indeed, the seniority variable (SEN) means that a senior borrower has 37% higher revenues and 27% higher net profit than a new borrower, holding all the other predictors constant. The result is significant at the 0.99% significance level and there is very little chance of a type I error. These results are consistent with recent empirical literature on the impact of microfinance lending schemes on firm performance in the region; Becho (2017) found a 35% increase in net profit and more than an 80% increase in revenues. However, there is no evidence that membership of PAMF-CI increases the number of people employed in these small firms.

Male borrowers earn 47% more profit than women, on average (see Appendix 5), controlling for other borrower characteristics, and also earn higher revenues. Once a gender interaction is included in the

¹⁰ The full regression results, including control variables, can be found in Appendix 5

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regression, SEN is not statistically significant, but the gender dummy retains its significance and the interaction coefficients are also significant. This indicates that the impacts of borrowing on sales and net profit are much larger for men. Senior male clients record around 59% higher sales and net profit than senior female clients (p value is <0.01). This increase is more than twice the baseline difference in net profit between new men and new women. This suggests that the impact of seniority on sales and profit observed in the regressions is mainly driven by the impact on the profits and revenues of male clients.

The results of including education interaction terms indicate that borrowing brings larger benefits to more educated clients. This is reflected in the fact that educated senior clients perform better than their non-educated peers: there is a significant difference between uneducated clients and those that have received a secondary or vocational education in terms of both profit and revenues, controlling for other characteristics.

Asset accumulation

We investigated the impact of PAMF-CI on asset accumulation by testing the difference in assets owned by mature clients and new ones. The investigation covered both productive assets and household assets, in line with PAMF-CI's TOC.

On average, 13.6% of senior borrowers reported having purchased at least three assets over the period 2013-2017, compared to nearly 15.5% of new clients. No significant effect of PAMF-CI lending on accumulation of productive assets was found. This contrasts with the results of some recent research (Onyina and Turnell, 2013; Zaman, 2000¹¹), which found a positive impact of microfinance on assets. Other studies show no or negative impacts of microfinance on asset accumulation. For example, Banerjee et al. (2015) and Brannen (2010) reported a decrease in durable stocks. Brannen (2010) revealed that in Tanzania there was no substantial difference in asset ownership between treatment and control groups, even though he reported that strong effects were found after considering asset expenditures. It is also possible that impacts on asset accumulation were simply not observed during the study, either due to the short timeframe or because of measurement issues: the results only take account of the number of assets purchased in the last three years, not their value. A review of the type of assets clients purchased suggests that those purchased by more senior clients may be slightly more valuable — this could be an avenue for investigation in future studies.

Further cross-analyses suggest that loan recipients initially purchase productive assets (i.e. after their first loan) but reinvest profits in their main activity thereafter. Indeed, a close examination reveals that the number of asset purchases decreases with the number of loan cycles, particularly after the second loan.

Economic well-being

The respondents were asked a number of questions about their perceptions of improvement in their level of earnings and related socio-economic improvements in the past year, as well as their expectations for the years ahead. The data on subjective economic well-being, therefore, combines perceptions of income security and improvements in living standards, both of which denote a decrease in vulnerability and an increase in resilience.

¹¹ Cited by Brannen (2010)

According to the results shown in Table 4, being registered in the PAMF-CI system for at least one year and for more than one loan cycle increases the probability of perceiving yourself as economically resilient by roughly 15%.

Table 4: Perceptions of economic well-being ¹²

Marginal effects	Beneficiaries	Including intermediary beneficiaries	With dropouts	Using the LPM
	(6)	(7)	(8)	(9)
Seniority (Ref. = New)				
Intermediary	-	0.12* (0.04)	-	-
Senior	0.15*** (0.04)	0.18*** (0.05)	0.15*** (0.04)	0.12** (0.05)

Note: Standard errors in parentheses * p<0.1, ** p<0.05, *** p<0.01

We performed three alternative regression equations and found these to be consistent across specifications and comparable with other research findings (C. Van Rooyen et al., 2013; Onyina and Turnell, 2013). Including dropouts does not change the positive effect of successive borrowing on economic security, but slightly reduces its magnitude. Level of education is positively correlated with economic security.

The findings also suggest that senior members of the programme whose businesses involve the sale of agricultural products are more likely to have noticed a positive improvement in their economic security than new members.¹³

Overall, borrowing from PAMF-CI not only reduces perceived vulnerability, but also reinforces borrowers' expectations and perceptions. Interestingly, new female clients report higher levels of subjective well-being than men, but this result is reversed as seniority in the MFI increases and clients move beyond the second loan cycle — underscoring how bigger loan sizes are not only associated with higher revenues and net profit but also greater subjective well-being.

Robustness checks

We test the robustness¹⁴ of our results in three ways:

First we split the group of 'senior' clients used in the basic specification into 'senior' and 'intermediate' clients. Intermediate clients were defined as clients who have been members for between six months and three years with at least two loan cycles and at most four loan cycles; and senior clients were those who have been through at least four loan cycles and have been members for more than three years. The results from the specifications that include the intermediate group indicate that the observed impacts of seniority on revenues, profits and subjective well-being are robust to introducing further differentiation within the group of more senior clients. In fact, introducing the intermediate group increases the effect on profit and sales from 37% and 27% to 63% and 48% respectively (Table 3). In other words, the longer a client has been with PAMF-CI and the greater the number of loan cycles, the greater is the impact on their profit and

¹² Appendix 6

¹³ This may be due to differences in sector profitability; descriptive statistics reveal that the sale of agricultural products is the most profitable activity (in terms of net profit).

¹⁴ Appendices 6 and 7

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revenues. There is, however, one important exception: the coefficient on asset accumulation remains non-significant, even for the most senior clients.

We also designed an alternative estimation technique that controls for the number of loans that senior clients have received (SEN3), regardless of their duration in the programme (DUR). This was performed in order to isolate the effect of the MFI's intervention and dissociate it from the time spent in the MFI. Another objective of this estimation was to test the moderating effect of gender on the relationship between PAMF-CI operations and outcome variables and thereby ascertain whether the sign or the significance of the effect of SEN3 on outcome (Y) depends on the value for gender. The moderating effect of gender on (Y) is tested by adding the interaction term 'SEN3 *gender' to the equation. The findings show that impact is highly correlated with PAMF-CI funding — i.e. the number of loans received. The coefficients of SEN3 are consistent throughout and remain positive and significant but the coefficients of DUR appear not to be significant. In addition, the results show that the impact of this variable on business performance is highly moderated by gender. This suggests that our conclusions regarding the implications of participation in the credit programme are robust, and that the impact is much stronger for men than for women for measures of profitability, consistent with the findings summarised above.

We also quantified the Net Promoter Score (NPS),¹⁵ a popular indicator of customer satisfaction within the market research community, to test whether our results are reflected in the perceptions of beneficiaries and dropouts towards PAMF-CI. The analysis reveals that more than eight out of ten microloan recipients (86.8%) are satisfied with PAMF-CI's products, services, and staff conduct and professionalism. A breakdown of the results by type of client shows that the NPS score for beneficiaries stands at 82.6%, more than 14% (14.5%) higher than that of dropouts, signalling positive feelings towards PAMF-CI from both groups (Appendix 4).

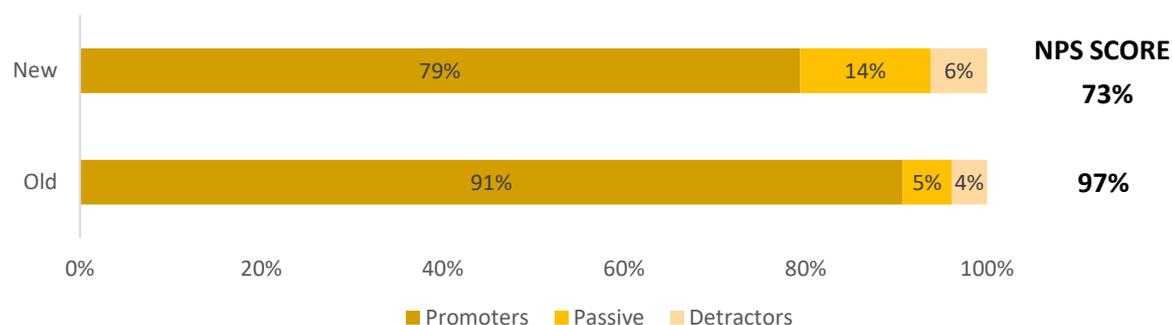
Based on the NPS, PAMF-CI borrowers can be classified into three distinct groups:

- *Promoters*: Beneficiaries who stated that they are satisfied with PAMF-CI products and services and would recommend the MFI (86.8%). They are more likely to spread positive messages, provide constructive feedback and bring in new customers.
- *Passive customers*: Borrowers who reported being neutral can be considered as passive customers who will either spread positive or negative messages (8.6%).
- *Detractors*: Customers who would not recommend the MFI because of their dissatisfaction (4.6%).

Data reveal that nine out of ten senior borrowers and about eight out of ten new borrowers are satisfied overall with PAMF-CI and willing to advocate the MFI (Figure 2). This leads to very high NPS scores: 97% and 73% among senior and new clients respectively.

Figure 2: Net Promoter Score by seniority

¹⁵ The Net Promoter Score is a metric used as a proxy for gauging the customer's overall satisfaction by measuring the willingness of customers to recommend a company's products or services to others. The higher the score, the more likely clients are to advocate the MFI.



Finally, PAMF-CI clients' willingness to advocate does not differ by gender: eight out of ten men and women can be classified as PAMF-CI ambassadors, willing to provide constructive feedback and positive messages about the MFI (Appendix 4).

Conclusions

This study assessed the relationship between access to microcredit and the financial performance of informal microenterprises and the social well-being of business owners in Côte d'Ivoire using a non-experimental, seniority-based approach. The study measured programme impact by separating clients into two categories: senior clients who have been with PAMF-CI for more than one year and have received at least two loans, and new clients who have been with PAMF-CI for less than one year and have been through one loan cycle at most. The main findings and lessons learned are as follows:

PAMF-CI is reaching out to entrepreneurs in some of the poorest areas of Côte d'Ivoire. Overall, the average respondent is uneducated or poorly educated, has an informal micro-business with fewer than ten employees and lives in a rural area in a household of eight members. PAMF-CI is one of the few MFIs that has a strong physical presence in rural areas in some of the poorest areas of Côte d'Ivoire, where the incidence of poverty has been consistently high (above 50%).

PAMF-CI is contributing to increasing financial inclusion in Côte d'Ivoire. Evidence shows that more than 94% of new clients are first-time borrowers who have never had any affiliations with any other conventional finance provider or MFI before joining PAMF-CI. PAMF-CI's contribution to financial inclusion is particularly important given the low rates of financial inclusion in rural areas of Côte d'Ivoire.

PAMF-CI lending schemes increase subjective well-being and decrease vulnerability. The funding provided by PAMF-CI appears to be sufficient to enable borrowers to improve their economic and social well-being and thereby enhance their resilience to adverse conditions.

Literacy and education matter. Another important contribution of the study is a deepened understanding of the importance of education for generating revenues and net profit and for maximising the benefits of microfinance.

Women entrepreneurs need to be empowered to increase positive impacts of lending. The research highlighted the marked differences in performance and firm profitability between men and women clients. While women are more likely to have more positive perceptions of economic well-being, men tend to earn higher revenues and net profits — in line with Koloma's (2016) findings for microfinance schemes in Mali. In addition, the inclusion of interaction terms suggests that men experience a greater positive impact of

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borrowing from PAMF-CI on their profits and revenues. It is, therefore, worth considering developing capacity-building initiatives that focus specifically on women.

Overall, customer satisfaction is high, but there is some dissatisfaction with the group lending approach.

The study shows that average customer satisfaction, measured using different dimensions of customer perceptions and expectations of PAMF-CI, is high. These positive opinions are shared across new and senior clients, as well as current and former clients. Group lending with cross-guarantees (where group members provide reciprocal guarantees for each other's liabilities) appear to be the main cause of dissatisfaction among borrowers, despite this being the collateral against which they are able to receive loans.

PAMF-CI loans have a positive outcome on local entrepreneurs. The results reveal a positive and statistically significant impact of successive borrowing on the economic and financial performance of local microenterprises, after controlling for individual background characteristics. These results imply that the number of loan cycles received by microbusinesses in support of their activities (including expansion) is an important determinant of business performance and business profitability. Our results also suggest that providing collateral-free loans to poor entrepreneurs has a strong and positive marginal effect on perceived economic well-being. However, our results do not reveal any significant impact on asset accumulation. This suggests that most of the profits have been reinvested back into the working capital of the businesses, enabling owners to generate substantial profits.

Data suggest that PAMF-CI loans are effectively invested in growing businesses. Despite the fact that money is fungible and could be used for a variety of purposes — such as household consumption or investment in alternative income-generating activities — the combination of both qualitative and quantitative data indicates that PAMF-CI microloans are mainly used for productive investments, in line with PAMF policies. 80% of clients reported that their businesses account for most of their income. Conversations with clients confirm that loans are used mainly to invest in and expand businesses. Separate data also show that one third of both senior and new participants who claimed to have developed at least one additional income-generating activity since joining PAMF-CI have generated higher incomes (16% more) than their counterparts. Discussions with PAMF-CI and cross-analyses of survey data reveal that, while only 30% of respondents have developed an alternative income-generating activity since becoming members of PAMF-CI, more than half of the respondents may already have had one or two additional income-generating activities prior to joining the scheme. PAMF-CI may wish to consider supporting clients in developing secondary or tertiary income-generating activities. This might help clients increase their economic stability and improve their vulnerability to economic shocks.

