

THE IMPACT OF PRIVATE SECTOR PROJECTS IN AFRICA

Studies from the EIB-GDN Programme

Cycle 3



The impact of private sector projects in Africa

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The impact of private sector projects in Africa: Studies from the EIB-GDN Programme, Cycle 3

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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 45, 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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Content

Content	i
Foreword	1
Introduction	3
Development Bank of Jamaica (DBJ), Jamaica	7
Summary.....	8
<i>List of acronyms</i>	9
1. Introduction	10
1.1. <i>MSMEs and microfinance in Jamaica</i>	10
1.2. <i>Research questions</i>	11
2. Literature review	12
2.1. <i>Conceptual framework</i>	12
2.2. <i>Microcredit access and the performance of MSMEs</i>	13
3. Data and methods	15
3.1. <i>Data</i>	15
3.2. <i>Analytical approach</i>	16
4. Results.....	18
4.1. <i>Graphical analysis</i>	18
4.2. <i>Suggestions from clients on improving credit administration</i>	25
4.3. <i>Descriptive statistics</i>	28
4.4. <i>Differences in means</i>	29
4.5. <i>Credit received and firm performance</i>	30
4.6. <i>DBJ activities with microfinance institutions</i>	39
5. Summary and conclusion.....	40
5.1. <i>Limitations of the study</i>	41
References	42
Annex A: Additional Tables.....	45
The impact of microfinance on business investment and outcomes in Haiti	51
Summary.....	52
1. Introduction	54
2. Literature Review.....	55
2.1. <i>Impact of microfinance on business outcomes</i>	55
2.2. <i>Theory of change</i>	57
3. Microfinance in Haiti	59
4. Methodology	61
4.1. <i>Data and sampling</i>	61
4.2. <i>Descriptive findings: ACME client profiles</i>	63
4.3. <i>Impact of microfinance on business outcomes: Multivariate analysis</i>	64
5. Results.....	67
6. Conclusion	69
References	72

Annex A: Additional Tables, Figures and Explanations	77
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The impact of digital distribution on the small retail sector in Nigeria: The case of the ShopTopUp platform93

Abstract	94
1. Introduction	95
2. Key characteristics of the Nigerian retail sector	95
2.1. <i>Size and structure of the retail sector</i>	95
2.2. <i>Consumer base and prices</i>	96
2.3. <i>Employment</i>	99
3. Barriers to the growth of small retailers	100
4. Potential efficiency gains from digital retail distribution: Case study of TradeDepot	102
4.1. <i>Company profile and services</i>	102
4.2. <i>Study approach</i>	103
4.3. <i>Results</i>	108
5. Discussion of findings	115
6. Conclusion	116
References	117
Annex A: ShopTopUp survey tool	119

The impact of Rensource solar energy on merchant subscribers in selected Nigerian markets 125

Abstract	126
Acknowledgements	127
Summary	128
<i>List of acronyms</i>	129
1. Introduction	130
2. Literature review	131
2.1. <i>Factors that influence subscription to solar energy</i>	131
2.2. <i>Impact of solar energy on MSMEs</i>	134
3. Theory of change	134
3.1. <i>Output</i>	135
3.2. <i>Intermediate impacts</i>	135
3.3. <i>Final impacts</i>	135
4. Research methodology	137
4.1. <i>Sampling and data collection</i>	137
4.2. <i>Conceptual and empirical framework</i>	138
5. Results and discussion	142
5.1. <i>Descriptive results</i>	142
5.2. <i>Determinants of merchants' choice of electricity supplier</i>	148
5.3. <i>Intermediate impacts</i>	149
5.4. <i>Empirical results</i>	152
6. Summary, conclusions and implications	157
References	160
Annex A: Tables	166

Foreword

The European Investment Bank (EIB) has been investing in Africa since 1963. In 2020, it stepped up its investments to help African partners respond to the COVID-19 health and economic crisis. The EIB provided €5 billion for new private and public investment across the continent in 2020 – setting a new record for the Bank’s annual engagement. This finance will back more than €12 billion in investments in 28 African countries, with 71% of the funding benefiting fragile states and the least developed economies. The support will help African countries deal with the immediate health emergency and mitigate the epidemic, as well as address the economic effects of the crisis and progress towards achieving the Sustainable Development Goals. Projects signed in Africa in 2020¹ are expected to contribute to 210 million people receiving COVID-19 vaccines, 595 400 households being supplied with newly generated energy, 778 000 people enjoying improved water supply, and farmers benefiting from 26 500 of hectares of newly irrigated land and 3 076 hectares of newly planted forest.

The EIB partners private and public sector clients and uses innovative impact finance to support high-impact projects in Africa. As in previous years, around 50% of EIB lending in Africa in 2020 involved private sector partners. The EIB uses a window of the Africa, Caribbean and Pacific Investment Facility, the Impact Financing Envelope, to support higher-risk private sector initiatives with a big impact for poorer populations.

As the European Union’s development bank, the EIB places the measurement of development impact at the very core of its business approach. Its [Additionality and Impact Measurement Framework \(AIM\)](#) captures evidence on the results of every EIB investment. The EIB aims to be at the forefront of rigorous impact assessment methodologies, combining information collected by the AIM with micro- and macro-level impact studies and independent evaluations. This creates a strong evidence base for gauging our development impact. Because we are accountable to our stakeholders, measuring our impact is essential. It also helps us and our clients learn what works, so that we can continually enhance our development impact. This learning process is particularly crucial for innovative approaches and projects, such as the initiatives supported under the Impact Financing Envelope.

The [Global Development Network \(GDN\)](#) and the EIB have partnered on an impact research programme which has deepened the EIB’s insight into its contribution to sustainable and inclusive development in Africa and the Caribbean. The programme produced 16 impact studies for investments funded under the Impact Financing Envelope, in sectors ranging from healthcare to microfinance in eight African and Caribbean countries. The studies met high standards of technical quality and academic rigour, as confirmed by a strong and independent scientific committee.

The EIB-GDN programme worked with local researchers and helped them develop their skills, while drawing on the technical know-how of top international experts. Under the programme, 30 [talented researchers from Africa and the Caribbean](#) spent a year developing an impact research study for an EIB-supported project. During this time, they were trained, guided and mentored by a [scientific committee of global experts in impact evaluation](#). With top-level academics and policymakers from institutions including the Paris School of Economics, the World Bank and the International Initiative on Impact Evaluation (3ie), the scientific committee was put in place to guarantee the quality and credibility of the research produced under the programme.

¹ 2020 Annual Report on EIB activity in the African, Caribbean and Pacific States and the Overseas Countries and Territories

The EIB will continue to invest in understanding our development impact as we work to build back better in the wake of the COVID-19 crisis, building on the lessons we have learnt from the EIB-GDN programme. The financing constraints faced by many of our partners and the high expectations of our EU stakeholders and citizens make it more important than ever that we support the investments capable of making the biggest difference on the ground. We are looking forward to continuing this research stream and leveraging the knowledge we generate to boost our accountability, our decision-making and the overall effectiveness of our development impact.

Werner Hoyer
President
European Investment Bank

Introduction

Authors: Nina Fenton and Claudio Cali

As the European Union’s international development bank, the European Investment Bank (EIB) puts measurement of development impact at the core of its business approach. The EIB’s [Additionality and Impact Measurement framework](#) captures evidence on the results of every EIB investment. The Bank also uses micro- and macro-level impact studies and independent evaluations to complement this information and create a strong evidence base on development impact.

The EIB partnered with the [Global Development Network \(GDN\)](#) on an innovative programme of impact research, covering projects in Africa and the Caribbean. The programme aimed to deepen understanding of the development impact of private sector impact investments while also enhancing capacity for impact assessment. The research was carried out in three 12-month cycles by [talented researchers from Africa and the Caribbean](#). Each researcher spent a year studying the impact of an EIB-supported project. During this time, the researchers were trained, guided and mentored by the GDN, the EIB and a [scientific committee of global experts in impact evaluation](#). The committee comprised top-level academics and policymakers from institutions including the Paris School of Economics, the World Bank and the International Initiative for Impact Evaluation (3ie). It served to guarantee the quality and credibility of the research.

The EIB-GDN programme has strengthened the Bank’s understanding of its contribution to sustainable and inclusive development. The supported researchers have produced 16 impact studies¹ of investments in sectors ranging from healthcare to microfinance, in eight African and Caribbean countries. The studies met high standards of technical quality and academic rigour, as confirmed by the strong and independent scientific committee.

The programme used, developed and created capacity for future impact research in partner countries by working with 30 talented researchers from Ethiopia, Cameroon, Ghana, Haiti, Mali, Nigeria, Kenya, Rwanda, Senegal, South Africa, The Gambia, Uganda and Zimbabwe. The researchers were trained in cutting-edge techniques for impact assessment and evaluation by international experts. Following this training, the researchers spent a year working closely with EIB clients on impact studies, supported throughout by the international experts, the EIB and the GDN. The programme gave them valuable practical experience of the realities of assessing the impacts of innovative private sector projects.

The EIB is pleased to present four studies completed in the programme’s third cycle. The studies used various econometric techniques, tailored to a diverse set of contexts and adapted to the operational realities of carrying out primary research during the coronavirus pandemic. In some cases, drawing on the experts’ technical advice, the researchers used experimental or quasi-experimental techniques to identify a causal relationship between EIB investment and impacts on the ground. Some of the emerging findings are described below.

¹ The results of the first two project cycles have been published on the EIB’s website: <https://www.eib.org/en/publications/the-impact-of-private-sector-projects-in-africa.htm> and [The impact of private sector projects in Africa: Studies from the EIB-GDN Programme, Cycle 2.](#)

The activities of the Development Bank of Jamaica (DBJ) seem to have had a positive impact on its partner microfinance institutions and on the entrepreneurs they serve, although it is challenging to conclusively demonstrate a causal link. The DBJ received EIB support under a loan signed in 2016 aiming to boost access to finance for small businesses in productive sectors². The researchers used phone interviews to collect information from staff of two microfinance institutions receiving DBJ credit and from 420 of their clients. The analysis of their feedback showed a positive relationship between the amount of credit received and firms' profits. Quantitative analysis using econometric methods designed to test for a causal link supported the results of the qualitative analysis, although it was not possible to conclusively demonstrate a causal relationship. Of the final beneficiaries interviewed, most indicated that the credit received from microfinance institutions improved their business performance. This support may have been particularly helpful during the COVID-19 pandemic, reported by 86% of firms as having negatively affected their business. The microfinance institutions also confirmed that the DBJ's credit line helped them to expand their portfolios and sustain their operations during a highly challenging period. However, the research indicated that microcredit had less impact on profits of female entrepreneurs, younger businesses and newer clients. The DBJ may need to do more to ensure these groups derive the maximum benefit from its support.

Microfinance appears to have helped Haitian micro-entrepreneurs to improve business outcomes.

The researchers focused on small businesses that borrowed from ACME, one of the biggest microfinance institutions in Haiti. ACME benefited from an EIB local currency loan in 2017³. The study compared the difference in outcomes between two groups: (1) the treatment group of around 700 borrowers that had completed at least three loan cycles; and (2) the control group of 300 new borrowers going through their first borrowing cycle. The evidence suggests that microloans support business expansion: compared to new clients, firms that had completed at least three loan cycles had a higher probability of hiring new workers, and a higher likelihood of increasing their merchandise stock as a way of expanding their business. They also reported higher profits and savings.

In Nigeria, a digital retail distribution platform is helping small retailers, mainly women, to avoid running out of stock of a specific selection of products, which is likely to positively impact on business outcomes. The business in question – TradeDepot – received funding from Partech Africa Venture Capital Fund, which secured EIB financing in 2017⁴. The researchers used a phone survey to collect business data from 356 stores that use TradeDepot's ShopTopUp service and from a comparison group of 124 stores not using the service. The study used econometric techniques, such as multivariate regression analysis and propensity score matching, to attempt to identify a causal relationship between use of the service and business outcomes. ShopTopUp users experience shorter stock-out periods compared to non-users (1.7 days vs. 3.4 days), which minimises the time that retailers lack products to sell, thus reducing associated revenue losses.

Nigerian market traders report significant benefits from the provision of renewable energy systems.