The study suffers from some limitations, including reliance on cross-sectional data and a focus on only one main client group. The study might pave the way to some further research, such as a deep dive assessment of smallholder farmers or an exploration of the impact of PAMF-CI on women, possibly at the household level. PAMF-CI's portfolio is largely composed of women and examining the causal effect of the loan schemes on them could be of benefit both for the institution itself and for its female clients. The development of an up-to-date electronic database of client histories and socio-demographic and financial data would make it easier to implement further research.

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Appendices

Appendix 1 — The dependent and independent variables

The dependent variables, independent variables and control variables are described below:

1. *SENIORITY (SEN)* is the main regressor — i.e. senior vs new — and was coded 1 for senior clients and 0 otherwise. In the case of an intermediary group of borrowers (*SEN2*), senior clients were coded 2; intermediary clients were coded 1 and 0 otherwise.
2. *LOAN CHARACTERISTICS (L)*: In addition to loan characteristics, which are captured in the main regressor, we also control for the average loan received by the borrower to date. The average loan received by a client is calculated as the ratio of total loans received divided by the number of loan cycles.
3. *CLIENT CHARACTERISTICS (X)*: we controlled for a set of clients' observable characteristics: age, gender, education, household size, sector of activity (sale of agricultural goods, sale of textiles/cosmetics, sale of processed products, services).
4. *FIRM CHARACTERISTICS (F)*: we used the lagged variable of the number of employees — i.e. the number of employees before joining the microfinance scheme — to control for firm characteristics: size.
5. *AREA CHARACTERISTICS (V)*: we controlled for the MFI branch area.
6. *REVENUES*: we use the accounting concept of sales — i.e. the income generated by a firm from the sale of goods and/or services within normal business activities.
7. *NET PROFIT*: net profit is computed from the total gross revenues earned by borrowers. The variable is calculated by subtracting additional business expenses (repayments, salaries, taxes and other expenditures) from annual total gross revenues.
8. *ASSET OWNERSHIP*: assets are defined to include property of any form that a client has purchased after joining the MFI. Some of the assets we tracked include property, equipment, furniture, machinery and land, all of which are highly regarded in Côte d'Ivoire. The assets variable is defined as binary, equal to 1 if the client purchased 3 assets or more, and 0 otherwise.
9. *(SUBJECTIVE) ECONOMIC WELL-BEING* is a composite index which equates to 1 if a client has reported having increased his overall earnings and seen an improvement in his/her overall living standards as a result of the loan, and 0 otherwise

Appendix 2: Impact indicators

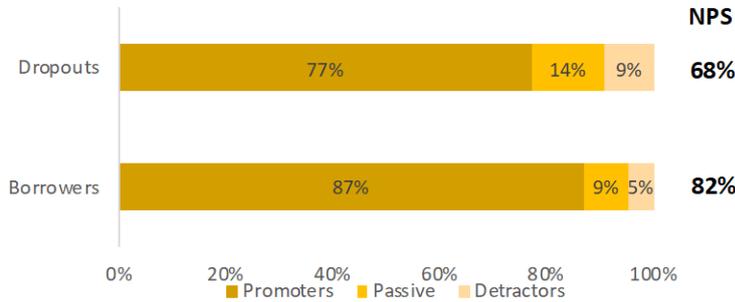
Questions		Indicators & Measures
How does the performance of microenterprises of 'senior clients' compare to those of 'new clients'? Are they benefiting from the loan scheme?	HYPOTHESIS 1. Successive borrowings from PAMF-CI has improved clients' business performance and profitability.	Revenues Gross profit Net profit
Are PAMF-CI 'senior borrowers' less vulnerable and more resilient to shocks?	HYPOTHESIS 2. PAMF-CI clients' access to microcredit has a positive effect on (1) objective and (2) subjective measures of welfare (indicators: (1) asset ownership; (2) perceived economic well-being).	Asset ownership Perceived improvement in living standards Perceived increase in overall earnings
Do PAMF-CI credit operations have a positive effect on subjective measures of well-being (perceptions of change in economic well-being)?		
Do PAMF-CI credit operations have a positive effect on objective measures of well-being (asset ownership)?		
NA	QUESTION 1. Who are PAMF-CI clients and former clients?	Indicators & Measures Gender Education Household size Age Marital status Type, sector and size of businesses
NA	QUESTION 2. What is the perception of clients and former clients of the quality of PAMF-CI services and products?	The interest rate of the loan Repayment frequency Technical assistance Quality perception Loan delivery period
NA	QUESTION 3. How likely are respondents to recommend PAMF-CI to a friend or relative?	Net Promoter Score

Appendix 3 — PAMF vs competitors (reported by enumerators)**PAMF vs competitors (reported by enumerators)**

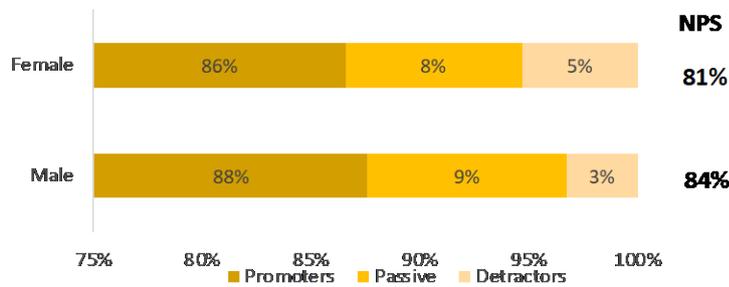
Items	PAMF	ADVANS	ECOCRED	UNACOOPEC	ATLANTIC MICROFINANCE
Interest rates	Fixed at 24% for solidarity loan	11% regressive	11% regressive	18.6% regressive	NA
Target	Poor population of northern and central regions	SMEs	Urban and peri-urban entrepreneurs		Microentrepreneurs and SMEs
Coverage	Northern and central regions (Khorogo, Boundiali, Dianra, Bouake)	Abidjan, Bouake, Khorogo	-	-	Bouake, Abidjan, Yamoussoukro
Products	Individual and solidarity loans	Individual and solidarity loans	Individual loan only	Individual and solidarity loans	Individual and solidarity loans Entrepreneurship training
Other conditions	Started business less than a year ago	Started business less than a year ago	Have a current account less than 2 months-old	-	NA
Collateral	No	Yes	Yes	Yes	A share of the required amount
Fees	No	Yes	Yes	NA	NA
Credit officer attitude		satisfied	satisfied		Not satisfied
Time spent on loan application	No	NA	NA	1 month	NA

Note: NA = Not Available

Appendix 4 — Level of satisfaction and NPS (Net Promoter Score)



Net Promoter Score: dropouts vs borrowers



Net Promoter Score by gender: male vs female

"I think the repayment frequency is very short."

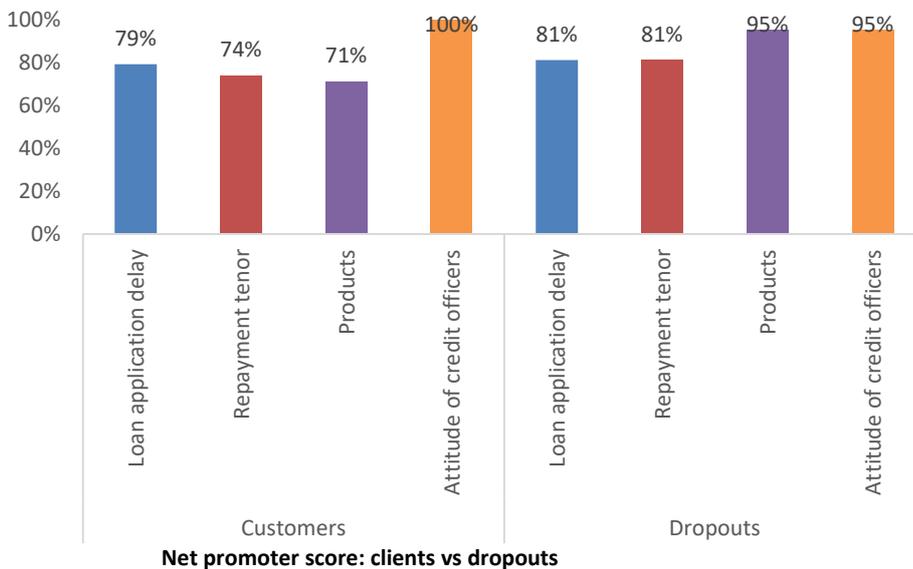
"I am not satisfied because the second microcredit loan was not received in time, so I couldn't turn to agriculture as a second activity."

"I am not satisfied as I did not receive the amount I asked for."

"Thanks to PAMF, I was able to start another business in addition to the farm I already had."

"I have a shop today and I can provide for my family, so I am happy."

"Microcredit loan I received has helped us in our group activities, but the problem is that the market is tough."



Net promoter score: clients vs dropouts

Appendix 5 — Revenues and profit

a) Main effects

	Log of sales		Net profit		With dropouts
	(1)	(2)	(3)	(4)	(5)
<i>Seniority (Ref. = New)</i>					
<i>Intermediate</i>	-	0.18 (0.09)**	-	0.17 (0.08)**	-
<i>Old</i>	0.37 (0.08)***	0.63 (0.10)***	0.27 (0.07)***	0.48 (0.09)***	0.23 (0.07)***
<i>Adjusted R-square</i>	0.34	0.38	0.31	0.35	0.29
<i>AIC</i>	554.16	531.88	462.25	454	521.46
<i>Branch (Ref. = Bouake)</i>					
<i>Bouadiali</i>	-0.69 (0.13)***	-0.69 (0.12)***	-0.06 (0.10)	-0.06 (0.1)	-0.04 (0.10)
<i>Gender (Ref. = Female)</i>	0.40 (0.10)***	0.37 (0.09)***	0.47 (0.09)***	0.51 (0.08)	0.47 (0.09)***
<i>Age group (Ref. = 18-35)</i>					
36-45	0.28 (0.12)**	0.27 (0.12)**	0.26 (0.11)**	0.27 (0.11)**	0.35 (0.13)***
46-55	0.15 (0.19)	0.11 (0.19)	0.37 (0.20)*	0.34 (0.21)*	0.50 (0.24)**
Over 55	-0.08 (0.37)	-0.10 (0.39)	0.26 (0.37)	0.20 (0.37)	0.52 (0.42)
<i>Age²</i>	0.00	0.00	0.00	0.00	0.00 (0.00)
<i>Education (Ref. = No education)</i>					
Primary	0.28 (0.12)**	0.25 (0.11)**	0.12 (0.09)	0.11 (0.08)	0.12 (0.09)
Secondary	0.32 (0.10)***	0.27 (0.1)**	0.30 (0.09)***	0.28 (0.09)***	0.34 (0.09)***
Vocational	0.50 (0.19)***	0.34 (0.21)	0.51 (0.21)**	0.39 (0.23)**	0.54 (0.21)**
University	0.64 (0.25)***	0.49 (0.22)	0.25 (0.17)	0.32 (0.17)*	0.39 (0.19)**
<i>Household size</i>	0.01 (0.01)	0.02 (0.01)*	0.03 (0.01)***	0.03 (0.01)***	0.03 (0.01)***
<i>Average loan received</i>	0.00	0.00	0.00	0.00	0.00 (0.00)
<i>Total employees prior to joining PAMF</i>	0.02 (0.02)	0.00	0.03 (0.03)	0.02 (0.02)	0.04 (0.03)
<i>Sale of textile and cosmetics</i>	-0.10 (0.08)	-0.06 (0.08)	0.01 (0.07)	0.03 (0.07)	0.01 (0.07)
<i>Constant</i>	14.83 (0.19)***	14.79 (0.18)***	13.47 (0.18)***	13.46 (0.18)***	13.50 (0.18)***
<i>Adjusted R-square</i>	0.34	0.38	0.31	0.35	0.29
<i>AIC</i>	554.16	531.88	462.25	454	521.46

N 270 269 269 269 287

Note: Standard errors in parentheses * p<0.1, ** p<0.05, *** p<0.01

b) With interactions (gender and education) and separation between duration and seniority

Promoting financial inclusion in Côte d'Ivoire

	Log of Net profit				Log of revenues			
	With gender only	With education only	With gender and education	DUR and SEN3	With gender only	With education only	With gender and education	DUR and SEN3
	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
<i>Seniority (Ref. = New)</i>								
<i>Intermediate</i>	-	-	-	0.04 (0.1)	-	-	-	0.01 (0.11)
<i>Old</i>	0.11 (0.09)	0.26 (0.11)**	0.12 (0.12)	0.00	0.14 (0.11)	0.37 (0.14)**	0.15 (0.15)	0.21 (0.13)
<i>Gender (Ref. = Female)</i>								
<i>Male</i>		0.48 (0.09)***	-	-	-	0.42 (0.11)***	-	-
<i>Male #0</i>	0.21 (0.11)*	-	0.21 (0.12)*	0.20 (0.11)*	0.10 (0.17)	-	0.13 (0.18)	0.06 (0.13)
<i>Male #1</i>	0.61 (0.10)**	-	0.61 (0.11)***	0.39 (0.11)***	0.60 (0.13)***	-	0.59 (0.13)***	0.38 (0.13)***
<i>Male #2</i>	-	-	-	1.1 (0.14)***	-	-	-	0.98 (0.14)***
<i>Branch (Ref. = Bouaké)</i>								
<i>Bouaké</i>	0.01 (0.10)	-0.07 (0.11)	-0.00	-0.06 (0.09)	-0.57 (0.13)***	-0.61 (0.14)***	-0.59 (0.14)	-0.79 (0.11)***
<i>Age group (Ref. = 18-35)</i>								
<i>36-45</i>	0.27 (0.11)**	0.27 (0.11)**	0.27 (0.11)**	0.25 (0.10)**	0.21 (0.13)	0.18 (0.13)**	0.21 (0.13)	0.34 (0.11)***
<i>46-55</i>	0.43 (0.20)**	0.43 (0.20)**	0.47 (0.20)**	0.34 (0.19)*	0.20 (0.21)	0.20 (0.21)	0.22 (0.21)	0.24 (0.18)
<i>Over 55</i>	0.28 (0.36)	0.38 (0.38)	0.40 (0.36)	0.13 (0.33)	0.06 (0.39)	0.14 (0.42)	0.13 (0.40)	-0.09 (0.35)
<i>Age²</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Education</i>								
<i>Primary</i>	0.19 (0.09)**	-	-	0.14 (0.08)*	0.33 (0.11)***	-	-	0.18 (0.09)*
<i>Secondary</i>	0.35 (0.09)***	-	-	0.28 (0.09)***	0.43 (0.11)***	-	-	0.24 (0.09)**
<i>Vocational</i>	0.55 (0.21)***	-	-	0.52 (0.22)**	0.52 (0.19)***	-	-	0.40 (0.22)*
<i>University</i>	0.37 (0.17)**	-	-	0.32 (0.14)**	0.66 (0.20)***	-	-	0.44 (0.19)**
<i>Primary#0</i>	-	0.22 (0.16)	0.31 (0.15)**	-	-	0.32 (0.23)	0.35 (0.23)	-
<i>Secondary#0</i>	-	0.19 (0.15)	0.25 (0.14)*	-	-	0.44 (0.24)*	0.44 (0.24)*	-
<i>Vocational#0</i>	-	0.48 (0.40)	0.57 (0.40)	-	-	0.41 (0.30)	0.47 (0.35)	-
<i>University#0</i>	-	0.09 (0.23)	0.24 (0.20)	-	-	0.14 (0.31)	0.24 (0.28)	-
<i>Primary#1</i>	-	0.07 (0.11)	0.12 (0.11)	-	-	0.25 (0.13)**	0.30 (0.12)**	-
<i>Secondary#1</i>	-	0.34 (0.12)***	0.38 (0.11)***	-	-	0.37 (0.13)***	0.40 (0.13)***	-
<i>Vocational#1</i>	-	0.50 (0.21)***	0.51 (0.20)**	-	-	0.53 (0.24)**	0.55 (0.23)**	-
<i>University#1</i>	-	0.66 (0.22)***	0.61 (0.20)***	-	-	0.94 (0.27)***	0.89 (0.26)***	-
<i>Household size</i>	0.03 (0.01)***	0.03 (0.01)***	0.02 (0.01)**	0.03 (0.01)***	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)*
<i>Average loan received</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Total employees prior to joining PAMF</i>	0.04 (0.03)	0.04 (0.03)	0.04 (0.03)	0.02 (0.02)	0.04 (0.02)*	0.04 (0.02)	0.04 (0.02)	-0.01 (0.02)
<i>Sale of textile and cosmetics</i>	0.01 (0.07)	0.00	0.01 (0.07)	0.05 (0.07)	-0.09 (0.08)	-0.08 (0.08)	-0.08 (0.09)	-0.06 (0.09)
<i>Constant</i>	13.52 (0.18)***	13.55 (0.19)***	13.60 (0.19)***	13.52 (0.17)***	14.90 (0.20)***	14.83 (0.22)***	14.94 (0.21)***	14.96 (0.16)***
<i>Adjusted R-square</i>	0.36	0.33	0.38	0.43	0.31	0.30	0.32	0.48
N	267	269	266	266	267	270	265	263

Note: Standard errors in parentheses * p<0.1, ** p<0.05, *** p<0.01

Appendix 6 — Economic well-being

a) Main effects

Marginal effects

Number of observations (N)

	<i>Beneficiaries</i>	<i>Including intermediary beneficiaries</i>	<i>With dropouts</i>	<i>Using LPM</i>
	(7)	(8)	(9)	(10)
<i>Seniority (Ref. = New)</i>				
<i>Intermediate (SEN2)</i>	-	0.12*	-	-
		(0.04)		
<i>Old</i>	0.15***	0.18***	0.15***	0.12**
	(0.04)	(0.05)	(0.04)	(0.05)
<i>Branch (Ref. = Bouake)</i>				
<i>Boundiali</i>	-0.53***	-0.52***	-0.52***	-0.50***
	(0.06)	(0.06)	(0.05)	(0.06)
<i>Gender (Ref. = Female)</i>	-0.09	-0.09	-0.11**	-0.05
	(0.05)	(0.03)	(0.05)	(0.06)
<i>Age group (Ref. = 18-35)</i>				
<i>36-45</i>	-0.17***	-0.17***	-0.02	-0.16***
	(0.05)	(0.05)	(0.08)	(0.06)
<i>46-55</i>	-0.15**	-0.14**	0.17	-0.19***
	(0.06)	(0.06)	(0.13)	(0.06)
<i>Over 55</i>	-0.51***	-0.53***	-0.01	-0.37***
	(0.10)	(0.09)	(0.28)	(0.10)
<i>Education (Ref. = No education)</i>				
<i>Primary</i>	0.25***	0.23***	0.16***	0.24***
	(0.06)	(0.05)	(0.05)	(0.07)
<i>Secondary</i>	0.17***	0.16***	0.10*	0.15**
	(0.06)	(0.06)	(0.06)	(0.07)
<i>Vocational</i>	0.34***	0.32***	0.30**	0.21
	(0.12)	(0.12)	(0.12)	(0.21)
<i>University</i>	0.17	0.15	0.26***	0.15
	(0.11)	(0.10)	(0.09)	(0.10)
<i>Household size</i>	-0.14**	-0.00**	-0.00**	-0.01
	(0.01)	(0.01)	(0.00)	(0.01)
<i>Log (Average loan received)</i>	-0.03	-0.03	0.00	-0.04
	(0.02)	(0.00)		(0.02)
<i>Total employees prior to joining PAMF</i>	0.05**	0.05**	0.05***	0.04***
	(0.02)	(0.02)	(0.01)	(0.01)
<i>Economic activity (Ref. = Sale of agricultural products)</i>				
	-0.12**	-0.12**	-0.17***	-0.10
	(0.05)	(0.05)	(0.05)	(0.07)
	-0.17***	-0.16***	-0.15**	-0.14**
	(0.06)	(0.06)	(0.06)	(0.07)
	-0.01	-0.01	-0.01	0.02
	(0.01)	(0.01)	(0.07)	(0.08)
	-0.30***	-0.31***	-0.27***	0.31***
	(0.08)	(0.08)	(0.08)	(0.11)
<i>AIC</i>	220.73	221.37	268.02	259.47
<i>LROC</i>	0.917	0.917	0.896	-

N 265 265 285 271

Note: Standard errors in parentheses * p<0.1, ** p<0.05, *** p<0.01

b) With interactions (gender and education) and separation between duration and seniorityOdds ratio

	<i>With interactions</i>	<i>Separation between loan cycles and duration in the programme</i>
	(11) OR	(12) OR
<i>Seniority (SEN) (Ref. = New)</i>		
<i>Old</i>	2.22(1.38)	
<i>Seniority (SEN3) (Loan cycles)(Ref.=one loan cycle)</i>		
<i>Old1</i>		3.42(2.35)*
<i>Old2</i>		2.88(2.43)
<i>Duration in the programme (DUR)</i>		
<i>Branch (Ref. = Bouake)</i>		0.53(0.28)
<i>Boundiali</i>	0.05(0.00)***	0.02(0.018)***
<i>Gender (Ref.=Female)</i>		0.21(0.15)**
<i>Old* Gender (Ref. = Female)</i>	2.50(1.52)	20.89(21.44) ***
<i>Age group (Ref. = 18-35)</i>		
<i>36-45</i>	1.26(0.96)	0.36(0.16)**
<i>46-55</i>	15.45(22.17) *	0.34(0.18) **
<i>Over 55</i>	16.26(38.66)	0.06(0.06)***
<i>Age2</i>		
<i>0.99(0.00)***</i>		
<i>SEN*Education (Ref. = No education)</i>		
<i>Old*Primary</i>	12.61(9.33) ***	0.25 (0.31)
<i>Old* Secondary</i>	1.23(0.63)	0.15(0.17)
<i>Old* Vocational</i>	-	-
<i>Old* University</i>	-	-
<i>Education</i>		
<i>Primary</i>	-	9.03(8.44) **
<i>Secondary</i>	-	6.01(4.68) **
<i>Vocational</i>	-	23.03(28.93)**
<i>University</i>	-	2.69(2.34)
<i>Household size</i>		
<i>0.92 (0.56)</i>		
<i>Log (Average loan received)</i>		
<i>0.91 (0.06)</i>		<i>0.99(4.12)</i>
<i>Total employees prior to joining PAMF</i>		
<i>1.57(0.30)**</i>		<i>1.28(0.28)</i>
<i>Economic activity (Ref. = Sale of agricultural products)</i>		
<i>0.48(0.20)*</i>		<i>0.76(0.27)</i>
		-
<i>AIC</i>	220.09	274.02
<i>LROC</i>	0.91	0.86

N 281 281

Note: Standard errors in parentheses * p<0.1, ** p<0.05, *** p<0.01

Appendix 7 — Estimation of poverty rates**a) Poverty measurement strategy — estimation technique**

There are various reasons why one might choose either consumption or income data when estimating the poverty rate of a group of households. Consumption is often deemed a superior measure of material well-being because consumption smoothing behaviour means that consumption measures are less volatile than income. On the other hand, income data are often considered easier to collect — this was certainly the case in our study, where the respondents had a limited number of income sources.

We define consumption expenditure as the sum of the total outflow of money from a household; this measure accounts for the main consumption categories (i.e. rent, electricity, water, etc.) but not for potential adjustments (i.e. consumption of own produce for farmers). In order to account for differences in household size, consumption is normalised using a common equivalisation method: the square root of the total number of household members. Adjusting downwards using this equivalisation method accounts for economies of scale that large families enjoy and for the fact that larger families include children who tend

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to consume less than adults, whereas the poverty line is calibrated for adult consumption. On the other hand, our income measure assumes only one income source, whereas with an average household size of eight, it seems highly likely that other household members are economically active.

The 2015 Household Survey reports regional poverty lines of XOF 699¹⁶ and XOF 581 in Bouaké and Boundiali respectively. Accounting for the inflation rate between 2015 and 2017, we increased these figures to an average of XOF 707 and XOF 588, resulting in the following poverty rates:

<i>Poverty measure</i>	<i>Average poverty rates</i>	<i>Boundiali</i>	<i>Bouaké</i>
Per capita consumption expenditures	29.54%	49.09%	10%

b) PAMF-CI poverty measurement strategy - PPI (Progress out of Poverty Index) scorecard

PAMF-CI has been using the PPI poverty measurement tool for nearly two years. The PPI scorecard for Côte d'Ivoire is an easy-to-use, country-specific, poverty scorecard that was developed by Schreiner (2013). It was calibrated on the 2008 National Household Survey (ENV2008) conducted by the Government of Côte d'Ivoire and was constructed using the data from 12 600 households.

The scorecard uses a series of ten questions on household characteristics to estimate the likelihood that a household has per capita consumption below the national poverty line. The poverty line was set at XOF578¹⁷ per adult per day in 2008 prices considering food and non-food expenditure. The latter was adjusted for household size, inflation, and differences in price levels.¹⁸

Using the PPI on a sample of about 309 PAMF-CI borrowers (2013-2017) reveals that the Boundiali branch has the highest poverty incidence, with 49.09% of the population, on average, living below the national poverty line, versus 14.40% in Bouaké. The lower poverty rate of the latter branch appears to be the result of a diversified portfolio and a greater concentration in urban areas. The results are roughly in line with our consumption expenditure-based measure, giving further confidence that the estimates can be considered meaningful.

<i>Poverty measure</i>	<i>Average poverty rates</i>	<i>Boundiali</i>	<i>Bouaké</i>
Progress out of Poverty Index (PPI)	31.74%	49.09%	14.40%

c) Limitations and points for consideration

- Consumption expenditures do not account for consumption of own production. More than 90% of respondents live in rural areas, where the majority are likely to be involved in farming as a secondary activity. Nevertheless, further analyses also suggest that secondary activities, whether in agriculture or any other sector, do not have a significant effect on reported expenditures.
- We cannot rule out some measurement error for consumption expenditures.

¹⁶ An analysis of a sample of more than 4 000 clients in Bouaké shows that only 8% of clients are from rural areas. As such, we use the poverty line for urban areas in Bouaké and find a poverty rate of 9.5% rounded up to 10% in the present study.

¹⁷ XOF 578 is the 2008 national poverty line for Côte d'Ivoire (2008 Abidjan proxy). This line is adjusted for price changes over time and also for price differences across geographic regions, with the base being average prices in Abidjan from June to August 2008 (Schreiner, 2013).

¹⁸ The 2018 PPI for Côte d'Ivoire, benchmarked on the 2015 Household Survey, has just been released. Source: http://www.simplepovertyscorecard.com/CIV_2015_ENG.pdf

- An analysis of the relationship between income and consumption shows that a 1% increase in respondents' net profits results in a 16% rise in consumption expenditure.
- The PPI used by PAMF-CI is benchmarked on the 2008 National Survey. According to Schreiner (2013), the 2008 Ivorian PPI will generally be biased, most probably underestimating poverty rates when applied after August 2008.