The researchers interviewed 700 merchants in the states of Lagos, Kano and Ondo. Of these merchants, 300 were using solar systems provided by Rensource, a small and growing enterprise. Rensource is supported by the IPAE2 Fund managed by Investisseurs & Partenaires, which secured

² [2016 Annual Report on EIB Activity in Africa, the Caribbean and the Pacific, and the Overseas Countries and Territories.](#)

³ [EIB Donors in Action 2019.](#)

⁴ [Partech Africa Venture Capital Fund \(eib.org\).](#)

finance from the EIB in 2017⁵. The vast majority of interviewed traders had lacked access to a grid connection before signing up for the service. Their reported business outcomes were compared with those of 400 merchants still relying on other energy sources, mainly noisy, polluting and dangerous petrol or diesel generators. By applying propensity score matching, the researchers found that subscription to Rensource solar energy has a positive impact on monthly earnings, sales volumes and profits. In addition, by subscribing to Rensource solar energy, merchants using the national grid and standby generators can cut their average monthly expenditure on electricity by over one-third.

⁵ [I&P Afrique Entrepreneurs II \(eib.org\)](http://eib.org).

Development Bank of Jamaica (DBJ), Jamaica

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Summary

This deep dive research focuses on understanding how the credit activities of the Development Bank of Jamaica (DBJ) affect the performance of microfinance institutions and micro, small and medium-sized enterprises (MSMEs) in Jamaica. The DBJ received support from the European Investment Bank (EIB) under the Impact Financing Envelope, which seeks to improve credit access among financial institutions and MSMEs in developing countries. This study therefore provides insights into the ultimate impact of EIB funding through the DBJ.

To achieve the study's objectives, we selected three microfinance institutions receiving DBJ credit, based on its recommendations. Two of the three microfinance institutions are currently active and were interviewed to assess the effectiveness of their activities with the DBJ. For the MSME sample, clients of one of the two microfinance institutions (the one with the largest client base) were sampled and used for analysis. The study collected and analysed primary data on 420 clients. Data were collected via telephone due to the limitations imposed by the COVID-19 pandemic.

To estimate the impact of credit received from microfinance institutions on the performance (sales/profits) of MSMEs, we used the instrumental variable technique, recognising potential endogeneity problems in our variable of interest (credit amount received). The sample was further disaggregated to analyse how the impact of credit on business performance differs across the sex and age of the business owner and according to how recently the loan was obtained. Individual- and firm-level characteristics were controlled for in all models.

The descriptive statistics suggest that relatively more female-owned businesses (compared to male-owned) were accessing credit. It is unclear if this reflects a national pattern in the proportion of female-owned businesses. The World Bank's 2010 Enterprise Survey noted that about 40% of firms in Jamaica have female participation in ownership. In terms of operating sector, the descriptive statistics further showed that the majority of firms were in the trading sector, followed by the agriculture and service sectors. Most respondents (87%) reported being satisfied with the loan operations/administration. About 57% of the businesses were also formally registered. The respondents noted that the credit has helped to sustain their businesses.

The econometric results show that the credit amount received is positively associated with MSME performance (particularly profits). These results imply that the size of the loan in support of these companies' activities is an important determinant of their profitability. This does, however, assume that firms receive sufficient amounts and use the loans to support business growth. The results further indicate that the positive effect of the loan amount on firms' performance was significant only for those that received the loan at least a year before the survey, those with older owners (more than 40 years old), and those owned by men.

The study also highlights some ideas from microfinance institution clients on how to adjust operations to better support firm performance. The suggestions include extending the frequency of loan repayment, increasing the loan amount (especially for those receiving less than requested), expediting the loan application process, and extending the loan repayment period, especially during the COVID-19 pandemic. It is important to note that these ideas were directly extracted from client interviews and their implementation will depend on what the microfinance institutions consider feasible. Clients also gave interesting responses on how the pandemic has impacted their businesses.

About 86% of respondents noted that COVID-19 has negatively affected their business operations. Most respondents also believed that the DBJ credit line has helped them cope with the impact of the pandemic.

The findings suggest that microfinance institutions' activities with the DBJ have significantly improved their operations by enhancing their portfolios and allowing them to increase their client base through innovative product development.

List of acronyms

DBJ	Development Bank of Jamaica
EIB	European Investment Bank
MFI	Microfinance institution
MSMEs	Micro, small and medium-sized enterprises

1. Introduction

Access to finance plays a crucial role in business development, sustainability and growth. Ayyagari et al. (2008) note that finance is the most robust obstacle to the growth and performance of firms. Raj and Sen (2013) also indicate that credit constraints significantly affect small firms' ability to make the investments necessary to transition to larger, more productive firms. Micro, small and medium-sized enterprises (MSMEs) play a prominent role in job creation and economic output in developed and developing countries. The growth of such companies has been touted as a sustainable solution to growing unemployment and high levels of poverty and inequality in developing countries, characterised by high informality and relatively youthful populations. A review by the International Labour Organization (2019) suggests that over 50% of job creation in developing and emerging countries comes from MSMEs.

However, the lack of or insufficient access to credit for MSMEs is widespread in developing and emerging countries. With financial markets in these countries generally underdeveloped, firms usually face high collateral requirements, which limits access to and the quantity of credit. MSMEs typically face interest rates that are simply unaffordable given their business size and prospects. The challenge of credit constraints is even worse for start-ups or relatively new enterprises and those considered to be growing slowly. Many financial institutions consider these enterprises to be high risk, and consequently either exclude them or offer credit only at relatively higher prices (Stiglitz & Weiss, 1981; Demirgüç-Kunt et al., 2006; Beck & Cull, 2014). Women also face considerable challenges in accessing credit for their enterprises, especially in underdeveloped countries, where their participation in economic activities is already limited by primary responsibility for household chores and childcare (de Mel et al., 2008a; Aterido et al., 2013). These and other conditions tend to create relatively tighter credit constraints for women in developing countries. Against this background, microfinance institutions have come to be an important driver of the economic growth of developing countries, helping to encourage entrepreneurial activity and reduce poverty (Brau & Woller, 2004). Paying particular attention to the activities of microfinance institutions and MSMEs is, therefore, a step in the right direction for any growing economy.

For the goals of microfinance to be achieved, however, microfinance institutions need to be able to sustain their operations. Studies have shown that microfinance institutions usually struggle with sustainability and collapse due to poor regulation, insufficient portfolios and high default rates among their clients (Brau & Woller, 2004). Another major challenge for microfinance institutions is the underdevelopment of financial markets across many developing and emerging countries, which creates significant uncertainty that hinders the prospects of long-term investments. In such environments, financial institutions are typically sceptical about investing large sums or granting loans to enterprises considered vulnerable. In this regard, interventions that seek to increase microfinance institutions' portfolios and ultimately improve their growth and sustainability are crucial.

1.1. MSMEs and microfinance in Jamaica

The government of Jamaica recognises the MSME sector as key to developing the Jamaican economy. In its 2017 MSME and Entrepreneurship Policy, it acknowledges that they are important partners in creating wealth, promoting employment and supporting the growth of the private sector as a whole. However, these enterprises face numerous challenges, prominent among which is access

to finance. According to the World Bank's 2010 Enterprise Survey, almost all formal MSMEs in Jamaica had access to checking or savings accounts, but only about 27% had been able to obtain a loan or line of credit. This figure falls woefully short of the regional average of 48% for Latin America and the Caribbean.

Some factors that have constrained lending to MSMEs in Jamaica include the lack of adequate collateral and financial products, and difficulties in assessing risk as reliable financial statements are scarce (World Bank, 2015). The consequent lack of funding means that MSMEs usually rely on internally generated funds, which affects their ability to invest, thus restricting their productivity and, ultimately, their growth.

Attempting to boost access to finance for micro-entrepreneurs, the Jamaican government has worked through the Development Bank of Jamaica (DBJ) to provide credit for MSMEs. This has mainly been accomplished through on-lending via financial institutions such as microfinance institutions. In 2012, the DBJ secured approval for over 8 000 loans, amounting to JMD 1.4 billion. About 40% of this sum was channelled through microfinance institutions (World Bank, 2015).

Aside from these domestic efforts to increase financing for microfinance institutions, this sector has also received external support. One example is the credit line provided by the European Investment Bank (EIB) under the Impact Financing Envelope, through which the Bank seeks to finance the growth and sustainability of enterprises across developing countries. The amount of investment and mode of operation varies significantly across countries.

Under the Impact Financing Envelope, the EIB provided wholesale loans to the DBJ for on-lending to selected financial institutions such as microfinance institutions. The DBJ recognises the role of MSMEs in developing and stimulating the Jamaican economy. Its microfinance unit, through its wholesale loans to microfinance institutions, provides indirect financial support for these firms. In effect, the DBJ's role is to identify microfinance institutions that serve as credit retailers.

The programme is designed to improve the performance of MSMEs while sustaining microfinance institutions. This is expected to fill a major gap in the Jamaican financial market, especially for these small businesses. In this study we sought to assess the impact of DBJ financing on the performance of MSMEs and microfinance institutions in Jamaica, focusing specifically on those that benefited from the Impact Financing Envelope.

1.2. Research questions

The research questions focus on two important stakeholders, namely microfinance institutions and MSMEs. The questions seek to reveal the relevance of support to the portfolios and sustainability of microfinance institutions. Regarding MSMEs, we aim to understand the impact of retail loans on their performance. The research questions also elucidate aspects of engagement at all levels that need improvement. The specific questions are as follows:

For MSMEs:

- Do loans from microfinance institutions impact the sales/profits of MSMEs?
- Does the impact of microfinance institution loans differ across the sex and age of MSME owners?

For microfinance institutions:

- How have DBJ loans contributed to portfolio size and growth?
- How have DBJ loans improved microfinance institutions' performance?

2. Literature review

2.1. Conceptual framework

This study's conceptual framework is based on the microeconomic theory of production, which posits that the primary objective of a firm is production – the transformation of inputs (or factors of production) into outputs. This implies that firms' performance is invariably linked to the supply of factors of production, specifically capital and labour. Adequate supply of financial capital is particularly key to improving firm performance. In the context of developing economies, where a large number of informal firms have little or no financial support, or the requirements of larger financial institutions make their services unattractive to MSMEs, access to credit plays a crucial role in improving outcomes (Giang et al., 2019).

Access to credit has been found positively related to the number of start-ups – an important indicator of the extent of entrepreneurial activity within the economy (Beck & Cull, 2014). Also, access to credit affects the productivity and growth of an existing firm through improvement of saving rates, investment decisions, technological innovations and capacity to expand in new markets (Ricupero et al., 2001; Levine, 2005). Sufficient access to finance enhances the activities of MSMEs by facilitating medium- and long-term investments, and by easing exchanges through short-term credit (Straub, 2005). Conversely, difficulties in accessing credit have been shown to limit the growth of MSMEs, thus hampering their ability to contribute to the economy (Beck & Demirgüç-Kunt, 2006).

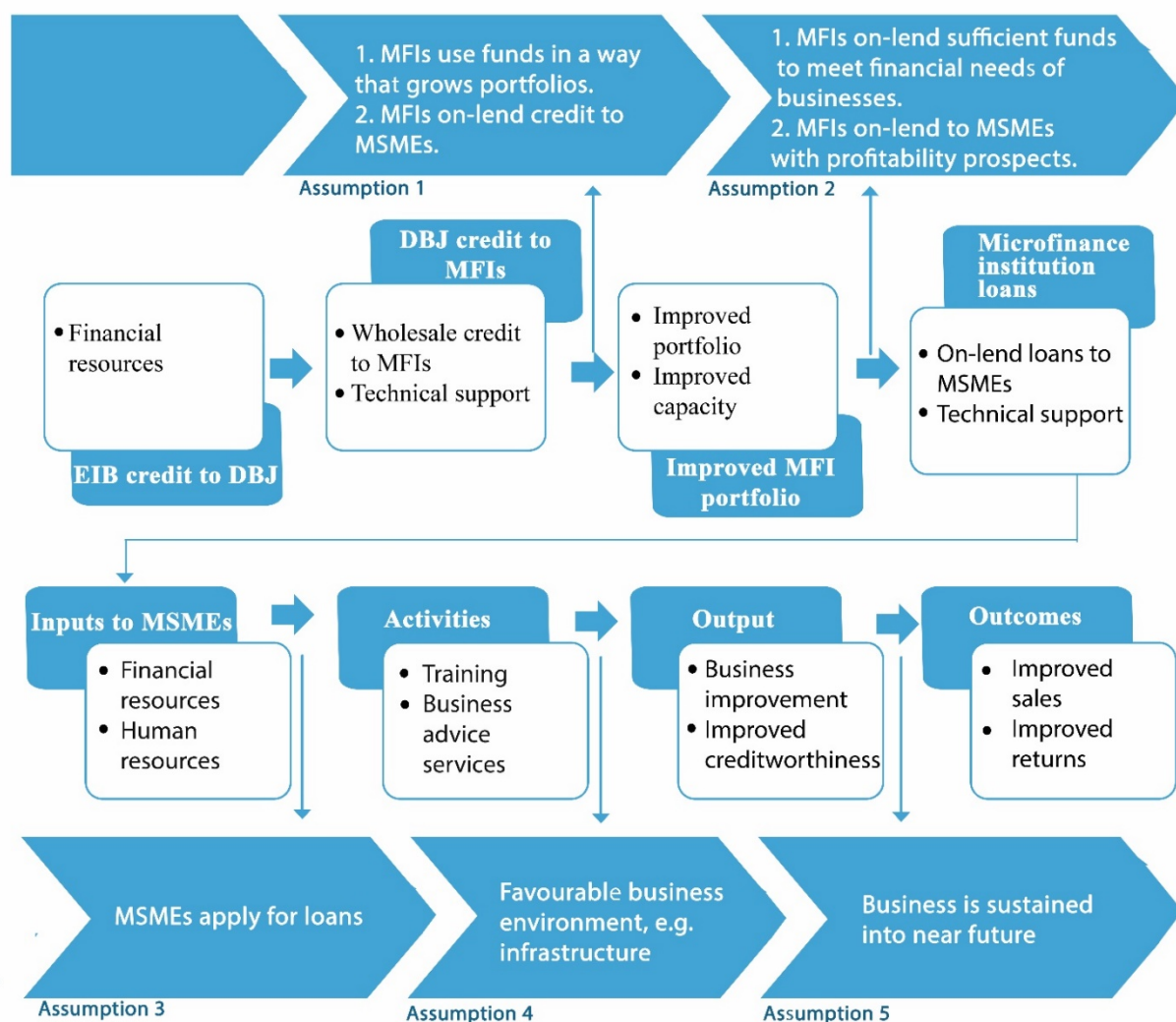
2.1.1. Theory of change

Figure 1 shows the pathway of the potential impact of EIB activities on the two main stakeholders: microfinance institutions and MSMEs. The top half shows the pathways of impact for microfinance institutions, while the bottom half shows the pathways for MSMEs. The process begins with EIB credit to the DBJ with the objective of providing financial incentives to Jamaican businesses. The main input at this point is the financial resources committed by the EIB to the DBJ. The next step in the chain is the DBJ providing credit to microfinance institutions. The inputs at this stage are wholesale credit and technical support to the microfinance institutions. The wholesale credit is expected to improve microfinance institutions' portfolios (in terms of profitability and client diversity, with smaller MSMEs included), as well as microfinance institutions' performance and capacity to provide financial services to MSMEs. In turn, these improvements are expected to translate into loans and technical support from the microfinance institutions to MSMEs.

The next phase of the theory of change concerns how these loans improve the performance of MSMEs. Here the main input is the credit provided by microfinance institutions. In many instances, the credit is complemented with technical support and monitoring to ensure the loans are used for the right purposes, reduce the default rate and improve MSMEs' performance. This mainly involves organising training programmes and offering business advice services, including business organisation and bookkeeping. The expected outputs are improvements in business performance, creditworthiness, business investment and savings. Ultimately, the main outcomes include improved sales/returns,

enabling entrepreneurs to invest in the expansion of their businesses and increase savings. At every stage of the theory, we made assumptions that are highlighted at the top and bottom of the figure. One possible implication of this theory of change is the likelihood that demand for credit increases as microfinance institutions' portfolios grow. It is therefore expected that the actual amount of loans granted will depend on the demand for loans and microfinance institutions' willingness to grant loans. Microfinance institutions are likely to grant loans to MSMEs with better profitability prospects. This point is highlighted in Assumption 2.

Figure 1: Theory of change



2.2. Microcredit access and the performance of MSMEs

Various empirical studies have emphasised the importance of MSMEs to growth and the development agenda of emerging economies, citing contributions to employment, job creation and economic output (Stein et al., 2013). Poor access to finance, however, still poses a major challenge to the growth and sustainability of many enterprises in developing countries (Kuntchev et al., 2013). Since the founding of Grameen Bank in Bangladesh in 1983, microfinance has evolved to become an important means of tackling credit constraints for MSMEs in developing countries around the world.

Microfinance is viewed as a means of tackling poverty by encouraging entrepreneurship among poorer people. In addition, microfinance has gained widespread popularity because it presents the possibility of alleviating poverty in a self-financing and potentially even profitable way (Brau & Woller, 2004). As a tool for poverty reduction, microfinance has been shown to work by providing credit to poorer people, who then use it to finance productive economic activities that enable income growth, all other things being equal (Weiss & Montgomery, 2005).

Studies evaluating the impact of microcredit on MSME performance have produced mixed results.

In a randomised control trial conducted to assess how microfinance affects the livelihood of households in Hyderabad (India), Banerjee et al. (2015) found that demand for microcredit was generally low, and that microcredit had a negligible impact on the profits of the small enterprises that received it. In Bangladesh, however, Ferdousi (2015) found that microcredit for MSMEs significantly increased the income of entrepreneurs, although this effect often depended on providing training and technical support alongside credit. de Mel et al. (2008a) found that microenterprises taking up microfinance generated mean real returns to capital of between 4.6% and 5.3% monthly, with returns varying by household wealth and entrepreneurial skill. Djossou et al. (2020) found that access to credit differently influences the performance of small and medium enterprises in Benin, depending on the type of credit (formal, informal or family) and the age and sex of the business owner.

Furthermore, de Mel et al. (2008b) note that microfinance institution lending tends to be directed towards women-owned enterprises, purportedly justified by female owners tending to have low incomes, facing greater credit constraints, and being able to use resources more efficiently.

Challenging this last belief, they provided evidence from Sri Lanka that women-owned microenterprises had zero average returns to capital, compared to over 11% for those owned by males. Atmadja et al. (2016) also examined the impact of microfinance on the performance of female-owned microenterprises in Surabaya (Indonesia). Their evidence suggests that microcredit had a negative impact on the performance of these microenterprises, a finding they explained by noting that these women may be driven to start enterprises by necessity, rather than opportunity, and so may lack the requisite knowledge and skills to operate profitably.

In a randomised experiment to determine the impact of microfinance in rural Morocco, Crépon et al. (2015) also found a rather low uptake of microcredit, despite which access to microcredit significantly increased investments and profits.

Attanasio et al. (2015) studied the impact of microfinance offered as joint liability loans and as individual liability loans. Using a sample of 1 148 women in rural Mongolia, they found that those who received group loans were more likely to own an enterprise compared to the control group, whereas individual loans had no significant impact on enterprise ownership.

While the goals of microfinance institutions to reduce poverty and encourage entrepreneurship are certainly worthwhile, microfinance institutions themselves need to function sustainably to be able to continue offering their services.

Weiss and Montgomery (2005) note that financially viable and sustainable microfinance institutions can increase access to funding, wean themselves off donor-fund dependence, and self-empower to provide a wider range of financial services. Several factors have been noted to promote microfinance institution sustainability. Using data from the Microfinance Information Exchange, Bhanot and Bapat (2015) computed sustainability scores for Indian microfinance institutions. They found that gross loan portfolio, the percentage of gross loan portfolio

at risk of default, and return on assets contribute significantly to microfinance institutions' sustainability.

Using data from over 200 microfinance institutions in 101 countries, Ayayi and Sene (2010) investigated what factors drive microfinance institution sustainability. They show that combining a high-quality portfolio with sufficiently high interest rates and sound management practices is key to ensuring that microfinance institutions remain sustainable. Bogan (2012) used panel data to examine how capital structure affects the sustainability of microfinance institutions in Africa, the Middle East, Latin America, Eastern Europe, East Asia and South Asia for 2003 and 2006. The long-term use of grants was found to negatively affect microfinance institutions' operational self-sufficiency. This was attributed to the lack of incentive to attract more competitive sources of funding such as the sale of shares.

The foregoing discussion reveals the diversity of the literature on how credit affects firm performance. There are mixed findings on the direction and magnitude of the impact. While some studies report a significantly positive impact (Ferdousi, 2015) on firm performance, others either found a negative impact (Atmadja et al., 2016) or no effect (Banerjee et al., 2015). The findings of these studies also highlight that the design of the credit scheme plays a crucial role in the impact achieved, which underscores the uniqueness of this study. By design, the EIB-DBJ credit facilities are likely to enhance the performance of both MSMEs and microfinance institutions.

3. Data and methods

3.1. Data

Our study had a two-part objective, so data were collected in two parts. First, primary data were collected from the final beneficiaries of DBJ credit (MSMEs) through telephone interviews. The original intention was for researchers to conduct a face-to-face field survey by visiting respondents for interviews. That approach was preferred because financial information on sales and operation costs, as well as other required information, is difficult to provide over the telephone. However, with the challenges posed by the COVID-19 pandemic, researchers were forced to conduct the survey by telephone.

Of the three microfinance institutions recommended by the DBJ for this study, we selected Access Financial Services Limited¹ (which is currently operating with the DBJ) as the microfinance institution whose clients would be invited for interviews. This choice is justified by Access's relatively large client base and willingness to provide relevant information to facilitate the survey. We first requested and received a comprehensive list of all beneficiaries of the DBJ's portfolio with Access. The list included about 4 600 MSMEs that have received some form of credit under the DBJ portfolio. Applying the criteria of a 95% confidence level and a 5% margin of error, we calculated that the sample size should be about 355². To interview respondents, calls were placed randomly to enterprises on the list received from Access. As expected, some enterprise owners declined to be interviewed. Of the 665 calls made in total, 426 interviews were successfully completed, representing a response rate of about 63%.

¹ <https://www.accessfinanceonline.com/>.

² The required sample size was calculated using <http://www.raosoft.com/samplesize.html>.

To collect the data, we identified a renowned research institution called [60 decibels](https://60decibels.com/)³. The process involved developing a questionnaire covering variables relevant to our research objectives. Research assistants based in Jamaica were identified and trained on telephone interview techniques. All calls were made from local telephone lines and respondents' consent was sought and confirmed at the start of each interview. All data were recorded in Excel and later transferred into Stata for further cleaning and analysis.

An important issue is the potential problem of missing data. Telephone interviews present the risk of respondents not reporting information they consider confidential. Our key outcome variables suffered from this difficulty, and some financial information was missing. For the purposes of econometric analysis, the respondents that did not provide responses for these variables were excluded. However, the descriptive analysis included the full sample for non-financial variables. A total of 161 respondents (about 38%) provided full information for our econometric analysis. It should be noted that the only missing information was financial data (such as sales, costs and profits). A comparison of summary statistics between firms providing complete information and those with incomplete information suggests minimal variations. However, we acknowledge that our comparison does not include financial information, so differences in these variables may persist. The comparison of summary statistics is presented in Table A1 in the Annex.

In the second part, primary data were collected from microfinance institutions using structured questionnaires. Of the three microfinance institutions recommended by the DBJ, two were invited to participate while the other was not approached as it is not currently operating with the DBJ. As for the final beneficiaries, face-to-face interviews were precluded by pandemic restrictions. Therefore, the questionnaires were sent by email to the two microfinance institutions to be completed and returned to the researchers. Responses were aggregated to avoid direct attribution and ensure anonymity.

3.2. Analytical approach

To answer our research questions on the final beneficiaries, we first present summary statistics from the data, including a graphical presentation of the firms' characteristics and a bivariate analysis of the variables of interest. We also conducted a mean difference test to identify differences across subsamples in the data. The mean difference tests were also useful in observing potential heterogeneities that were later explored in the econometric analysis.

3.2.1. DBJ credit and MSMEs' performance: Econometric analysis

The econometric specification to identify the role of DBJ loans in the performance of final beneficiaries was estimated using the following equation:

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 f_i + \beta_3 l_i + \varepsilon_i \quad (1)$$

where y_i represents the outcome variable of interest (sales and profit), x_i represents the independent variable of interest (amount of credit received by the firm), f_i is firm-level characteristics, l_i captures owner characteristics, β_i are the parameters to be estimated, and ε_i represents the error. The definitions of all variables as used in the context of this study are shown in Table A7 in the Annex.

³ <https://60decibels.com/>.