Appendix 8 — An estimation of a lower bound of the rate of return

Question: *What is the average rate of return that yields a net profit gap of XOF 648 000 between senior and new borrowers after four years?*

Background

Descriptive statistics show that senior clients who have received at least two loans have earned about XOF 2.524 million in net profit; that is about XOF 648 000 more than new clients. At the same time, PAMF-CI granted XOF 430 000 on average per cycle to senior borrowers, whereas new borrowers received XOF 413 000 on average, at a nominal interest rate of 24% per annum.

Assumptions:

- The research focuses on a four-year microlending programme and assumes that senior clients have received at most one loan every year for a total of four years;
- The loan proceeds are received at the beginning of each year, but principal payment is made at the end of the year;
- Interest repayments are made on a monthly basis, resulting in an effective annual interest rate (EIR) of 26.8% per annum adjusted for the number of compounding periods;
- The rate of return is on an annual basis and the client reinvests 100% of its profits back into the business;
- Revenues earned by both new and senior borrowers are observed at the end of the year after repayment of both the loan principal and interest cost.

Let us assume that L is the average loan received by clients once every year for four years; $L = 430\,000$ and is invested at the beginning of the year. If we consider r as the annual nominal interest rate compounded 12 times a year, and R the expected annual rate of return that yields a net profit gap of XOF 648 000 between senior and new clients at the end of year four, then, the estimated lower bound of R is nearly 78.8%. This lower bound of the rate of return appears to be sensitive to the number of loan cycles: it fluctuates from 28.44% for two loan cycles to 40.5% for three loan cycles, and up to more than 100% for four loan cycles.

Overall, this is a proxy measure of the social return of the whole programme, but the estimation technique highlighted here is purely theoretical and should be used with caution.

Irrigation technology adoption and microfinance in rural Benin: RENACA's agricultural loan programme

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Headline impacts

Farmers in rural Benin find it difficult to access finance to improve agricultural productivity. Although 70% of respondents are financially included via microfinance, banking or mobile money, most (60%) have never accessed a formal loan, and only 16% have received an agriculture loan.

RENACA (Réseau National des Caisses d'Épargne et de Crédit Autogérées) is contributing to financial inclusion. Thanks to its comprehensive product, which combines working capital and investment assets, the institution is close to farmers' needs. In fact, surveyed farmers recognised that access to credit to finance non-machinery inputs (fertilisers, seeds) is as important as access to capital for investment in irrigation equipment.

Lack of collateral reduces the ability of farmers to access finance and to invest. Farmers who rent or borrow land indicated a lower willingness to invest in their activities and adopt advanced technologies, including irrigation equipment. Instead, they invest in transport. This allows them to get perishable products to markets in time but does not improve productivity in the long run.

Company overview

RENACA is a microfinance institution whose mission is to provide high-quality financial and support services to strengthen the economic well-being of both urban and rural populations in Benin. They are increasing their agricultural lending with a new agricultural loan programme, which is expected to improve productivity for smallholder farmers and consequently increase their income levels.

RENACA was created in 2005 and has received funding and technical assistance under the Participatory Microfinance Group for Africa (PAMIGA), a microfinance investment vehicle that received funding from the European Investment Bank under the IFE.

Summary

Introduction

The productivity of agriculture has been stagnant since the 1980s, which explains its modest contribution to the continent's gross domestic product (AGRA, 2018). Thus, in Benin as elsewhere in Africa, improving productivity is a priority for economic transformation and for food security (Hazell 2011), especially since annual population growth in Benin (average of 3.2%) is higher than overall agricultural growth per year which averages 3% (Amegnaglo, 2018; Calderon et al., 2018). Changes in productivity would be expected to occur through the adoption of enhanced inputs and farm equipment – a shift away from reliance on increased acreage and family labour. According to the theory of agricultural intensification (Binswanger-Mkhize and Savastano, 2017), population growth and urbanisation may trigger a virtuous cycle of higher use of inputs, higher investment in mechanisation and irrigation in farming systems. Research in agricultural economics has also shown that the absence of irrigation systems is an obstacle to higher agricultural productivity in Africa (Binswanger-Mkhize and Savastano, 2017).

Agriculture represents over half of total employment in sub-Saharan Africa (AGRA, 2018; ILO, 2017). In Benin, it accounts for around 32% of GDP and nearly 70% of total employment (Calderone et al., 2018). A major feature of African agriculture is the dominance of smallholder farmers, mainly subsistence-oriented, and a limited number of large-scale commercial farms. According to various sources (FAO, 2015; Cuevas and Anderson, 2016; ISF, 2016), there are between 400 and 500 million smallholder households worldwide¹, located mainly in Asia and sub-Saharan Africa. Smallholders represent 38% of those living on less than two dollars a day and are the main source of household, regional and national food production. Agricultural production systems of smallholders rely mostly on family labour, with limited use of improved inputs, production methods or farm equipment.

Calderone et al. (2018) show that only 7% of cultivated land is irrigated in Benin, leaving large potential for further adoption of irrigation technology with an estimate of 205 000 hectares available for irrigation. A likely explanation for the low level of investment in agriculture, at a time when market potential is growing, is the lack of financial capital. Agriculture in general, and small-scale farming, is often outside the business models of banks and credit institutions in developing countries. According to a report by the Initiative for Smallholder Finance (ISF), informal and formal financial institutions and value chain actors currently provide an estimated USD 50 billion of credit annually, compared to the more than USD 200 billion needed by smallholder finance in developing countries (ISF, 2016). In the absence of access to capital, smallholders tend to adopt labour-intensive practices, which are associated with low productivity growth (Cuevas and Anderson, 2016). Lack of access to credit limits opportunities to implement the necessary agricultural investments, specifically in irrigation (Amegnaglo, 2018). In Benin, only 17% of the population had a bank account in 2015 (IMF, 2018) and access to finance is particularly difficult for vulnerable groups, such as smallholder farmers.

Innovations offered by financial services providers relaxing smallholder farmers' credit constraints have led to promising results. Cash-flow friendly lending mechanisms, with flexible payment schedules, and hybrid products incorporating technical assistance, such as training, are some of the prominent developments emerging in the last five years (Hystra, 2015). In Benin, RENACA agricultural loans fit into this emerging trend. RENACA is one of the two MFIs in the PAMIGA network in Benin. PAMIGA is a microfinance

¹ Defined as those who own less than two hectares of farmland and rely on agricultural production for their livelihoods.

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investment vehicle which has partially financed RENACA's agricultural loans portfolio and water and energy access programme².

RENACA's stated mission is to strengthen the economic well-being of rural populations by providing quality financial products and services. Its current business model also aims at increasing its footprint in the market for agricultural credit. The objective of RENACA's agricultural loan programme is to improve productivity for smallholder farmers and consequently increase their income levels.

In this report, we focus on RENACA's loan programme for smallholder farmers to document and analyse background data on the farming practices, constraints and outputs of those farmers who already form part of the promoter's portfolio, or, prospective clients. We designed a baseline survey with the goal of preparing the ground for a future impact assessment, and to enable us to address the following research questions:

1. Which financial and output market and non-market mechanisms are associated with smallholder farmers' decisions to invest in agriculture in general, and in irrigation technology in particular?
2. How do these mechanisms explain differences in irrigation technology adoption among farmers?

The main objective of this research is to provide insights on Beninese smallholder farmers' investment decisions and, specifically, the mechanisms which explain the adoption of irrigation technology.

Literature review

Smallholder farming and low productivity characterise the agricultural sector in most sub-Saharan African economies. In our study, we seek to research two of the issues that analysts have identified as obstacles to agricultural productivity, namely financial constraints and the adoption of quality, tangible and intangible inputs.

Factors associated with smallholder productivity

Major contributions to the literature on smallholder farming cite access to markets, including input, output and credit markets, as well as the adoption of critical infrastructures, such as water and irrigation systems (Cuevas and Anderson, 2016), as important factors constraining farm output growth.

According to the Boserup-Ruthenberg (BR) theory of agricultural intensification, two main factors may trigger a virtuous cycle of higher use of inputs, higher investment in mechanisation and irrigation in the farming system, namely urban population growth, and wider market opportunities and easy access to urban markets. An increase in investment levels and use of inputs may lead to higher production in response to higher demand, which raises farmers' incomes. On the other hand, an agricultural involution could occur if population growth and market access are insufficient to initiate intensification and higher food production (Sheahan and Barrett, 2017; Christiaensen, 2017)³.

² The European Investment Bank (EIB), under its Impact Financing Envelope (IFE), invested in the Participatory Microfinance Group for Africa (PAMIGA), a microfinance investment vehicle. The purpose of this investment is to develop microfinance institutions (MFIs) loan portfolios dedicated to micro and small projects in renewable energy, irrigation and/or drinking water. The EIB financed one third of PAMIGA's programme, totalling EUR 12 million over a 7-year term.

³ Agricultural involution refers to increasing output per acre without increasing output per worker.

The literature shows that agricultural intensification in Africa has progressed since the 1980s in line with the first scenario predicted by the BR theory. A recent study by Binswanger-Mkhize and Savastano (2014) has sought to shed more light on this intensification. Describing the status of intensification across six countries (Ethiopia, Malawi, Niger, Nigeria, Uganda and Tanzania), the authors find that farming systems in these countries lag behind those of other parts of the world, especially with respect to investment in both mechanisation and irrigation. Higher levels of demand for food are met through labour-intensive production, which leads to low marginal returns on non-labour inputs for farmers (Cuevas and Anderson, 2016).

In the BR model, investment in irrigation and mechanisation should be the principal policy instruments in the case of population pressure and proven market opportunities. However, Binswanger-Mkhize and Savastano (2017) show that the average irrigated area per farm is 0.03 hectares (ha), which corresponds to 4.4% of total arable land in the surveyed countries. This result contradicts the BR theory, which predicts higher irrigation levels conditional on strong population growth and urbanisation in these countries. This result also leads to a question regarding observed low levels of irrigation in a country like Benin, exhibiting the same prerequisites, namely strong population growth and urbanisation (Amegnaglo, 2018). Enhancing the productivity of the agricultural sector in Benin is a major challenge. Current production systems rely heavily on extension of cropped areas and on family labour, with only limited use of improved inputs and farm equipment (IMF Country Report: Selected Issues, 2018/2; Calderone et al., 2018).

An alternative explanation discussed in Binswanger-Mkhize and Savastano (ibid.) is the scarcity of groundwater. Smallholder farmers would be likely to increase their production if they were equipped with irrigation equipment to access water. Recent studies by Burney et al. (2013) highlight the importance of investments in irrigation systems for improving rural development and nutritional outcomes throughout sub-Saharan Africa. In Benin, investment in irrigation appears particularly promising in this regard (Calderone et al., 2018).

Thus, low agricultural productivity in Benin, and in most countries of the region, would appear to be linked to low investment in mechanised equipment, irrigation systems and seeds, even though demand is rising constantly. According to the ISF (2016) report, interventions built on productivity-enhancing technologies, such as micro-irrigation, could yield up to 140% income gains for smallholders. These productivity-enhancing technologies typically require finance whereas, in reality, financial limitations constrain smallholders' investment decisions.

Capital constraints and investment

In many regions of the world, smallholders are among the most excluded groups from access to formal financial services. The need to improve access to adequate financial services for smallholders is well documented (Meyer, 2011; Miller et al., 2011; Binswanger-Mkhize and Savastano, 2017). Small farmers were left behind during the rise of financial liberalisation in the past three decades in sub-Saharan Africa, with only a small fraction of loans (5-7% of total) allocated to agriculture. Because of limited access to capital, smallholders tend to adopt labour-intensive practices, compatible with off-farm activities in some cases (Cuevas and Anderson, 2016).

In Benin, Calderone et al. (2018) show that access to credit is scarce for farmers outside the cotton sector. This limits their ability to carry out needed investments, specifically in irrigation. The capital investment for productivity-enhancing technology may require a lump-sum outlay that is not readily available to farmers.

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Thus, access to credit markets for the acquisition of technology may be the key to clarifying the question raised above. According to Karlan et al. (2014), potential welfare gains from improved financial market access for smallholders may be significant due to high marginal returns on investment. Innovations from financial services providers seeking to relax constraints to credit access for smallholder farmers have become increasingly common in African financial markets, including in Benin. However, improved access to credit may be insufficient to bring about an increase in investment in agriculture as idiosyncratic factors also come into play in investment decisions.

Investment and access to information and output markets

In the literature, urban population growth is assumed to increase demand for agricultural products and thus lead to intensification. However, farmers in rural areas with little infrastructure do not always have market access. Thus, as noted by Amegnaglo (2018), improved access to markets increases the yield of maize producers in Benin. Improved access to markets leads to greater intensification and reduces financial losses arising from perishable goods. Under these conditions, market access is a major factor that can boost investment in agriculture.

Other factors, such as farmers' access to information and training, also come into play. For example, information and training can play major roles in increasing access, adoption and the impact of irrigation technology for farmers. According to Colback et al. (2017), farmers' skills and training are key enabling factors determining the impact of efficient irrigation technology on productivity, alongside soil quality and the quality of the adopted technology. Christian et al. (2018) conducted a randomised control trial in Mozambique and found that, in the context of irrigation schemes, feedback tools, which provide information on general and individualised water requirements for crops, lead to higher reported and observed water sufficiency relative to expected levels. It will be interesting to provide insights into the merits of different irrigation technologies in a setting where farmers adopt a heterogeneous set of irrigation technologies and have different skill sets.

Karlan et al. (2014) examine the effects of risk perception on agricultural investment levels. They note that aversion to rainfall volatility and low confidence in the effectiveness of the benefits from the investment, coupled with an absence of insurance policies adapted to smallholder farmers, are potentially constraining factors to investment decisions (Hystra, 2015). Training and information can help overcome the lack of confidence in productivity-enhancing technologies and boost the profits farmers can derive from them (Buehren et al., 2017).

In summary, a review of the relevant literature in agricultural economics indicates that labour-intensive practices, showing low marginal returns to inputs, characterise smallholder farming in developing countries such as Benin. Investments in mechanised equipment and in efficient irrigation systems should serve to improve productivity. Yet, recent research-(Christian et al., 2018) indicates that in Mozambique only 30% of farmers adopt technologies suitable for irrigation. We believe that market forces related to access to credit and the difficulty of selling to output markets in urban areas may constitute significant obstacles to investment decisions on irrigation technologies. Institutions, such as RENACA, by delivering loan programmes to assist farmers to invest in mechanised equipment and irrigation systems, could alleviate the negative effects of these market failures on farm growth. Such programmes, designed to encourage farmers to invest in mechanised equipment and irrigation systems, should include technical assistance and training components to address what we call 'non-market forces', such as agricultural skills.

Background

In February 2018, we conducted a first mission to Benin to gain a better grasp of RENACA's operations and to organise focus group discussions with farmers designed to better understand the contextual environment and the main constraints facing farmers. We held three focus group discussions with farmers who were current or prospective clients of RENACA.

In our research, we targeted smallholder farmers who grow vegetables in Bohicon District in northern Benin and in the Mono Region in the south. Most of these farmers were members of professional associations in the agricultural sector.

Our objective during these discussions was to identify and document constraints to investment in irrigation equipment and to understand farmers' access and demand for financial services.

We conducted semi-structured interviews on the adoption of irrigation technologies (current systems, level of information on alternatives, constraints to investing in better performing systems), on the commercialisation of crops (access to markets, role of intermediaries, price information, competition) and on financial inclusion (access to credit, relationships with banks and microfinance institutions). We gained many useful insights from these focus group discussions, e.g.:

- a. Access to credit for purchasing non-machinery inputs (fertilisers, seeds) is viewed as being as important as access to capital for investment in irrigation equipment⁴.
- b. Land ownership also emerged as a major issue for these farmers: farmers who rent or borrow land indicated a lower willingness to make investments. Such farmers are not able to access loans exceeding CFA 500 000 (USD 862) from RENACA. Beyond this threshold, RENACA requires a lien on property as a guarantee.
- c. The most frequent transition between irrigation systems is from the Californian system⁵ to the perforated strips system⁶. Drip irrigation systems⁷, which are more sophisticated and costlier, are scarce.
- d. Based on the outcome of our focus group discussions, we noted that it would be worthwhile measuring the effect of investment in terms of productivity indicators, such as time savings and lower expenditure on hired labour, rather than in terms of output indicators of yield per acre.
- e. Access to markets is an important factor when assessing the impact of investments in agriculture. Based on our interviews, few individuals or organisations access markets through intermediaries. Most farmers sell their crops directly. For those who produce easily perishable goods, the risks are then high.

⁴ For this reason, RENACA offers more comprehensive credit than other lenders, combining working capital with investment capital.

⁵ The Californian system is a network of PVC pipelines buried underground to deliver water from the source to the field and distributed through furrows.

⁶ A system with holes perforated in lateral irrigation pipes designed to distribute water uniformly in the field.

⁷ A system which drips water into the soil at very low rates of flow from a network of small diameter plastic pipes with outlets. It applies water close to the plant in such a way that only parts of the soil where the roots grow are irrigated.

Methodology

Analytical framework

Theory of change (TOC)

We present a stylised model that we use in conjunction with information collected during our mission to develop a theory of change. The literature on agriculture intensification cites several factors that determine the production function of small farmers. Among the inputs, there are elements of physical capital – such as the quality of soils, crops, irrigation technology – as well as individual characteristics, such as farmers' skills (Cuevas and Anderson, 2016). Opportunities for acquiring physical capital are contingent on market forces such as access to finance. Farmers can acquire production-enhancing skills through training and advice.

We present here the stylised model as follows, as a guide to our research hypotheses. We assume a farmer has production function $Y(\cdot)$ with productivity A and uses three inputs: namely, labour (L), capital (K) and skills (S). The decision problem then amounts to choosing capital and labour, given a level of productivity and skills. Assuming well-behaved technology and complete markets, the first order conditions of the farmer's optimisation problem lead to equality between the marginal products of capital and labour with respect to their factor prices (w and r). That is,

$$Y_L(A, K^*, L^*, S) = w \quad (1)$$

$$Y_K(A, K^*, L^*, S) = r \quad (2)$$

From the results produced by equations (1) and (2) above we can derive several hypotheses regarding the relationship between market and non-market forces and how these affect farmers' investment decisions.

Hypothesis 1: Where farmers are *not* credit-constrained, but do *not* act on available information on the advantages of efficient irrigation technologies, access to credit for irrigation technology would only serve to increase their physical capital.

Hypothesis 2: Where farmers are *not* credit-constrained, but do *not* act on available information on the advantages of efficient irrigation technologies, non-market forces, such as access to information and training, can enhance farmers' irrigation skills, which represent complements to capital. In other words, $\frac{dK}{dS} > 0$. In such a case, non-market forces boost production through lower levels of expenditure on irrigation. Farmers may also increase expenditure on other inputs, such as chemicals and fertilisers. The effect on labour would depend on the relationship with the adopted technology (whether technology is a complement to or a substitute for it). Finally, the probability of adverse credit events (default) is also lower than in the case without access to information and training.

Hypothesis 3: Where farmers *are* credit-constrained, and do not benefit from learning of the advantages of irrigation technology, loans create higher levels of physical capital in the form of irrigation technology. The effect on labour is ambiguous and dependent on the type of irrigation technology adopted. Some types of technology (such as drip and sprinkler) might form substitutes for labour, whilst others might be complements (such as hand irrigation). In either case, the net effect of credit on production is ambiguous. Without a change in skills, loans may not affect production levels.

Hypothesis 4: Where farmers *are* credit-constrained but would benefit from learning of the advantages of irrigation technology, an increase in production would take place through two channels: firstly, farmers would increase their physical capital through the acquisition of an irrigation system; secondly, they would be equipped with a new set of skills in order to benefit from the adopted irrigation technology. There is also a third possible channel, namely that farmers might also adopt improved seeds and fertiliser.

The following theory of change summarises the operationalisation of these hypotheses in the context of Benin.

Table 1: Theory of change

Needs/Problems	Inputs/Activities	Outputs	Outcomes	Impact
Inefficient irrigation technologies (hand watering) require high labour inputs and induce high fuel expenditure for pumping water	Farmers are informed about efficient irrigation technologies and the possibility of obtaining credit through RENACA to finance such products	Credit take-up to finance working capital and/or irrigation systems	Farmers invest in efficient irrigation equipment	Reduction in time spent watering plants
Cash constraints and limited access to credit hinder farmers' ability to purchase efficient irrigation technologies	Following the information sessions, interested farmers can apply for a RENACA loan dedicated to agriculture and irrigation technology	Take-up of efficient irrigation technologies	Farmers have additional working capital to run operations	Increase in time spent on other productive activities
Weak property rights to pledge as collateral hinder access to credit for most borrowers	RENACA provides individual loans of up to CFA 500 000 (USD 862 in 2019) without collateral and up to CFA 3 million (USD 6 042) with collateral			Lower expenditure on hired labour for irrigation tasks
Limited knowledge of the benefits of superior irrigation technologies is an obstacle to adoption				Savings from efficient irrigation technology are either reinvested or spent on welfare-enhancing items
				Increase in output and income

Research questions and assumptions

In our theory of change, we posit that the production function of smallholders includes both elements of physical capital, such as irrigation technology, and individual characteristics, such as skills. We associate the level of physical capital with the strength of financial and output market forces, while the acquisition of agricultural skills falls into the category of non-market forces. Thus, based on the theory of change presented above, together with our analysis of the local context, we formulate a main research question in line with the priority areas identified by the promoters and the investee company. The main question addressed in the research is:

Which market and non-market mechanisms are associated with smallholder farmers' decisions to invest in agriculture in general, and in irrigation technology in particular?

The secondary question we seek to answer is as follows:

How do these mechanisms explain differences in irrigation technology adoption among farmers?

To be able to answer these research questions, we will examine the roles of market forces (access to market and access to finance) and of non-market forces (access to information, training, socio-environmental aspects) in forming farmers' investment decisions, and in determining outcomes from the adoption of irrigation technologies.

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Three assumptions will direct our analysis of the main and subsidiary research questions:

- a) **Market forces:** the decision to invest in agriculture and to adopt irrigation technology can depend on farmers' desire to increase their outputs in response to higher demand and greater market opportunities (Karlan et al., 2015; Hystra, 2015).
- b) **Market forces:** access to credit and finance are enabling factors in determining irrigation technology adoption.
- c) **Non-market forces:** investment decisions depend on farmers' and farms' individual characteristics, as well as on the business environment. More specifically, other aspects, such as the level of agricultural knowledge, come into play (based on access to information, training opportunities and skills) along with other factors, such as access to subsidies, soils and crop types, and farm location.

Table 2: Research assumptions, outcome variables

Research assumptions	Explanatory variables	Indicators
1 - Market forces.	Investment in land, inputs and irrigation technology	Land ownership, total area under cultivation, number of land transactions Previous growing season expenditure on seeds and other inputs (fertilisers, pesticides) Water resources at disposal, investment in irrigation equipment since the beginning of farming activity Production per acre for the three main crops in the last season Turnover/sales for each crop
a) The decision to invest in agriculture and to adopt an irrigation technology can depend on farmers' desire to <u>increase their crops</u> in response to higher demand and market opportunities	Access to agricultural markets	Type of sale (direct, intermediate, futures contract) Distance to the largest market/city
b) Access to credit and equipment markets are enabling factors in irrigation technology adoption	Access to finance	Account ownership (bank, MFI or mobile money account) Membership of a ROSCA (Rotating Savings and Credit Association) Use of credit in financing investments since the start of farming activity
	Access to equipment market	Access to information or training provided by irrigation equipment suppliers
2 - Non-market forces.	Interaction with peers	Access to information and training through the CRM (Regional farmers' centres)
Among non-market forces: social or peer interaction, access to information, access to subsidies and training opportunities can all shape farmers' decisions regarding investment	Access to information	Education level
	Access to support and training	Ownership and use of TV, radio and mobile phone Access to financial or in-kind support from public or private organisations Access to training on agriculture and irrigation-related topics

We adopted a methodology combining field surveys with information sessions on irrigation techniques. The following section provides details on this design.

Sampling, instrument design and data collection

Since the disbursement of the first project loans only commenced in July 2017, we designed an extended baseline survey aiming to provide meaningful answers to our research questions and to gather valuable baseline data for future impact assessments.

We used the qualitative results from the focus groups' discussions to develop the quantitative questionnaire for the baseline survey.

The survey was complemented by information sessions on irrigation techniques and the agricultural loan scheme, organised in partnership with RENACA and farmers' associations and held prior to conducting the surveys.

To meet the objective of collecting baseline data, whilst seeking to increase RENACA's credit portfolio, our intervention used information sessions, such as those conducted by Buehren et al. (2017) in Ethiopia for agricultural extension services, or, those by Mel et al. (2011) for credit extension to micro entrepreneurs in Sri Lanka.

In partnership with farmers' associations, we obtained membership lists which we used to construct the sampling frame for extending invitations to farmers to the information sessions. From this sampling frame, we randomly selected respondents who were not RENACA members for participation in the baseline survey.

We organised eight information sessions of this kind. A few days prior to the scheduled session (two to five days), our enumerators contacted farmers by telephone and invited them to attend. During these events, the facilitators⁸ shared information on different irrigation techniques and the specificities of RENACA's agricultural loan scheme and explained the underwriting process⁹. We present a brief narrative and protocol of the information sessions in Box 1 that follows.

Following the conclusion of the information sessions, we built a sampling frame of 450 farmers from which we randomly drew a sample for the baseline survey.

Data collection design

We developed a survey questionnaire to identify the drivers of smallholders' investments and to determine the extent to which access to credit can affect the level of investment in irrigation equipment and in other investment items.

The questionnaire included various modules, mainly on the socio-demographic characteristics of the farmers, economic characteristics, investment needs and constraints, access to markets (output, input and financial), irrigation systems and productivity, as well as on access to information, training and subsidies.

⁸ A team consisting of RENACA's Water Champion (specialised in agricultural issues and irrigation techniques), a local MFI branch manager, the research assistant, and a farmer who has benefited from agricultural credit was present at each site.

⁹ Table 1 in the annexes summarises the information on farmers' invitations and attendance at these meetings.

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Enumerators administered the survey to the farmers included in the sample a few days following the information sessions.

In July 2018, we visited 328 farmers most of whom had been present at the information sessions and who, at that time, had not been part of RENACA's agricultural loan portfolio. Using a different version of the first questionnaire to include a module on loan characteristics and the purpose of the loan, in September 2018 we administered the questionnaire to 50 farmers who had received a RENACA agricultural loan. It is worth recalling that RENACA's agricultural loan programme had barely taken off when we started. At the time of the launch of our project, RENACA had disbursed around 88 loans. We attempted to interview all recipients of the loans; however, those in default refused to meet us, suspecting that the survey was linked to recovery attempts.