3.2.2. Identification strategy

A potential identification challenge with the equation (1) specification is the problem of endogeneity, which can lead to the emergence of two types of biases. This problem arises when the decision to seek credit and the amount of credit secured depend on some characteristics of the participant (i.e. the MSME owner). In this case, the decision to take up credit depends on characteristics of the firm. For instance, firm age or the level of sales may determine why one firm takes up more credit than another. Where these characteristics are observable, the bias can be minimised by including them in the econometric specification. However, where these factors are not observable, the estimated coefficients could be biased and may lead to misleading policy conclusions. This is termed self-selection bias. Another potential source of bias in our specification comes mainly from the supply side: microfinance institutions are willing to offer larger loans to firms with greater potential to be profitable, and thus representing a higher likelihood of loan repayment. This is likely to result in selection bias in the loan amount granted by the microfinance institution. We sought to remove both types of biases arising from endogeneity by using the instrumental variable technique, which can potentially absorb biases that arise from selection.

While the instrumental variable approach has been widely used in the literature to correctly identify programme effects, its major limitation is the difficulty of selecting good instruments. A good instrument is correlated with the endogenous covariate (in our case, credit received) but only correlated with the outcome variables (sales/profit) through the endogenous covariate. We used the amount of credit requested as an instrument for the amount of credit received. The data show that the majority of respondents received the loan amount they requested. We also found a strong correlation (0.92) between the two variables. Some studies have used instruments such as collateral and distance from microfinance institution as instruments to help identify the impact of credit on firm performance (e.g. Ayyagari et al., 2010). Despite the challenges of finding a perfect instrument, the credit amount requested provides a way to identify the relationship between the amount of credit received and firm performance. We also used various post-estimation tests to confirm the validity of the technique, including the under-identification test and the weak instrumental variable test (Stock & Yogo, 2005).

The null hypothesis of the under-identification test is that excluded instruments are not relevant. A rejection of the null hypothesis of the under-identification test indicates that the instruments are indeed relevant; that is, the instrument is correlated with the endogenous covariate. The weak instrumental variable test checks if excluded instruments are correlated with the endogenous regressor, but only weakly. It is expected that there is no correlation between them. As the post-estimation test statistics showed consistent estimates, the instruments are considered to be valid and satisfy all the necessary conditions. The models were estimated using the two-stage least squares technique. In the first stage, the instrumental variable was used to compute estimated values of the endogenous variable. These predicted values were then used in the second stage to estimate a linear regression model of the outcome variable. Results from the first stage are reported in the Annex for each of the models estimated.

3.2.3. Impact assessment for microfinance institutions

The second step of the analysis used qualitative techniques to assess the impact of DBJ operations on the microfinance institutions' performance. This was done through self-administered

questionnaires completed by the two selected microfinance institutions. The responses were aggregated and analysed based on the predetermined themes. The final analysis was conducted with responses strictly anonymised, so as to avoid potential biases in the conclusions.

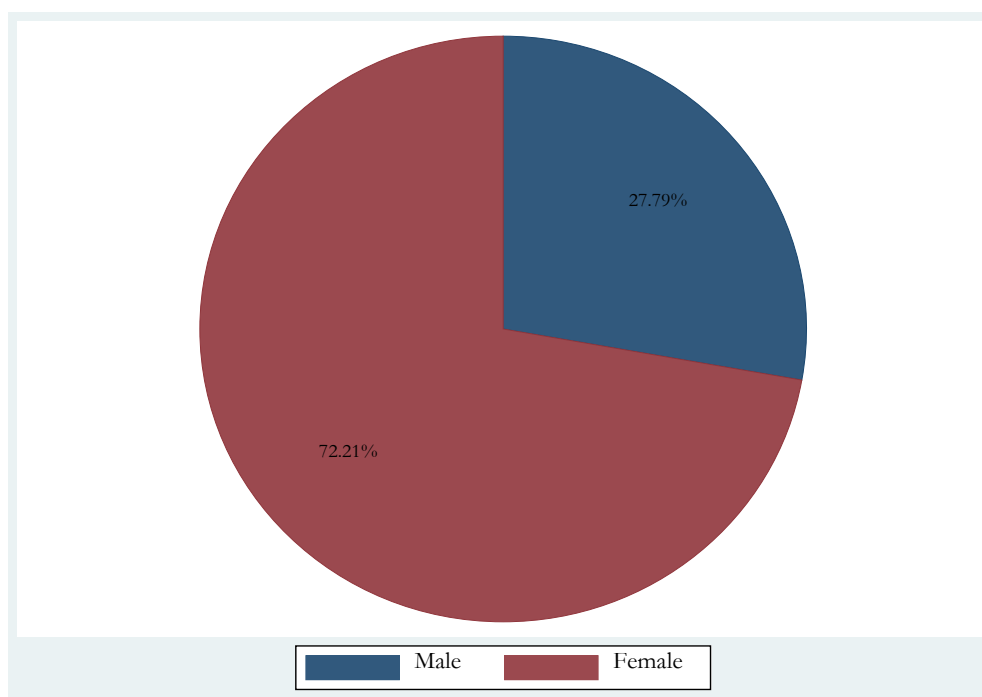
4. Results

4.1. Graphical analysis

4.1.1. Sex of MSME owners

The data show that most of the MSMEs were female-owned (72.2%), while the remaining 27.8% were male-owned. It is unclear if this high proportion of female-owned businesses reflects a national pattern. The World Bank's 2010 Enterprise Survey noted that about 40% of Jamaican firms have female participation in ownership (Nugent & Schmid, 2014). This may, however, have changed over the last decade. There were no clear policies by microfinance institutions that facilitated access to credit for women, and no products or services were introduced that specifically targeted women. The high female representation could be explained by women tending to face more challenges in accessing credit (Aterido et al., 2013), with the result that improved access to credit disproportionately favoured women-owned businesses.

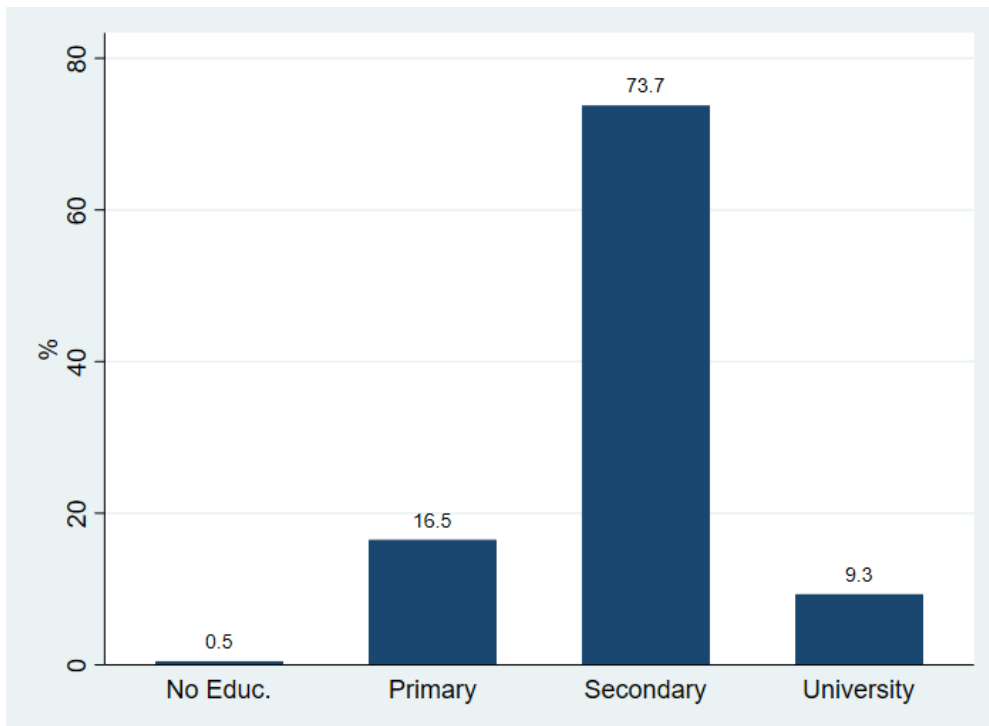
Figure 2: Gender of MSME owners



4.1.2. Education level of MSME owners

It was also interesting to note that the majority of owners had some level of education, with less than 1% of the sample lacking any formal education. About 74% of owners had completed secondary education, while about 17% and 9% had completed primary and tertiary education, respectively.

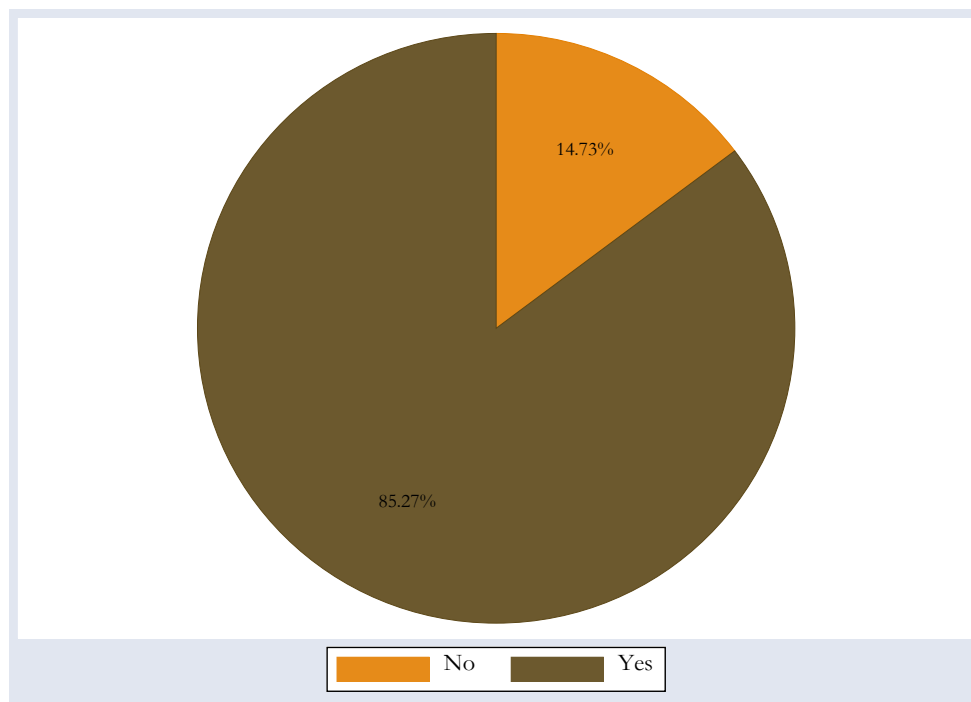
Figure 3: Education level of MSME owners



4.1.3. Bank account ownership

Only a small proportion (14.7%) of firm owners indicated that they did not have a bank account; the majority (85.3%) of owners had an account.

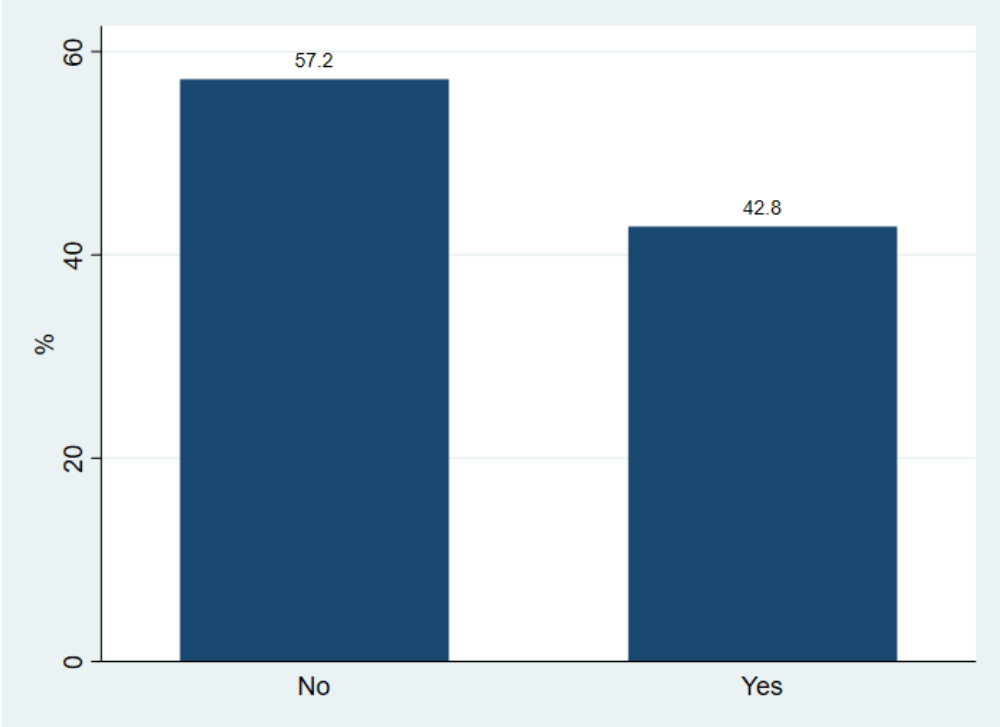
Figure 4: Does the MSME owner have a bank account?



4.1.4. Registration of the enterprise

The data highlight the predominance of informal firms in the MSME sector. About 57.2% of businesses in the sample indicated they were not registered, while about 42.8% were registered.

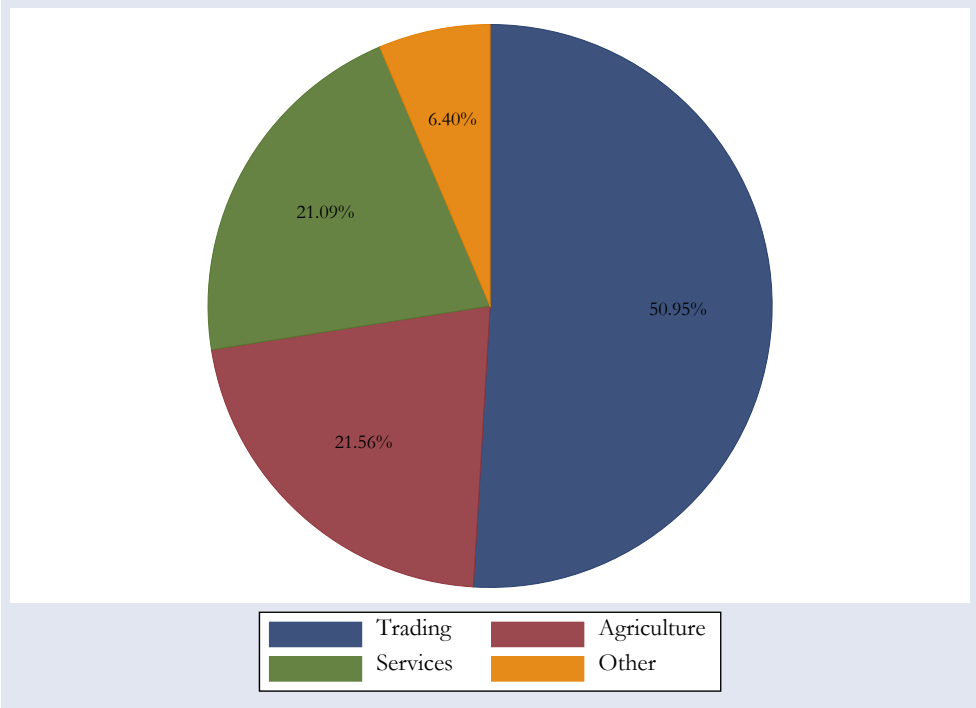
Figure 5: MSME registered?



4.1.5. Main activity funded by the loan

About 51% of firms indicated that they channelled the credit received into trading, while about 22% used the credit to engage in agriculture. About 21% of firms used the loan for activities in the service sector, and the remaining 6.4% applied the loan to support other activities (this category includes businesses involved in multiple sectors).

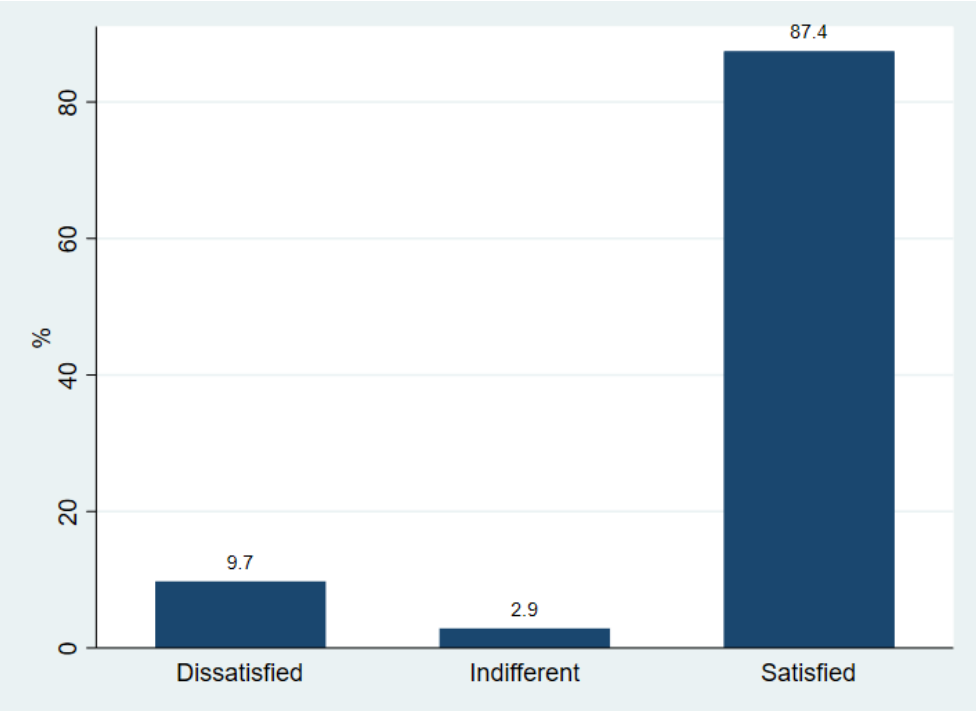
Figure 6: Main activity supported by loan



4.1.6. Satisfaction with credit operation

The vast majority of firms (87%) responded that they were satisfied with the microfinance institution’s operations; only 10% of firms were dissatisfied, while the remaining 3% were indifferent. We detail the reasons for dissatisfaction in section 4.2. Some clients believe that addressing these concerns would help improve their engagement with the microfinance institution.

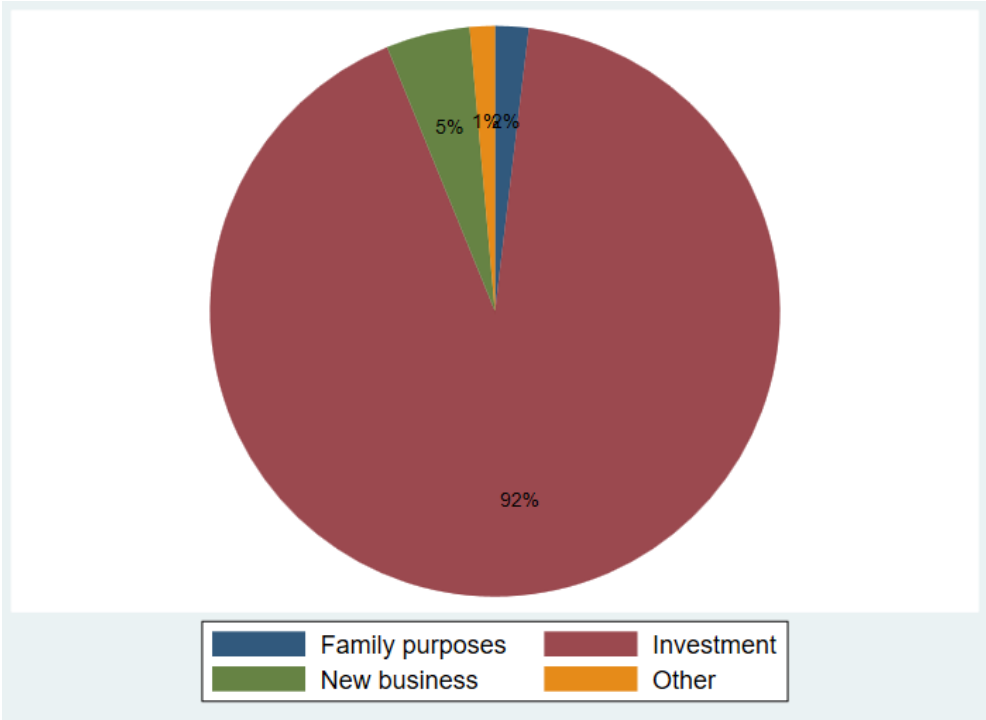
Figure 7: Satisfaction with credit operations/administration



4.1.7. Credit utilisation

As expected, the most popular use of credit received from the microfinance institution was investment (92%). The next most popular use was forming new businesses (5%). Only 2% of firm owners reported using the credit to address a family matter, while 1% indicated other uses. This distribution supports our assumption that firms use credit for business-related investment purposes.

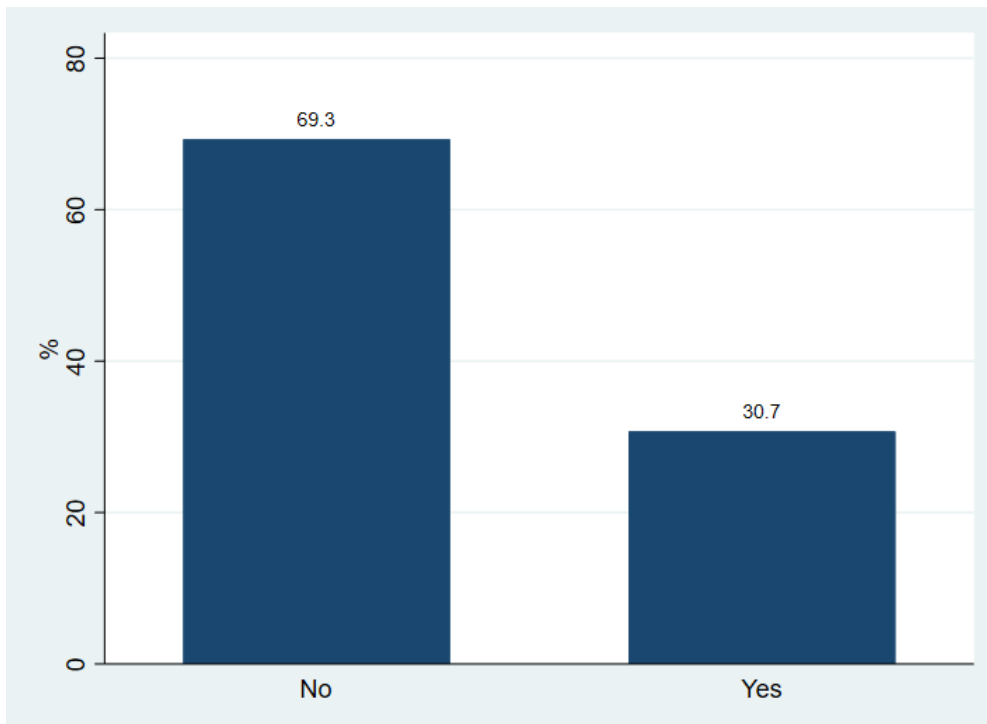
Figure 8: Utilisation of credit



4.1.8. Assistance in credit management

Close to 70% of firms indicated that they had not been supported by the microfinance institutions in proper management of the credit received, while the remaining 30% reported receiving support. It is important to note that the microfinance institutions expressly identified this aspect of credit administration as challenging. The microfinance institutions’ responses suggest that, in many cases, the MSMEs failed to attend the training workshops organised for them. We discuss this further when presenting the findings from microfinance institutions in section 4.6.2.

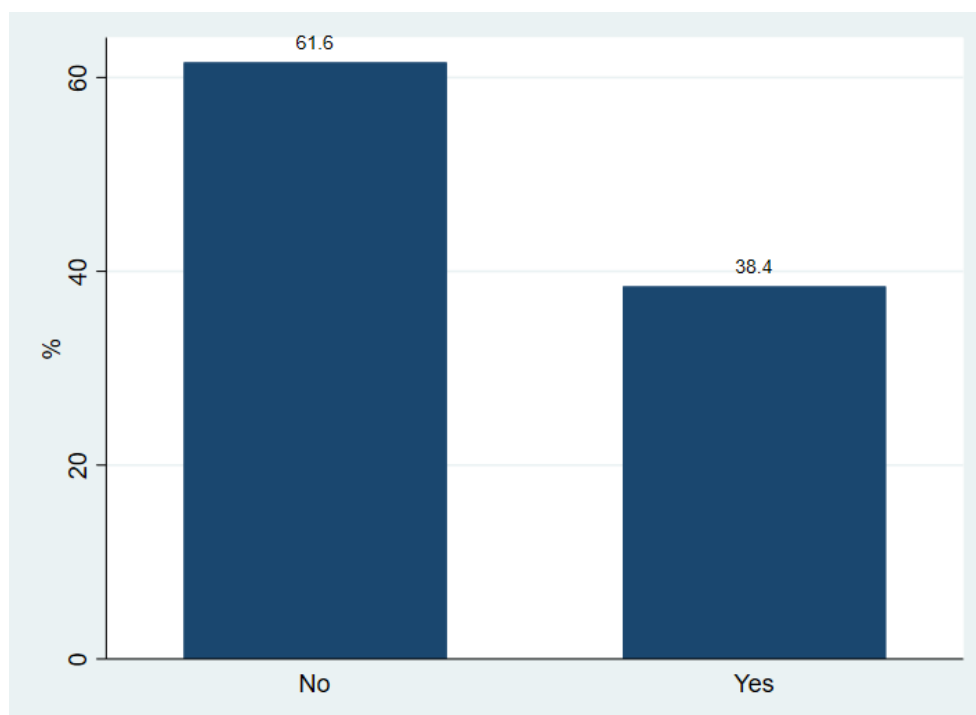
Figure 9: Assistance from microfinance institution in credit management?