Information sessions: narrative and protocol

We organised information sessions in cities where RENACA has branches. Table 3 provides a list of information sessions, their dates, headcount of attendees and participants. Sessions were well attended in all cities except for Bohicon where heavy rain on the day of the session led to low attendance. We proceeded with the following steps:

1. A rollcall to ensure the presence of invited farmers. We identified attendees whose names did not appear on the list and added them to the attendance sheet accordingly.
2. A presentation of various irrigation techniques and their advantages, emphasising the difficulties that farmers usually encounter in the use of inefficient irrigation tools. At the end of this presentation, a question and answer session followed to provide clarifications and additional details on different irrigation technologies. Judging from these questions, it appeared that financial constraints were one of the main barriers to irrigation technology adoption.
3. To provide information on agricultural loans, one of RENACA's managers presented the various financial services offered and explained the procedures to be followed in order to benefit. Firstly, the manager explained the procedure for opening an account, which then gives access to all these services as members of the MFI. Secondly, he explained to former members present the conditions of renewal and the underwriting timeline following receipt of the request. Finally, he spoke about RENACA's irrigation credit for investment in irrigation equipment that can be disbursed up to CFA 500 000 (USD 900) without collateral. Several participants asked questions to enhance their understanding of RENACA's agricultural credit scheme. Former customers with outstanding arrears expressed the wish to see an extension of loan tenor in order to facilitate repayments. They also explained that defaults were due to poor market access contributing to net losses.
4. We explained the subsequent steps to participants related to the baseline survey and requested that they welcome our enumerators. During the first training session, we randomly selected a handful of farmers to conduct a pre-test of the questionnaire. Through this exercise, we were able to identify issues related to measurement units for different crops and were able to correct them through the input from pilot respondents.

The first session was held on 28 June in Ouidah. On Thursday 28 June and Friday 29 June 2018, we held additional sessions in Comè, Grand-Popo and in Kpinnou. We noted in Grand-Popo that farmers expressed dissatisfaction at the outset at not having received credit after a year following the submission of their

request. RENACA's local manager provided clarification, which helped smooth the way for the meeting. Finally, the session in Parakou took place on 12 July 2018. In this area, we noted that many respondents were not keen on taking credit in general for religious reasons; the region has a mostly Muslim population. Participants also raised difficulties they face in terms of market access and selling their products at prices that would enable them to make a profit.

Results

Descriptive statistics

Socio-demographic characteristics

Table 4 contains the socio-demographic characteristics of the baseline survey participants. The highlights from these data can be summarised as follows:

- Only 24% of people included in the sample were women. This suggests that men tend to be the primary individuals in charge of managing agricultural businesses, including members of credit organisations such as RENACA and of farmers' associations. This does not imply, however, that women play only a minor role in farming: it could be that women play a greater role in day-to-day farm activities, including in sales activities.
- The youngest farmer in our survey was 18 years old and the oldest 74.
- The nuclear family structure is dominant (73% of households surveyed), and the average household size was six members. On average, households were composed of three children, with a maximum of 16 children under the age of 18.
- Around 19% of respondents had no formal education, but nearly 54% had reached at least secondary level of education.
- Most farmers (73%) had received no formal agricultural training, and some of those with some form of formal agricultural training had not obtained a diploma (12%). Thus, although more than half of respondents had received formal education to secondary level, they had limited exposure to acquiring organised knowledge specific to agriculture.

Farm characteristics (See Table 5)

All participants in our survey were vegetable producers. The average number of cropped vegetables was three, and the maximum was nine. The leading cropped vegetable was tomatoes (47%), followed by chillis (23%) and *crin-crin*, a leafy vegetable (13%). The remaining 17% cultivated other crops, such as watermelon, cabbage or onions. It is worth mentioning here that the Mono region, where 93% of the surveyed population was drawn, is the main vegetable farming region in the country.

Among the surveyed farmers, who are both actual clients and prospective clients, the average size of plot of cultivated land was 1.65 hectares, with a standard deviation of 1.89 and a maximum size of 14 hectares. 55% of farmers owned the cultivated land, regardless of whether they have formal titles¹⁰.

Economic characteristics

¹⁰ Adjimoti 2018 reports an average of 13 ha based on a survey of 522 farmers in the Collines region. Our survey covers a larger area.

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Table 6 presents respondents' economic characteristics. It shows that agricultural activity was the main source of income for most respondents (88%). We also note that for 23% no other household member other than the farmer and head of household derived non-farm income. About 52% of farmers had a monthly income of between CFA 35 000 (USD 61) and CFA 100 000 (USD 175), whilst 38% of respondents had a monthly income above CFA 100 000 (USD 175).

Market forces: access to financial markets

Most farmers have had at least some exposure to institutions which supply credit. In Table 7, 72% of interviewed farmers held an account with a financial services provider. The rate of financial exclusion appears to be lower than in the Beninese population as a whole. Nevertheless, focusing on those respondents who declared holding at least one account with a financial services provider, only about 40% of farmers held a bank account. Hence, 60% of farmers do not hold a bank account. The gap is mainly filled by MFI accounts (59% of farmers hold one) and mobile money accounts (32%).

However, access to a financial services account is distinct from the actual use of a financial service. This becomes apparent when we examine the intensity of agricultural credit use within our sample. According to the summary statistics contained in Table 7, only 16% of farmers had ever received an agriculture loan, whilst 24% had received a loan more than once. More than half (60%) had never received a loan from a bank, nor from a microfinance institution, including RENACA.

Some 93% of respondents self-financed investments in seeds, inputs, machinery, land, and irrigation equipment. For such outlays, only 3.6% used formal credit as a financing source (see Table 8 for more details). In short, credit constraints appear to be an issue for respondents, implying that only hypotheses 3 and 4 in our theory of change are relevant.

Market forces: access to output sales markets

Table 9 provides summary statistics on the type of channels that farmers use to sell their products. Among respondents, 63% sold their produce directly, either on the production site (37%) or at markets (26%). About 26% sell indirectly, either through wholesaler intermediaries (14%) or through a producer cooperative (12%). 12% of farmers indicated that they make sales on a forward sales basis. Regarding the distance from the farm to the largest market in the region, 92% of farms are located within 20 km of the largest market in the region, and about 8% are more than 20 km away.

Market forces: access to and use of irrigation equipment

Table 10 shows that nearly 84% of the sample did not have an irrigation system in place other than a hose system. Only 6.4% and 5.8% owned the two best performing irrigation systems: namely perforation and drip. The clear majority of farmers (91%) expressed dissatisfaction with the equipment they were currently using. The most commonly reported constraint to carrying out adequate investment in irrigation equipment was stated to be lack of funding (34.3%), closely followed by poor quality of equipment (34.0%).

Market forces: investment in seeds and other inputs

The data in Table 12 show that many survey respondents invested in seeds and other inputs, such as fertilisers. During the previous season, 82.93% of the 328 farmers had made expenditure on inputs, with 77.74% of the total outlaying money on seeds. Expenditure on other inputs takes priority over the purchase of seeds. This result is unsurprising, as we learned through our focus group discussions conducted in Benin that farmers aim to increase yields through the use of fertilisers. These results also underline the importance for smallholders of having working capital, particularly as most expenditure is self-funded.

Client survey

In this section, we present results from a survey of 47 existing clients who had received agricultural credit from RENACA since the launch of its programme in July 2017.

Socio-demographic and economic characteristics

Table 13 contains clients' socio-demographic and economic data. The main features can be summarised as follows:

- Out of the 47 participants, only five were women (11%). The average age was 38.4, with the youngest 23 years old and the oldest 69. The age range was smaller compared with the baseline non-client survey where it ranges from 18 to 74 years old.
- The nuclear family structure, although dominant (49%), was less prevalent when again compared with the non-client baseline survey data (73%). The size of the extended family structure reached 40%¹¹. On average, households had seven members, including three children under the age of 18.
- Around 8.5% of respondents had not received formal education – half as much as in the baseline survey (19%) and 55% had reached at least secondary level of education. However, a larger proportion (98%) had received no formal agricultural education.
- Agriculture represented the main source of income for 92% of the sample. Average monthly income was less than CFA 100 000 (USD 172) for 47% of respondents, between CFA 100 000 and CFA 300 000 (USD 517) for 51%, and between CFA 300 000 and CFA 500 000 (USD 862) for 2%. These figures are above those reported in the baseline survey, where 52% of farmers were in the first income bracket (less than USD 172).

Farm characteristics and agricultural activity

In Table 13 we provide summary statistics on farm characteristics and agricultural activity. The main findings were as follows:

- Agriculture represented a traditional activity in the family for 95% of the participants, which may explain why a large majority had not participated in formal agricultural training. The size of land under cultivation was reported to be 1.88 ha on average, going up to 12.5 ha for the largest. Only 45% of the participants owned their land, compared with 55% of the respondents in the baseline survey.
- All the respondents reported growing vegetables. On average, they produced two vegetables and a maximum of three. The participants appear to be more specialised than the baseline farmers, who grow on average three vegetables and a maximum of nine. The leading crop vegetables were tomatoes for 49% of respondents, followed by chillis (25.5%) and *crin-crin* vegetables (19%).
- The distance between the largest market in the region and the farm was less than 10 km for 87% of the farmers, and less than 20 km for the remainder.
- Farmers combine several distribution methods. 96% sell directly on their production site, 62% at markets, and 77% to intermediaries, some of whom export to neighbouring countries. No respondent reported using futures contracts.

¹¹ The extended family structure comprises the household head, more than one spouse, ascendants and brothers.

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Access to finance

All participants are, or have been, members of the local RENACA agency, an initial pre-condition for benefiting from agricultural credit. In Table 13 we report that 66% of the participants had been members of RENACA at the time of the survey for more than 12 months. In addition, nearly 29% held a bank account and 83% a mobile money account. The high financial activity of farmers is also demonstrated by their participation in informal savings groups – 57% of the sample were members of such a group or association.

Access to agricultural credit

We provide summary statistics below on access to agricultural credit as contained in Table 13:

- On average, 53% of participants had received agricultural credit once, 36% twice and 11% three times. For an average amount of CFA 693 000¹² requested, the average credit received was CFA 420 000. The maximum amount granted under the RENACA agricultural credit scheme is CFA 3 000 000. This ceiling is lower than the maximum amount requested of CFA 6 000 000.
- Credit maturity ranges from 12 to 24 months for 70% of the clients, and from 24 to 36 months for 26%. The most common repayment frequency is quarterly for 53% of loans, followed by monthly for 30%.
- RENACA's agricultural loans can be used as working capital, or to finance the installation of an irrigation system, or for both. In the sample, nearly 64% used the credit only for working capital, 4% to finance irrigation equipment and 32% for both.

Overall satisfaction

The low credit levels extended may explain the limited take-up of irrigation technology observed. Most participants stated that they were very satisfied with the agricultural credit extended (63%); however, they expressed dissatisfaction with some of the loan terms: amounts were deemed too low by 89% of respondents.

Investment in land, machinery and inputs

The importance of credit for working capital is clear when we analyse investment levels. Thus, as in the baseline, we report in Table 13 that most farmers invested each season in inputs (100%) and in seeds (65%). At the same time, few participants had invested in land since their establishment (32%), and even fewer in machinery (3%). 42% to 48% of clients reported using agricultural credit to finance the purchase of inputs and seeds, while agricultural land purchases were self-funded in all cases. 53% of participants indicated that their low investment in agricultural land was due to lack of finance (see Table 13).

Irrigation systems and equipment (Table 13)

Table 13 provides summary statistics on the use of irrigation systems and other equipment. The main findings are as follows:

- The best performing irrigation system, the drip system, was more dominant in the client sample than in the baseline survey, with 19% (compared with 5.8%) using this type of equipment. Nevertheless, the basic hose-based irrigation system remains the most commonly used system (62%).

¹² These data relate to the most recent credit granted to the participants.

- 60% of participants reported that credit had had no effect on their irrigation system, while 36% of clients reported improvements in the existing system as a result of the credit, and 4% reported having changed their irrigation systems as a result.
- Agricultural credit meets some of the farmers' needs for financing investments in inputs. However, irrigation equipment requires amounts that are difficult to obtain, given the specific conditions of RENACA's agricultural credit scheme.

Regression results

To test our hypotheses and the proposed theory of change, as well as to answer the main research questions, we use ordered probit and probit specifications on the baseline data.

As discussed in the literature review, investment in mechanisation and irrigation is an essential factor in enhancing the productivity of smallholders (Binswanger-Mkhize and Savastano, 2017). In the case of Benin's smallholder farmers, based on the focus group discussions we conducted, access to agricultural land also emerged from the discussions as an important element for sustainability of farmers' operations.

Thus, we consider three types of investment, which could act as complements, and are associated with the productivity of smallholders: (i) investment in irrigation equipment; (ii) investment in agricultural machinery; and (iii) investment in land ownership. We can classify these three types of investments as medium or long-term. We apply each of these investments as a dependent variable in our regression models. We also constructed an investment index which combines the three types of investments and used this as a dependent variable in our ordered probit and probit specifications. In Table 14 we show differences in means and their significance levels for the two sub-groups – owners and non-owners of irrigation technology. We provide differences in means for outcome and explanatory variables, which we later apply in order to answer the research questions. We note that for outcome variables, such as the investment index, turnover or employee headcount, the differences in means are statistically significant for farmers who own irrigation technology versus those who do not. We also observe that the proportion of farmers who have at some stage received agricultural credit and own an irrigation system is not statistically different from the proportion of those who have never accessed credit, nor own irrigation equipment.

Our data shows the low level of investment that has taken place in these three elements (i) irrigation equipment; (ii) agricultural machinery; and (iii) land (See Table 11 for details). Only 16% of the 328 randomly sampled farmers had bought land since their establishment; about 20% had invested in small machinery outside of irrigation technology; and around 16% of the surveyed farmers owned at least one type of irrigation system. Furthermore, it should be noted that expenditure on inputs such as fertilisers and seeds represented a sizeable short-term investment. Around 83% of individuals in our sample had spent money on inputs in the previous season. This result confirms that short-term investments can be an important part of farmers' operations.