4.1.9. Credit required guarantee

The majority (61.6%) of firms received loans that did not require any form of guarantee. This accords with the general objective of the credit line provided by the EIB to the DBJ under the Impact Financing Envelope, which aims to support small businesses without the capacity to provide collateral.

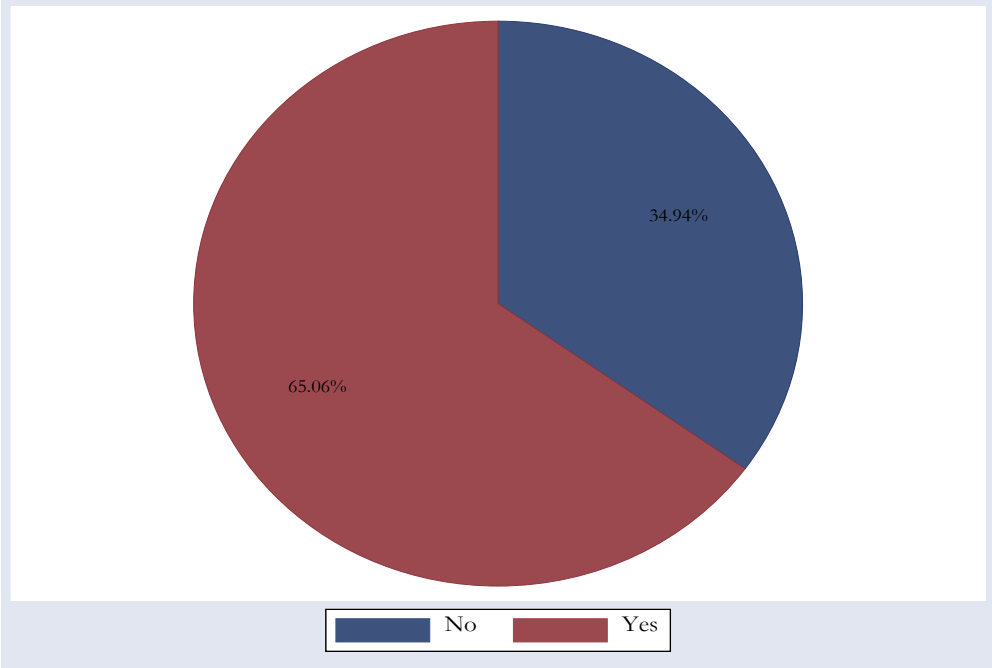
Figure 10: Credit required guarantee?



4.1.10. Contribution to firm sustainability

About 65% of firms reported that the credit received had contributed to the survival of their business up to that time. However, about 35% indicated that their continued operations were not dependent on the credit received.

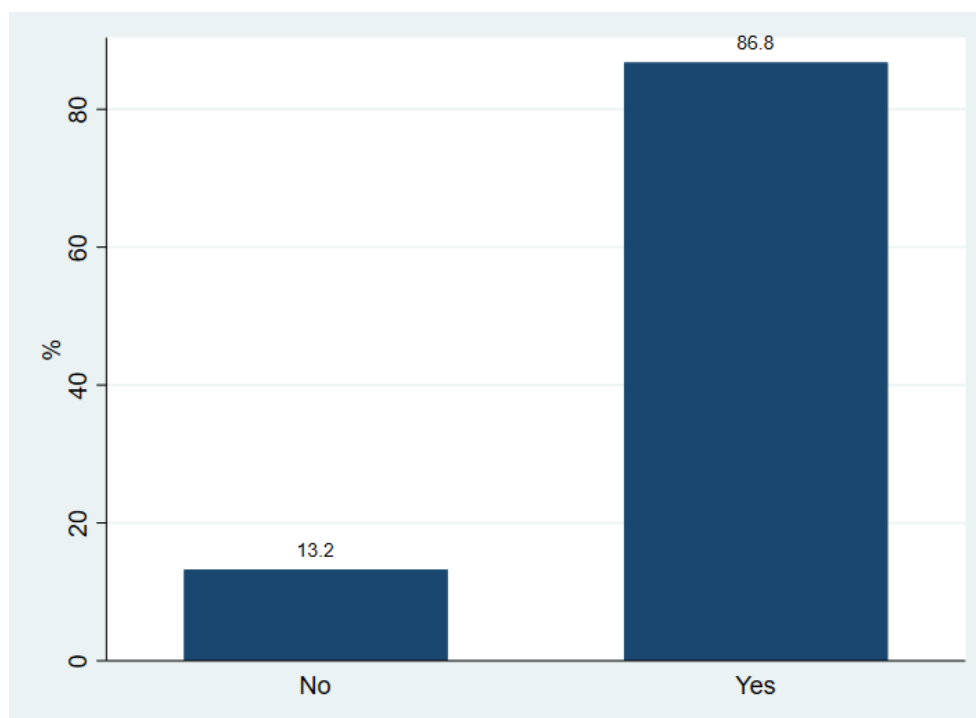
Figure 11: Credit contributed to business sustainability?



4.1.11. Effect of COVID-19 on business

The devastating global effects of the COVID-19 pandemic on businesses was also highlighted by the respondents. Approximately 86% of firms agreed that COVID-19 had negatively affected their business, while close to 14% of firms indicated that the pandemic had not affected their business at the time of data collection. Given that the majority of the businesses interviewed were in trade, this finding was expected, as the pandemic led to restrictions on the movement of goods and services.

Figure 12: Has COVID-19 negatively affected the business?



4.2. Suggestions from clients on improving credit administration

This section summarises some of the responses to the question “What can be done to improve the credit administration?” Both dissatisfied and satisfied clients (94 in total) provided ideas for improvement. The comments fall under certain broad themes that are indicated below. We have also included some of the actual statements from respondents. It is important to note that these responses are extracted directly from client interviews and presented here for the microfinance institution’s consideration; they may not necessarily be feasible options.

4.2.1. Review frequency of repayments

The most common suggestion was to change the frequency of loan repayments from weekly to monthly. Numerous respondents indicated that this would be a more flexible payment plan. This view is typified by one respondent’s comment:

“Restructure how to make the payments. I do farming so to pay on a weekly basis is rough as we don't earn weekly. You may not get money [until] 8-10 weeks down the line.”

Another respondent echoed this claim as follows:

“I wish that they would make it easier for you [clients] to change from making payments on a weekly basis to either making them every fortnight or every month. That would be easier for me.”

4.2.2. Reduction of interest rates

Some respondents also indicated that reducing the interest rate would be a good way to improve services. Various respondents expressed concern that the interest rates on loans were too high.

4.2.3. Increase loan amount

Numerous respondents emphasised that an increase in the loan amount would be beneficial. This was also among the most common concerns raised, as illustrated by the following comments:

“They can increase the loan amount being offered and reduce the interest rates.”

“They couldn't give me the amount I needed.”

“They can give me access to a higher credit limit.”

4.2.4. Paperwork involved in the application process

The amount of paperwork involved in the loan application was also raised as a concern by numerous respondents. As one noted:

“It would be nice if they had less paperwork. They could possibly reduce the loan application form to one sheet.”

Another also indicated that:

“They can cut down on the amount of paperwork you [clients] have to do by utilising technology.”

4.2.5. Expedited application process for repeat customers

Respondents who were repeat customers expressed their frustration about being treated like new customers each time. They believe that for customers who have taken loans before, the process could be revised to make it much easier and quicker. The following responses are illustrative:

“If you are reapplying for a loan, they should use the information that is already on the system so that you don't have to go back through the paperwork again, unless you explicitly state that your information has changed, in which case you would go through the process again. They could also make it an option for salary deductions to serve as loan payments, for those persons who have other jobs outside of their business. I know that option would've been easier for me, as someone who works in a remote area and cannot always make it on time to the payment location.”

“I don't like that they are treating me like I am a new customer. I have to go over the same exact processes every time and bring in the same documents over and over again. Just make the loan application process easier.”

“Too much paperwork. Even though I am not [a] new customer I sign too many of the same documents and bring in the same things every time. This doesn't make any sense.”

4.2.6. Leniency over loan repayments

Some respondents suggested the need for leniency with respect to loan repayments due to the COVID-19 pandemic:

“In COVID time, for a while I had no other source of income. Even though I always finish [repaid] my loans before COVID time, they don’t recognise how I always finish [repay] on time. They weren’t understanding when COVID came around. My loan officer called and I told her I have no source of income. She said I still have to try and make payments. She called me again and asked if I have any other source of income, I told her no. Then she asked ‘How do I eat?’ Then she hung up on me. They need to be more understanding and communicate more. They also need more contingency plans for COVID time.”

“They can give some leniency on the payment terms, in particular the late fees, given COVID.”

4.2.7. Direct deposit of loan amount to customers’ bank accounts

Some respondents expressed concerns about having to come to the office of the microfinance institution to collect their loans. They indicated that it would be more convenient to have the loans paid into their accounts:

“I would like for my loan to be deposited to my account instead of coming into the office to collect [it].”

“They sent me to NCB [National Commercial Bank] to change the cheque for the loan, even though I don’t have an account at NCB. Instead, they could have sent the cheque directly to my bank account.”

4.2.8. Transparency in transactions with clients

Some customers felt that the microfinance institution could be more transparent in its dealings with them:

“Give more information. Tell me more information, like why I was denied a loan sometimes.”

“I got documents from Access to sign up for the two-month break in payments because of COVID-19. I signed the papers and brought them home. When I reached home and read them, I saw that there would be a J\$25 000 increase. They should have told me this as I would not have signed if I knew. Transparency is all I need from Access Finance.”

4.2.9. Online repayments

Some respondents indicated that being able to make repayments remotely would be much more convenient than having to travel to and queue in the bank. They believed that this would save time that could be devoted to other activities. The following responses are illustrative:

“Access’s payment method requires review, they can create a way to pay without going to the bank.”

“I want to get the option to repay directly online instead of joining lines to pay.”

4.3. Descriptive statistics

Table 1 presents descriptive statistics on all variables used in the econometric analysis. The majority of entrepreneurs interviewed (64%) were at least 41 years old, while more than half (51%) of respondents indicated that they engage in some form of trading.

The table shows that the average loan amount received is lower than the average credit amount requested. This suggests that some enterprises received less than they requested. The majority of respondents (87%) had received a credit facility more than once, while about 48% of respondents received their most recent credit facility in the 12 months preceding the survey. Interestingly, the average number of both full-time and part-time employees is less than one. The highest number of full-time (part-time) employees recorded in the sample was eight (five). The statistics also suggest that, on average, about half of both full- and part-time employees were women. Lastly, only about 43% of firms were formally registered.

Table 1: Descriptive statistics

	N	Mean	SD	Min.	Max.
Young owner (<41 years old)	407	0.36	0.48	0	1
Weekly sales	278	42 817.49	54 625.62	0	350 000
Weekly costs	269	28 836.41	36 547.22	0	280 000
Weekly profit	232	26 931.16	132 929	-50 000	2 000 000
Sex of owner (female)	421	0.72	0.45	0	1
<i>Activity</i>					
Trading	422	0.51	0.50	0	1
Agriculture	422	0.22	0.41	0	1
Services	422	0.21	0.41	0	1
Other	422	0.06	0.25	0	1
<i>Owner's education</i>					
No education	419	0.5	0.07	0	1
Primary	419	0.16	0.37	0	1
Secondary	419	0.74	0.44	0	1
University	419	0.09	0.29	0	1
Amount of credit requested	371	121 062.2	107 497	60	1 000 000
Amount of credit received	397	108 460.2	108 687.3	60	1 000 000
Received credit once	399	0.13	0.33	0	1
Most recent credit in previous 12 months	419	0.48	0.50	0	1
Full-time employees	422	0.33	0.95	0	8
Full-time employees (women)	422	0.17	0.57	0	5
Part-time employees	421	0.36	0.98	0	6
Part-time employees (women)	421	0.17	0.57	0	4
Registration status	421	0.43	0.50	0	1

4.4. Differences in means

Before the regression analysis, we tested for differences in the mean value of sales among three groups. Panel A of Table 2 compares firms whose most recent loan was more than a year before the survey with those who took it less than a year prior; Panel B compares firms whose owner is 41 or older with those whose owner is younger than 41; and Panel C compares male-owned firms with female-owned firms. At the 5% level of significance, we find a statistically significant difference in mean sales favouring those who took their most recent loan less than a year before the survey. However, no statistically significant differences are found between firms based on owner's age and sex, despite mean sales being noticeably higher for firms with a younger or male owner. We test these heterogeneities further in section 4.5.1.

Table 2: Difference in mean sales (two-sample t-test with equal variances)

Panel A: Firms that took a loan at least a year before vs. less than a year before the survey			
At least a year before (N=144)	Less than a year (N=133)	Diff. in mean	t-statistic
32 235.09	54 257.77	-22 000	-3.4
Panel B: Is owner less than 41 years old (young)?			
Non-young (N=214)	Young (N=58)	Diff. in mean	t-statistic
42 480.61	45 472.6	-2 991.996	-0.35
Panel C: Sex of owner			
Male (N=80)	Female (N=197)	Diff. in mean	t-statistic
52 533.79	39 089.13	13 444.66	1.85

We replicate the mean differences analysis for firm profit (Table 3). No statistically significant differences in mean profit are found between firms based on owner's age and sex. However, again at the 5% significant level, we find a statistically significant difference in mean profit favouring firms who received their most recent credit less than a year (vs. more than a year) before the survey.

Table 3: Difference in mean profit (two-sample t-test with equal variances)

Panel A: Firms that took a loan at least a year before vs. less than a year before the survey			
At least a year before (N=130)	Less than a year (N=115)	Diff. in mean	t-statistic
5 585.88	21 439.73	-15 853.85	-2.90
Panel B: Is owner less than 41 years old (young)?			
Non-young (N=191)	Young (N=51)	Diff. in mean	t-statistic
12 620.42	15 280.71	-2 660.28	-0.40
Panel C: Sex of owner			
Male (N=71)	Female (N=174)	Diff. in mean	t-statistic
14 515.24	12 750.69	1 764.55	0.30

4.5. Credit received and firm performance

In Table 4 we examine the impact of the credit amount received on firms' performance. In columns (1) and (2) the dependent variable in the model is firm sales, while in columns (3) and (4) the dependent variable is profit. Columns (1) and (3) are estimated with the ordinary least squares method, while columns (2) and (4) are estimated using the instrumental variable technique. The results across the four columns reveal a positive relationship between the credit amount received and firm performance. However, this relationship is not statistically significant when sales is used as the dependent variable. With profit as the dependent variable, the ordinary least squares result indicates that a 1% increase in credit amount is associated with a 0.232% increase in profits. This result is, however, not statistically significant at the conventional 5% level. The instrumental variable result indicates that a 1% increase in credit amount is associated with a 0.226% increase in firm profits, significant at the 5% level. Three tests were conducted to check the validity and reliability of instrumental variable model estimates: the weak identification and under-identification tests. The results of all three tests confirm that the estimates obtained from the instrumental variable model are valid and reliable. The first-stage results are shown in Table A2 in the Annex.

The results also show that female entrepreneurs have lower sales and profits compared to male entrepreneurs. This result is statistically significant in all models at the 5% level. We also find that entrepreneurs who gave guarantees to obtain credit have higher sales and profits compared to those who did not offer guarantees.

Table 4: Impact of credit received on firms' sales and profits

	Sales (log)		Profit (log)	
	(1) Ordinary least squares	(2) Instrumenta l variable	(3) Ordinary least squares	(4) Instrumenta l variable
Credit received (log)	0.209 (0.133)	0.156 (0.095)	0.232* (0.123)	0.226** (0.103)
Female-owned	-0.408** (0.191)	-0.438** (0.180)	-0.511** (0.239)	-0.522** (0.221)
Education (ref=None)				
Primary	0.198 (0.266)	0.184 (0.935)	-0.378 (0.302)	-0.313 (0.947)
Secondary	0.233* (0.138)	0.266 (0.909)	-0.087 (0.207)	-0.043 (0.918)
University	0.523 (0.339)	0.589 (0.944)	0.051 (0.419)	0.101 (0.962)
Main activity (ref=Trading)				
Agriculture	-0.261 (0.254)	-0.345* (0.203)	0.342 (0.251)	0.347 (0.257)
Services	-0.084 (0.217)	-0.121 (0.203)	-0.070 (0.313)	0.051 (0.240)
Other	-0.777 (0.526)	-0.722* (0.375)	-0.906** (0.454)	-0.707 (0.546)
Registered	-0.142 (0.165)	-0.168 (0.155)	-0.092 (0.215)	-0.026 (0.194)
Management assistance	-0.138 (0.161)	-0.103 (0.168)	-0.486** (0.203)	-0.516** (0.201)
Term of loan	-0.013 (0.014)	-0.015 (0.013)	0.043* (0.026)	0.026 (0.028)
Guarantee given	0.534*** (0.155)	0.568*** (0.151)	0.414** (0.192)	0.523*** (0.187)
Constant	8.130*** (1.461)	8.725*** (1.387)	7.209*** (1.381)	7.280*** (1.457)
N	162	151	109	100
R-squared	0.186		0.266	
Adjusted R-squared	0.120		0.175	
Centred R-squared		0.196		0.283
Under-identification test		133.748		89.595
Weak identification test		1 069.834		749.112

Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.5.1. Heterogeneities across loan year and owner's age and sex

We present results of the heterogeneous effects of credit received across loan recency, owner's age, and owner's sex in Tables 5 to 10. We hypothesised earlier that the effect of credit amount on sales and profit may differ across these subgroups of the sample. Accordingly, we tested these potential heterogeneities by splitting the sample. Table 5 presents comparisons of ordinary least squares

estimations between firms that received their most recent loan less than a year before the survey and firms whose most recent loan came at least one year prior. We expect the length of time since receiving a loan to influence sales and profit. For some firms, a boost to sales in the first few months after receiving the loan may be difficult to sustain, whereas other firms may need a longer period to experience any significant changes in outcomes. This disaggregation was, therefore, meant to unpack potential nuances that may not be obvious in the full sample. Sales is the dependent variable in columns (1) and (2), while profit is the dependent variable in columns (3) and (4). Columns (1) and (3) show the results for firms that received their most recent credit less than a year ago, while columns (2) and (4) show the results for firms whose most recent credit came at least a year ago.

Across the four models, the coefficient of credit received is positive, again confirming the positive association between the credit amount received and firms' financial performance. However, the relationship is only statistically significant for firms receiving their most recent credit at least a year ago. Columns (2) and (4) show that, on average, a 1% increase in credit received is associated with increases of 0.41% in sales and 0.55% in profit, respectively. We also find that the magnitude of the coefficient of credit received is higher for firms that received credit at least a year before the survey.

Table 5: Impact of credit received on firms' sales and profit (by recency of loan) – ordinary least squares results

	Sales (log)		Profit (log)	
	(1) < a year	(2) > a year	(3) < a year	(4) > a year
Credit received (log)	0.152 (0.106)	0.407** (0.193)	0.155 (0.125)	0.553** (0.254)
Sex	-0.319 (0.244)	-1.073*** (0.289)	-0.593* (0.297)	-0.922** (0.441)
Education (ref=None)				
Primary	0.000 (0.000)	0.492 (0.940)	0.000 (0.000)	0.452 (1.033)
Secondary	0.132 (0.279)	0.298 (0.874)	0.571 (0.347)	0.136 (0.949)
University	0.886* (0.481)	0.610 (0.933)	0.716 (0.674)	0.208 (1.014)
Main activity (ref=Trading)				
Agriculture	0.092 (0.260)	-1.082*** (0.347)	0.695** (0.335)	-0.923 (0.606)
Services	-0.073 (0.300)	-0.105 (0.270)	0.385 (0.349)	-0.552 (0.354)
Other	-1.442** (0.555)	-0.285 (0.541)	0.394 (1.565)	-1.375** (0.651)
Registered	-0.137 (0.221)	-0.323 (0.223)	-0.283 (0.282)	-0.260 (0.315)
Management assistance	-0.401* (0.240)	-0.087 (0.240)	-0.580* (0.301)	-0.548* (0.303)
Term of loan	0.002 (0.016)	-0.083*** (0.027)	0.043 (0.042)	-0.016 (0.050)
Guarantee given	0.324 (0.206)	0.854*** (0.216)	0.378 (0.273)	0.533* (0.303)
Constant	8.900*** (1.283)	6.738*** (2.226)	7.481*** (1.452)	4.351 (2.878)
N	89	72	63	45
R-squared	0.208	0.452	0.317	0.453
Adjusted R-squared	0.095	0.340	0.170	0.248

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

As reported in Table 6, the instrumental variable results generally confirm the ordinary least squares results, except that the relationship between credit received and firm profit becomes significant (at the 10% level) for firms that most recently received credit less than a year before the survey. The first-stage results are reported in Table A3 in the Annex. The magnitude of the coefficient remains higher for firms that last received credit at least a year before. All post-estimation tests confirm that the instrument is valid and the coefficients robust.

Table 6: Impact of credit received on firms' sales and profit (by recency of loan) – instrumental variable results

	Sales (log)		Profit (log)	
	(1) < a year	(2) > a year	(3) < a year	(4) > a year
Credit received (log)	0.140 (0.101)	0.253 (0.222)	0.198* (0.119)	0.589** (0.248)
Sex	-0.220 (0.227)	-1.146*** (0.262)	-0.613** (0.278)	-0.874*** (0.333)
Education (ref=None)				
Primary	-1.024** (0.453)	0.578 (0.847)	-0.689 (0.630)	0.591 (0.774)
Secondary	-0.766** (0.379)	0.289 (0.786)	-0.120 (0.566)	0.236 (0.715)
University	0.000 (0.000)	0.655 (0.838)	0.000 (0.000)	0.285 (0.757)
Main activity (ref=Trading)				
Agriculture	-0.020 (0.243)	-1.134*** (0.320)	0.633** (0.316)	-0.809* (0.463)
Services	-0.014 (0.282)	-0.253 (0.257)	0.433 (0.330)	-0.337 (0.288)
Other	-1.324*** (0.504)	-0.230 (0.488)	1.283 (1.566)	-1.085** (0.500)
Registered	-0.199 (0.207)	-0.295 (0.206)	-0.210 (0.263)	-0.186 (0.247)
Management assistance	-0.344 (0.220)	-0.052 (0.226)	-0.499* (0.281)	-0.705*** (0.242)
Term of loan	-0.006 (0.015)	-0.069** (0.028)	0.006 (0.046)	-0.048 (0.044)
Guarantee given	0.340* (0.194)	0.887*** (0.200)	0.388 (0.256)	0.692*** (0.235)
Constant	9.936*** (1.305)	8.376*** (2.453)	7.928*** (1.531)	3.946 (2.693)
N	82	68	58	41
Centred R-squared	0.211	0.465	0.308	0.557
Under-identification test	76.986***	44.940***	54.510***	26.951***
Weak identification test	1 074.757***	107.187***	718.558***	53.711***

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Tables 7 and 8 present heterogeneous analysis for the age of the business owner. We test the hypothesis that enterprises with younger owners benefit more from credit received compared to businesses with older owners. The ordinary least squares results are reported in Table 7, followed by the instrumental variable results (accounting for endogeneity) in Table 8. Columns (1) and (3) report estimates for young business owners, while columns (2) and (4) report estimates for business owners older than 40 years. The ordinary least squares results show that the positive associations of credit received with sales and profits are statistically significant only for older entrepreneurs (aged >40).