We present below the relationship between the explanatory variables, categorised as either market or non-market, and farmers' outcomes in association with the different investment decisions.

Market forces and investment decisions

In order to test our hypotheses on the associations between market access variables, such as credit constraints and investment decisions, we run an ordered probit regression, firstly with investment in the most common irrigation technology as the outcome variable, followed by a probit specification with other

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investments as outcome variables. We present and discuss our findings below related to both financial and output markets.

Financial market access and investment levels

We used variables which proxy for access to financial services – such as the use of agricultural credit since the start of a farmer’s agricultural activities and the ownership of an account at a microfinance institution – as explanatory variables in explaining investment decisions. We observe no significant relationship between these variables and investment in land and in agricultural machinery. In the correlation analysis and dependence test of Chi squared only the investment in land variable has a statistically significant relationship with the use of agricultural credit. These results run counter to hypotheses 3 and 4 in our theory of change where we posited that access to credit may induce greater investment in physical capital. We explain these findings by the prevailing constraints on loan underwriting. Loan amounts are insufficient to trigger investment levels high enough to boost agricultural output. Our focus group discussions with farmers support this result. RENACA has a CFA 500 000 (USD 900) cap on loans without guarantees. In most cases, the size of disbursed loans is insufficient for investments in modern irrigation technologies, land or equipment. Disbursed loans are more suitable for financing short-term investment in seeds and inputs rather than in irrigation systems or machinery. A third explanation for our findings is that the impact of access to finance is greater on the side of savings than of credit. Savings are the main vehicle for financing both short-term and long-term investments. Thus, holding a bank account or a savings account with an MFI can be expected to also increase farmers' savings and their capacity to self-fund investments in irrigation technology.

Access to output sales markets and investment levels

We proxy market access for outputs with the type of distribution channel used and distance to the largest market in the region. To see how these indicators relate to investment, we first constructed an investment index, composed of the sum of the three components of investment, namely the binary variables for purchase of land, purchase of machinery and irrigation equipment for each farmer (See Table 15 for more details). We obtained an ordered variable ranked from 0 (no investment) to 3 (investment in the three items: land, machinery and irrigation). As a second specification, we ran probit regressions¹³ with the type of irrigation system adopted, investment in land and investment in machinery as dependent variables on a set of regressors including indicators on market and non-market forces¹⁴.

In our probit regression specifications (see Table 16), we found no significant relationship between the type of distribution channel and the main investment variables. However, distance to the largest market has a negative and significant relationship with the probability of investing in sophisticated irrigation equipment. The direction of this relationship confirms the assumption that easy market access encourages investment. Our result shows that the greater the distance to the market, the less likely it is that farmers will invest in a more sophisticated and expensive irrigation system. We surmise that higher expenditure required for transporting goods to local markets could explain this result. It could also be the case that farmers at a greater distance from markets will be averse to the risk of being unable to sell their produce before it perishes.

Nonetheless, distance to output markets shows a positive and significant relationship with the probability of investing in machinery outside of irrigation systems. This result is not surprising as greater distance from

¹³ Ordered or simple probit.

¹⁴ See Table 14 for details of the dependent variables.

markets would also be associated with the purchase of transport vehicles. Such an explanation is also consistent with the previous result.

Non-market forces and investment decisions

We hypothesise that some non-market forces, such as those related to farm and farmer characteristics, or those related to the business environment, could also affect investment decisions. We present below the results of our analyses on this dimension.

Individual characteristics and investment decisions

We look at potential relationships between farmer and household characteristics, on the one hand, and investment in irrigation equipment, land and machinery, on the other. Other controls of interest such as gender, education level, household size and proportion of family labour employed in the overall labour force are included as independent variables in the various specifications.

From the summary statistics presented earlier, we recall that 23% of our sample was composed of women, which is in line with the national average for farmer population. The explanatory variable for gender (1= male) has a significant relationship with investment in both irrigation equipment and machinery (see Tables 16 and 17). However, the coefficient is positive for machinery, suggesting that men invest more in this category, while the negative coefficient for irrigation equipment (Table 17) suggests that men invest less in this asset. In other words, everything else being equal, on average, women are more likely to invest in irrigation technology. It is worth recalling that women tend to have a greater role in carrying out sales activities and, as a result, would enjoy greater access to markets. This greater opportunity that women enjoy could explain the gender difference in the propensity to invest in irrigation systems.

We measure education with an ordered index from 1 (no formal education) to 5 (university degree and more). We found a statistically significant relationship between the probability of investing in machinery and education. However, the coefficient is negative, suggesting that, on average, farmers with a higher level of formal education invest less in machinery. Though counterintuitive, this result is in line with the findings of Amegnaglo (2018) in his study on the efficiency of maize production in Benin. Amegnaglo (*ibid.*) reported that farmers with higher education levels tend to display lower production efficiency. This observation may be due to possible income effects, whereby farmers with higher education levels are more likely to have regular sources of external income and would therefore use farm revenue only as a complement to regular income. Thus, they are less likely to behave as profit maximisers on the farm.

Household size does not show a significant relationship with any of the investment indicators. The share of family labour in total farm employment has a positive relationship with investment in irrigation systems and a negative one with investment in machinery. Thus, the direction of the relationship is counterintuitive, insofar as higher levels of family labour are associated with advanced irrigation systems. We hypothesised that these two factors could be substitutes for each other. The availability of family labour is often associated with labour-intensive production systems with low efficiency and low productivity (Amegnaglo, *ibid.*). Low investment in machinery is consistent with this assumption. However, the result for irrigation is more surprising. In fact, higher availability of family labour is associated with the adoption of advanced irrigation systems.

Farm characteristics and investment decisions

We found no significant relationship between cultivated area in hectares and investment in irrigation systems. We explain this result by the fact that most farms are small and have fewer than two hectares of

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cultivated land, which makes it difficult to isolate a size effect. The focus group discussions suggested that land ownership is an important factor for farmers in their decision to invest, but the dummy variable on land ownership does not show a statistically significant association in our regressions.

The indicator for the water-constrained¹⁵ variable shows a positive and significant relationship with investment. Nevertheless, it is negatively associated with investment in machinery. Water and non-irrigation machinery could act as substitutes for each other. Water-constrained farmers can direct their investment decisions towards the acquisition of irrigation technology as watering is essential in vegetable production, while forgoing other types of investment such as in agricultural machinery.

Non-market forces: Agricultural training and investment decisions

In terms of business environment-related factors, we looked at opportunities for training, information and access to subsidies for smallholders. Among these variables, only the dummy variable for agricultural training is significantly associated with investment in machinery. Here, no distinction is made between training from government, non-government organisations or producer associations; however, training provided by equipment suppliers is excluded. The results produced are similar to those of Buehren et al. (2017) in Ethiopia, showing that access to agricultural extension services helps farmers switch to more commercialised agriculture.

Conclusions

The objective of this analysis was twofold. Firstly, we aimed to understand the market and non-market forces that explain the decisions of smallholder farmers in Benin to invest in agriculture in general, and to invest in irrigation technology. In terms of market forces, we identified access to financial and output sales markets as key factors associated with decisions to invest in agriculture and in irrigation technology, thus increasing the livelihoods of smallholders. We collected data by conducting a baseline survey to document both investment and market access for a group of randomly selected farmers who were both existing and prospective clients of RENACA in Benin. We find no significant relationship between access to agricultural credit and investment in either irrigation technology, land or machinery. These results do not support the hypotheses in our theory of change where we had expected that access to credit alone could be enough to stimulate investment and increase farmer income. While smallholders have access to credit on the extensive margin, loan amounts tend to be inadequate to trigger a virtuous cycle of higher investment in mechanisation and irrigation. This is consistent with the findings of Binswanger-Mkhize and Savastano (2017) who observed low levels of irrigation in six African countries, despite urbanisation and population growth.

The other market force we sought to explore and which is related to the BR theory of agricultural intensification is access to markets, potentially allowing farmers to commercialise their products. Such markets can be both physical locations, as well as forward sales contracts for collection of goods by the client at the point of production. We find no association between investment decisions and forward sales markets, while access to physical markets has a negative and significant relationship with investment in sophisticated irrigation equipment. This result is explained by substitution effects in the face of liquidity constraints. Risk-averse farmers will spend more on the transportation of goods to physical markets with the aim of selling perishable products rapidly. In short, our analyses of market forces showed that access to credit on the intensive side is limited due to caps on loan amounts. Loan amounts are often capped by

¹⁵ Water-constrained means that the farmer has difficulties to access a water source or has no water source nearby.

financial service providers in the absence of collateral held by the applicant. Hence, operating in this environment, smallholders in Benin prefer not to invest in irrigation technology, but rather in transportation to access physical sales markets. So, in addition to addressing credit constraints, it could be worthwhile encouraging microfinance institutions to increase the size of loans to cover the purchase of sophisticated irrigation technology and for the State to promote policies that provide greater land security to farmers for pledging as collateral.

We found that better educated farmers are less likely to invest in irrigation technology, which is in line with the findings of Amegnaglo (2017). A further indicator for non-market forces used in our study was the training sessions provided to farmers as part of our project. Thus, in a follow-up survey, it will be worthwhile comparing the randomly selected sample of farmers who attended these training sessions (328 individuals) to a control group of similar size which did not take part. Additionally, we could measure credit take-up following our training sessions and estimate a treatment effect on the treated group of those smallholder farmers who participated in our baseline survey. A follow-up survey could be an opportunity to gain a better understanding of the continuing presence of a relationship between the training sessions and the take-up of agricultural credit for irrigation systems. Finally, a follow-up survey would be useful for fully testing the theory of change, to measure the impact of RENACA's loan programme on the economic outcomes of smallholder farmers.

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Data appendix

Table 3: Information sessions statistics

Session number	City/RENACA agency	Date	Headcount of invited farmers	Number of attendees	Attendance rate
1	Ouidah-Kpomassè-Pahou	06/28/2018	33	59	179%
2	Comè	06/28/2018	49	53	108%
3	Grand-Popo	06/29/2018	31	38	123%
4	Kpinnou	06/29/2018	75	78	104%
5	Abomey	07/05/2018	11	11	100%
6	Bohicon	07/05/2018	37	11	30%
7	Zogbodomè	07/05/2018	22	22	100%
8	Parakou	07/12/2018	64	64	100%

Table 4: Descriptive statistics

Variables	Percent	Mean	Std. Dev.	Min.	Max.	Obs.
Gender						
Men	76.52					328
Women	23.48					328
Age		39.88	10.88	18	74	328
Education						
No formal education	18.90					328
Primary level	27.74					328
Secondary level	41.77					328
Non-university post-secondary qualifications (certificate, professional or technical diploma)	5.18					328
University, Bachelor level	3.66					328
University, beyond Bachelor level	2.74					328
Agricultural Education						
Yes, without diploma	15.24					328
Yes, with diploma	11.59					328
No	72.56					328
Residence						
Urban	37.80					328
Peri-urban	24.39					328
Rural	37.80					328
Marital Status						
Married	60.37					328
Single	10.98					328
Divorced	0.61					328
Widower/widow	3.66					328
Cohabitation	24.39					328
Family structure						
Nuclear	73.78					328
Extended with more than one spouse	9.15					328
Extended with ascendants	5.79					328
Extended with ascendants and brothers	7.32					328
Other	3.96					328
Household size		6.11	3.40	0	30	328
Number of children under 18 years old		2.64	2.20	0	16	328

Table 5: Farm characteristics

Variables	Freq.	Percent	Mean	Std. Dev.	Min.	Max.	Obs.
Number of crops			3.058	1.157	1	9	328
Cultivated area (ha)			1.650	1.888	0.001	14	328
Main crops		100					328
<i>Tomato</i>	154	46.95					
<i>Onion</i>	15	4.57					
<i>Chilli</i>	74	22.56					
<i>Cabbage</i>	32	9.76					
<i>Leafy crin-crin</i>	44	13.41					
<i>Lettuce</i>	6	1.83					
<i>Watermelon</i>	3	0.91					
Land ownership		100					328
No	147	44.82					
Yes	181	55.18					

Table 6: Household income sources

Source of income	Obs.	Percent
Self-employed income	328	9.45
Salary(ies)	328	0.91
Rental income	328	0.3
Remittances from relatives	328	0.3
Agriculture	328	87.5
Other	328	1.52
Monthly income (in CFA francs)		
0- 35 000	328	9.76
35 000 - 100 000	328	52.44
100 000 - 200 000	328	22.56
200 000 - 300 000	328	5.49
300 000 - 500 000	328	5.49
500 000 - 1 million	328	2.44
> 1 million	328	1.52
No information	328	0.3
Household members (apart from the respondent) with a regular revenue		
0	328	22.87
1	328	57.62
2	328	13.72
3	328	3.05
4	328	1.52
5	328	0.61

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Table 7: Access to formal finance and use of credit

	Freq.	Percent	Cumul.
Number of accounts			
0	92	28.13	28.13
1	140	42.81	70.95
2	71	21.71	92.66
3	24	7.34	100.00
Total	327	100.00	
Hold a bank account	131	39.94	
Hold an MFI account	194	59.15	
Hold a mobile money account	104	31.71	
Use of agricultural credit			
Yes, once	54	16.46	16.46
Yes, more than once	78	23.78	40.24
No, never	196	59.76	100
Total	328	100	

Table 8: Sources of investment financing

	Self-financing (savings)	Informal loan (relatives)	Formal loan	Obs.
Seeds	92.94%	2.75%	4.31%	255
Other inputs	92.63%	2.20%	5.17%	271
Machinery	96.8%	1.60%	1.60%	62
Irrigation equipment	88.93%	5.30%	5.77%	208
Purchase of land	98.00%	1.00%	1.00%	50

Table 9: Access to agricultural markets

Type of sale	Freq.	Percent	Cumul.
Direct - at production site	116	36.94	36.94
Direct - to the market (s)	81	25.8	62.74
Intermediary - agent	44	14.01	76.75
Intermediary - producers association	37	11.78	88.54
Futures contracts	36	11.46	100
Total	314	100	

Table 10: Types of irrigation equipment

Irrigation equipment	Freq.	Percent	Cumul.
Californian	10	3.05	3.05
Sprinkler	21	6.4	9.45
Drip	19	5.79	15.24
More than two types of equipment	3	0.91	16.16
No equipment	275	83.84	100
Total	328	100	

Table 11: Investment in irrigation, land and machinery since establishment

	Freq.	Percent	Cumul.	Obs.
Investment in irrigation				328
Yes	53	16.16	16.17	
No	275	83.84	100.00	
Investment in farmland				328
Yes	51	15.55	15.55	
No	277	84.45	100.00	
Investment in machinery (other than related to irrigation)				328
Yes	65	19.82	19.83	
No	263	80.18	100.00	

Table 12: Investment in seeds and other inputs in last season

	Freq.	Percent	Cumul.
Expenditure on seeds			
Yes	255	77.74	77.74
No	72	21.95	99.7
Does not know	1	0.3	100
Total	328	100	
Expenditure on non-seed inputs			
Yes	272	82.93	82.93
No	55	16.77	99.7
Does not know	1	0.3	100
Total	328	100	

Table 13: Client data

- Socio-demographic and economic characteristics

	Proportion	Mean	Std. Dev.	Min.	Max.	Obs.
Gender						47
Men	0.894					
Women	0.106					
Age		38.447	9.623	23	69	47
Marital Status						47
Married	0.128					
Single	0.043					
Divorced	0.043					
Cohabitation	0.787					
Household structure						47
Nuclear	0.489					
Extended with more than one spouse	0.213					
Extended with grandparents	0.106					
Extended with grandparents and siblings	0.191					
Household size		6.894	3.440	1	16	47
Number of children under 18 years old		3.489	2.653	0	14	47
Residence						47
Urban	0.553					
Peri-urban	0.106					

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Rural	0.340					
Education level						47
No formal education	0.085					
Primary level	0.362					
Secondary level	0.404					
University, Bachelor level	0.043					
University, beyond Bachelor level	0.106					
Agricultural Education						47
Yes, without diploma	0.021					
No	0.979					
Main source of income						47
Self-employed income	0.064					
Salary(ies)	0.021					
Agriculture	0.915					
Monthly income (in CFA francs)						47
0- 35 000	0.043					
35 000 - 100 000	0.426					
100 000 - 200 000	0.383					
200 000 - 300 000	0.128					
300 000 - 500 000	0.021					
Other household members with a regular revenue		1.489	1.516	0	9	47
Other household members' revenue amount (in CFA francs)		62 128.3	57 100.88	0	300	47

- Farm characteristics and agricultural activity

	Proportion	Mean	Std. Dev.	Min.	Max.	Obs.
Agriculture is traditional family activity	0.956					47
Cultivated area (ha)		1.877	2.242	.0225	12.5	47
Land ownership	0.447					47
Number of crops		2.149	0.780	1	3	47
Cultivated area by main crop (ha)		0.307	0.940	0.0025	6	47
Main crops						47
Tomato	0.489	0.074				
Onion	0.064	0.036				
Chilli	0.255	0.064				
Leafy <i>crin-crin</i>	0.191	0.058				
Livestock ownership						47
Yes	0.638	0.071	0.488	0.766		
No	0.362	0.071	0.234	0.512		
Type of sales						
Direct - on production site	0.957					47
Direct - on market (s)	0.617					47
Intermediary - agent	0.766					47
Intermediary - producers association	0.021					47
Futures contracts	0.000					47
Production partially exported	0.404					47
Distance to the largest market						47
Less than 5 km	0.426					
5 to 10 km	0.447					
10 to 20 km	0.128					

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- Access to finance

	Proportion	Mean	Std. Dev.	Min.	Max.	Obs.
Access to finance						
<i>Hold a bank account</i>	0.298					47
<i>Hold an MFI account</i>	0.957					47
<i>Hold a mobile money account</i>	0.830					47
Savings group membership	0.574					47
Duration of CAVECA membership						47
1-6 mths	0.043					
6-12 mths	0.298					
12-24 mths	0.234					
More than 24 mths	0.426					

- Access and use of agricultural loan

	Proportion	Mean	Std. Dev.	Min.	Max.	Obs.
Number of agricultural loans		1.574	0.683	1	3	47
Last requested amount		693 404.300	1 001 447.0	100	6 000 000	47
Last obtained amount		490 212.800	608 710.3	100	3 000 000	47
Pearson's correlation between requested and obtained amount	0.9294*					
Duration of the last loan						47
<i>6-12 mths</i>	0.043					
<i>12-24 mths</i>	0.702					
<i>24-36 mths</i>	0.255					
Repayment frequency						47
<i>Monthly</i>	0.298					
<i>Bi-monthly</i>	0.128					
<i>Quarterly</i>	0.532					
<i>Semi-annual</i>	0.043					
Use of the loan						47
<i>Only for working capital</i>	0.638					
<i>Only for irrigation equipment</i>	0.043					
<i>Both</i>	0.319					
Overall credit satisfaction						47
<i>Very satisfied</i>	0.638					
<i>Moderately satisfied</i>	0.319					
<i>Not at all</i>	0.043					
Unsatisfactory characteristics						
Low amount	0.894					
Duration	0.043					
Repayment frequency	0.043					
Cost	0.021					
Credit potential effect on revenue						47
<i>Higher revenue</i>	0.787					
<i>No effect</i>	0.213					

- Investment in land, machinery and inputs

	Freq.	Percent	Obs.
Investment in farmland	15	0.326	47
Financing source of land purchase			15
<i>Savings</i>	3	0.200	

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<i>Agricultural income</i>	12	0.800	
Investment in seeds	31	0.652	47
Financing source of seeds			31
<i>Savings</i>	4	0.129	
<i>Agricultural income</i>	12	0.387	
<i>Commercial loan</i>	15	0.484	
Investment in other inputs	47	1.000	47
Financing source of inputs			47
<i>Savings</i>	10	0.226	
<i>Agricultural income</i>	14	0.290	
<i>Informal loan</i>	3	0.065	
<i>Commercial loan</i>	20	0.419	
Investment in machines	1	0.031	47

- Investment constraints

	Freq.	Percent	Obs.
Reasons for low investment in land			47
<i>Lack of agricultural land</i>	1	0.021	
<i>Difficult access to ownership</i>	3	0.064	
<i>Lack of finance</i>	25	0.532	
<i>Other reasons</i>	18	0.383	

- Irrigation equipment

	Freq.	Percent	Obs.
Water source on the farm site			47
<i>Well</i>	4	0.085	
<i>Drilling</i>	27	0.574	
<i>River/lake</i>	6	0.128	
<i>Other</i>	3	0.064	
<i>No water source</i>	7	0.149	
Irrigation equipment			47
<i>Californian</i>	29	0.617	
<i>Sprinkler</i>	2	0.043	
<i>Drip</i>	9	0.191	
<i>No equipment</i>	7	0.149	
Loan used to finance irrigation system			47
<i>A complete system with well</i>	1	0.021	
<i>Piping for an existing water point</i>	2	0.043	
<i>Only one part of the irrigation system</i>	20	0.426	
<i>No use in irrigation system</i>	24	0.511	
Loan effect on existing irrigation system			47
<i>Change</i>	2	0.043	
<i>Improvement</i>	17	0.362	
<i>No effect</i>	28	0.596	

Table 14: Differences in means for selected outcomes and individual factors between owners and non-owners of irrigation technology

	Variables	N	Mean_	SE_all	Mean_i	SE_irrig	Mean_	SE_No_	Differe	
			all		rrigatio	n	No_irri	Irrigati	on	nce
Outcomes	Investment index	328	0.515	0.034	1.151	0.05	0.393	0.034	0.758	***
Outcomes	Log sales	328	13.252	0.122	12.535	0.351	13.39	0.127	-0.855	***
Outcomes	Employees	328	5.357	0.238	3.868	0.375	5.644	0.271	-1.776	***
Farmer	characteristics									
	Family size	328	6.119	0.188	6.472	0.446	6.051	0.207	0.421	
Farmer	characteristics									
	Gender	328	1.235	0.023	1.509	0.069	1.182	0.023	0.328	**
Farmer	characteristics									
	Education level	328	2.552	0.063	2.283	0.189	2.604	0.065	-0.321	*
Farmer	characteristics									
	Source of revenue	328	5.494	0.084	5.679	0.18	5.458	0.094	0.221	
Farmer	characteristics									
	Farm location = Urban	328	0.534	0.028	0.604	0.068	0.52	0.03	0.084	
Farmer	characteristics									
	Vegetable crops	328	0.567	0.027	0.358	0.067	0.607	0.03	-0.249	***
Market forces	Access to forward markets	328	0.113	0.017	0.151	0.05	0.105	0.019	0.045	
Market forces	Distance to big market	328	2.201	0.053	1.755	0.12	2.287	0.058	-0.533	***
Market forces	Sales to export market	328	0.341	0.026	0.075	0.037	0.393	0.03	-0.317	***
Non-market forces	Agricultural training (1=Yes)	328	0.268	0.025	0.132	0.047	0.295	0.028	-0.162	**
Non-market forces	Received subsidy	328	0.095	0.016	0.113	0.044	0.091	0.017	0.022	
Non-market forces	Agricultural advice from the State	328	0.348	0.026	0.396	0.068	0.338	0.029	0.058	
Access to credit	Ever accessed agricultural credit	328	0.402	0.027	0.302	0.064	0.422	0.03	-0.12	
Access to credit	Microfinance account ownership	328	0.591	0.027	0.434	0.069	0.622	0.029	-0.188	**
Constraints	Water constraint	328	0.412	0.027	0.547	0.069	0.385	0.029	0.162	**

*** p<0.01, ** p<0.05, * p<0.1

Table 15: Investment indicators (dependent variables) details

Variable name	Variable label	Variable type	Description
Invest_index	Investment index	rank ordered, 0-3	sum of investment occurrence in irrigation, land and machinery
Irrigation System	Type of irrigation system	rank ordered, 0-4	0= no irrigation system; 1= Californian; 2= sprinkling; 3= perforated strips; 4: drip
Land	Investment in land	dummy variable	1= farmer invested in land; 0= otherwise
Machinery	Investment in machinery	dummy variable	1= farmer invested in machinery; 0= otherwise

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Table 16. Probit regression, dependent variable: Investment in land and machinery

	Land	Machinery
Water-constrained	-0.020 (0.10)	-0.445 (2.35)*
Ever taken agricultural credit	0.229 (1.02)	-0.276 (1.31)
MFI account	0.237 (0.91)	0.018 (0.08)
Forward sale	-0.324 (0.90)	-0.246 (0.81)
Distance to large market	0.024 (0.22)	0.252 (2.57)*
Training	0.134 (0.69)	-0.445 (2.39)*
Farmland in ha	0.213 (4.46)**	0.048 (1.08)
Education level	0.309 (2.95)**	-0.263 (2.78)**
Household size	0.043 (1.42)	-0.020 (0.67)
Gender	0.261 (0.84)	0.517 (2.13)*
Family labour share	0.002 (0.65)	-0.010 (3.32)**
_cons	-3.246 (5.61)**	-0.042 (0.10)
<i>N</i>	328	328
<i>Pseudo R2</i>	0.1708	0.1325
	Probit regression Number of obs = 328 LR chi2(11) = 48.43 Prob > chi2 = 0.0000 Log likelihood = -117.51892 Pseudo R2 = 0.1708	Probit regression Number of obs = 328 LR chi2(11) = 43.2 Prob > chi2 = 0.0000 Log likelihood = -141.66062 Pseudo R2 = 0.1325

* $p < 0.05$; ** $p < 0.01$

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Table 17: Ordered probit regression: Type of irrigation system vs farmer characteristics

Ordered probit	Type of irrigation system
	Water-constrained
	0.380 (1.99)*
	Ever taken agricultural credit
	-0.123 (0.54)
	MFI account
	-0.043 (0.19)
	Forward sale
	0.153 (0.56)
	Distance to large market
	-0.345 (3.13)**
	Training
	0.027 (0.14)
	Farmland in ha
	-0.092 (1.39)
	Education level
	-0.013 (0.14)
	Household size
	0.034 (1.17)
	Gender
	-0.664 (3.08)**
	Family labour share
	0.008 (2.61)**
	Own land
	-0.265 (1.38)
cut1	_cons
	0.403 (0.96)
cut2	_cons
	0.567 (1.34)
cut3	_cons
	0.623 (1.48)
cut4	_cons
	1.184 (2.75)**
<i>N</i>	328
<i>Pseudo R2</i>	0.1515

Ordered probit estimates

Number of obs = 328

LR chi2(12) = 63.41 Prob > chi2

=0.0000 Log likelihood = -177.59082

Note: Ordered probit investment variable ranked from 0 (no investment) to 3 (investment in the three items: land, machinery and irrigation)*
p<0.05; ** p<0.01

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