Table 7: Impact of credit received on firms' sales and profit (by age of owner) – ordinary least squares results

	Sales (log)		Profit (log)	
	(1) ≤ 40 years	(2) > 40 years	(3) ≤ 40 years	(4) > 40 years
Credit received (log)	0.219 (0.290)	0.211** (0.101)	0.608 (0.422)	0.224** (0.105)
Sex	-0.310 (0.378)	-0.513** (0.229)	-0.328 (0.479)	-0.656** (0.285)
Education (ref=None)				
Primary	-0.441 (1.173)	0.000 (0.000)	-0.436 (1.317)	0.000 (0.000)
Secondary	0.251 (1.065)	-0.057 (0.245)	-0.384 (1.202)	0.453 (0.310)
University	0.178 (1.215)	0.461 (0.410)	-0.005 (1.501)	0.494 (0.505)
Main activity (ref=Trading)				
Agriculture	-0.737* (0.422)	-0.011 (0.252)	0.635 (0.636)	0.206 (0.300)
Services	0.312 (0.386)	-0.414 (0.268)	0.414 (0.464)	-0.528 (0.353)
Other	0.497 (1.016)	-1.065** (0.444)	2.746 (2.816)	-1.128* (0.566)
Registered	-0.108 (0.352)	-0.185 (0.190)	-0.314 (0.466)	-0.115 (0.233)
Management assistance	-0.033 (0.337)	-0.201 (0.210)	0.199 (0.498)	-0.798*** (0.239)
Term of loan	-0.026 (0.021)	-0.009 (0.022)	-0.059 (0.119)	0.026 (0.032)
Guarantee given	0.463 (0.310)	0.614*** (0.188)	0.083 (0.411)	0.364 (0.232)
Constant	8.075** (3.303)	8.416*** (1.182)	3.864 (4.484)	7.205*** (1.254)
N	54	107	38	70
R-squared	0.200	0.277	0.228	0.416
Adjusted R-squared	-0.034	0.193	-0.143	0.306

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

As Table 8 reports, results from the instrumental variable technique are generally consistent with the ordinary least squares results in terms of the direction of effects. However, the association between credit received and sales is no longer statistically significant for firms with older owners (column (2)), while the association with profit in this group is less significant (10% vs. 5% level with ordinary least squares) and smaller in magnitude: a 1% increase in the amount of credit is associated with a 0.17% increase in profits for firms with older owners (column (4)). Notably, the association between credit received and profit becomes statistically significant (at the 1% level) for firms with younger owners: column (3) shows that a 1% increase in the credit amount leads to a 1.10% increase in profits. The first-stage results are reported in Table A4 in the Annex.

Table 8: Impact of credit received on firms' sales and profit (by age of owner) – instrumental variable results

	Sales (log)		Profit (log)	
	(1) ≤ 40 years	(2) > 40 years	(3) ≤ 40 years	(4) > 40 years
Credit received (log)	0.511 (0.326)	0.119 (0.098)	1.103*** (0.374)	0.171* (0.099)
Sex	-0.310 (0.346)	-0.569** (0.215)	-0.061 (0.365)	-0.811*** (0.264)
Education (ref=None)				
Primary	-0.569 (1.068)	-0.462 (0.388)	-0.673 (0.992)	-0.447 (0.474)
Secondary	0.165 (0.969)	-0.521 (0.332)	-0.240 (0.908)	-0.075 (0.378)
University	0.062 (1.110)	0.000 (0.000)	0.220 (1.191)	0.000 (0.000)
Main activity (ref=Trading)				
Agriculture	-0.698* (0.388)	-0.108 (0.239)	0.768 (0.486)	0.213 (0.280)
Services	0.364 (0.369)	-0.393 (0.247)	0.664* (0.364)	-0.486 (0.319)
Other	0.492 (0.919)	-0.964** (0.408)	3.484 (2.420)	-0.884* (0.525)
Registered	-0.078 (0.330)	-0.190 (0.179)	-0.049 (0.381)	-0.005 (0.218)
Management assistance	-0.108 (0.313)	-0.184 (0.199)	0.031 (0.380)	-0.807*** (0.222)
Term of loan	-0.035* (0.020)	-0.014 (0.022)	-0.121 (0.106)	0.004 (0.034)
Guarantee given	0.386 (0.296)	0.687*** (0.179)	0.252 (0.342)	0.449* (0.218)
Constant	5.015 (3.629)	9.965*** (1.190)	-1.598 (4.000)	8.465* (1.243)
N	50	100	34	65
Centred R-squared	0.157	0.290	0.307	0.427
Under-identification test	41.378***	90.219** *	28.907***	59.835***
Weak identification test	177.575***	811.701* **	119.179***	614.014***

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The final heterogeneous analysis compares the estimates across the sex of the business owner. We report estimates from the ordinary least squares and instrumental variables in Tables 9 and 10, respectively. In both tables, columns (1) and (3) present estimates for female-owned businesses, while columns (2) and (4) present those for male-owned businesses. In Table 9 the coefficient of credit

received is positive in all columns, but the associations are only statistically significant for male-owned businesses, which also have coefficients of larger magnitude than those of female-owned businesses. For male-owned businesses, a 1% increase in the amount of credit received is associated with increases of 0.63% in sales and 0.75% in profits (both significant at the 5% level).

Table 9: Impact of credit received on firms' sales and profit (by sex of owner) – ordinary least squares results

	Sales (log)		Profit (log)	
	(1) Female	(2) Male	(3) Female	(4) Male
Credit received (log)	0.148 (0.102)	0.630** (0.256)	0.143 (0.111)	0.751* * (0.345)
Education (ref=None)				
Primary	0.126 (0.984)	0.000 (0.000)	-0.180 (0.997)	0.000 (0.000)
Secondary	0.247 (0.961)	-0.315 (0.492)	-0.141 (0.970)	0.555 (0.827)
University	0.327 (1.006)	-0.005 (0.875)	-0.239 (1.025)	2.885* (1.566)
Main activity (ref=Trading)				
Agriculture	-0.361 (0.239)	0.487 (0.496)	0.185 (0.313)	0.130 (0.757)
Services	0.053 (0.252)	-0.087 (0.405)	-0.044 (0.287)	0.251 (0.643)
Other	-0.346 (0.466)	-1.963* * (0.790)	-1.153* (0.628)	0.237 (1.771)
Registered	-0.233 (0.180)	0.401 (0.369)	-0.202 (0.227)	-0.309 (0.635)
Management assistance	-0.264 (0.205)	-0.211 (0.387)	-0.506** (0.249)	-0.638 (0.508)
Term of loan	-0.008 (0.016)	-0.061* (0.034)	0.076** (0.030)	-0.079 (0.084)
Guarantee given	0.408** (0.179)	0.934** (0.363)	0.259 (0.215)	0.177 (0.580)
Constant	8.486*** (1.452)	3.634 (2.859)	7.624*** (1.520)	1.781 (3.569)
N	123	39	83	26
R-squared	0.119	0.485	0.256	0.471
Adjusted R-squared	0.032	0.301	0.141	0.119

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 10 shows that the instrumental variable results are consistent with the ordinary least squares estimates in terms of the direction of effects and which associations are significant, although the association between credit received and sales in male-owned businesses became less significant (10% vs. 5% level with ordinary least squares). Regarding magnitude, the estimates are mostly lower in the instrumental variable models than in the ordinary least squares models. For male-owned businesses, a 1% increase in the amount of credit received is associated with increases of 0.46% in sales and 0.66% in profits. As with the ordinary least squares, the estimates for female-owned

businesses were not significant at any of the conventional statistical levels. The post-estimation tests show that the instrument used is valid. The first-stage results are reported in Table A5 in the Annex.

Table 10: Impact of credit received on firms' sales and profit (by sex of owner) – instrumental variable results

	Sales (log)		Profit (log)	
	(1) Female	(2) Male	(3) Female	(4) Male
Credit received (log)	0.120 (0.102)	0.457* (0.261)	0.149 (0.107)	0.662* * (0.306)
Education (ref=None)				
Primary	0.190 (0.926)	-0.248 (0.777)	-0.130 (0.921)	-2.816 ** (1.198)
Secondary	0.313 (0.897)	-0.361 (0.679)	-0.071 (0.890)	-2.214 * (1.262)
University	0.444 (0.940)	0.000 (0.000)	-0.192 (0.941)	0.000 (0.000)
Main activity (ref=Trading)				
Agriculture	-0.495** (0.230)	0.382 (0.433)	0.155 (0.303)	0.135 (0.577)
Services	-0.048 (0.248)	-0.130 (0.353)	0.105 (0.278)	0.189 (0.502)
Other	-0.314 (0.436)	-1.834* ** (0.681)	-0.982 (0.608)	0.196 (1.350)
Registered	-0.239 (0.172)	0.348 (0.319)	-0.133 (0.220)	-0.266 (0.489)
Management assistance	-0.249 (0.196)	-0.079 (0.344)	-0.557** (0.237)	-0.590 (0.396)
Term of loan	-0.012 (0.015)	-0.045 (0.032)	0.061* (0.033)	-0.067 (0.067)
Guarantee given	0.485*** (0.175)	0.881** * (0.326)	0.371* (0.211)	0.213 (0.446)
Constant	8.743*** (1.405)	5.582* (3.043)	7.544*** (1.432)	5.445* (3.184)
N	113	38	74	26
Centred R-squared	0.140	0.447	0.255	0.469
Under-identification test	103.544***	26.942* **	69.467***	19.108 ***
Weak identification test	1 105.954***	65.788* **	950.242***	41.585 ***

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.6. DBJ activities with microfinance institutions

The second part of this research focuses on the nature of engagement between the DBJ and microfinance institutions. We seek to highlight how the DBJ operates with microfinance institutions and identify whether this is satisfactory to the latter. We also report microfinance institutions' assessment of the impact of this engagement. As noted earlier, only two microfinance institutions participated; their collated responses to the questionnaires are summarised in this section. Challenges in the relationships between the microfinance institutions and their clients are also reported.

The mode of operation between the DBJ and microfinance institutions was largely consistent. Microfinance institutions borrow from the DBJ at predetermined rates, which are typically preset by the DBJ and reviewed by the microfinance institutions. The rates proposed by the DBJ are confirmed by the microfinance institutions without major disagreements. This is attributed to the rates generally being in line with market levels, which allows the microfinance institutions to compete favourably in the market. It was also reported that the preset interest rates only apply to the microfinance industry, as this is the principal focus of the DBJ. For microfinance institutions that also provide credit for large firms, the preset rates do not apply. Instead, the rates are adjusted by the respective microfinance institution for large firms based on market conditions. Default rates are relatively low across the microfinance institutions, with an average default rate of 14% being reported. This situation was attributed mainly to the role of loan collection officers in monitoring loans and ensuring repayments. Regular reminders are also sent to clients to facilitate repayment.

4.6.1. Impact on microfinance institution growth and profit

There was general agreement that the DBJ's credit arrangement with the microfinance institutions has improved the latter's growth. The microfinance institutions admitted that operations would be significantly affected without support from the DBJ. A significant proportion of the microfinance institutions' portfolio is supported by the DBJ, which has allowed them to increase the number of products and clients. For one microfinance institution, the number of clients grew from 1 471 in 2015 to about 8 023 in 2020, at the time of data collection. It was also noted that the majority of clients under the DBJ portfolio are MSMEs. While both microfinance institutions acknowledged growth in the number of clients, the impact on lending to riskier businesses was not the same across microfinance institutions. Specifically, one microfinance institution claimed it can now lend to riskier businesses through specifically designed programmes under the DBJ portfolio, whereas the other microfinance institution denied this and said the current arrangement does not provide flexibility to lend to risky businesses. It explained that because there is no significant markup on the interest rate, lending to riskier businesses would require the microfinance institution to assume a higher risk of default without receiving commensurate returns.

Returns under the DBJ have improved for one microfinance institution but not changed substantially for the other. The microfinance institution that saw little change explained that most of the growth in its client base was accounted for by small businesses, which generally produce lower returns compared to larger businesses. There was, however, evidence of innovation across both microfinance institutions: while one had designed products for risky businesses, the other had designed products to encourage repayment and expand the client base. Given that the DBJ loans target MSMEs, these innovations were necessary to reach out to more small businesses while also increasing returns.

The microfinance institutions also reported a significant improvement in the DBJ's engagement with them. Both microfinance institutions expressed satisfaction with the nature of the DBJ's operations, and neither identified any areas needing improvement. One microfinance institution noted that while some rigidities had limited the type of businesses that could receive credit, these had been addressed over time. One example is the recent removal of the requirement for businesses to have a Tax Compliance Certificate before receiving credit. This move was expected to enlarge the client base and growth of both microfinance institutions.

4.6.2. Challenges in microfinance institution operations

The microfinance institutions' questionnaire responses also revealed several challenges, which mostly concern operations with their clients. For instance, it was noted that some clients fail to attend training workshops organised to facilitate loan implementation. For one microfinance institution, the average attendance by clients at these workshops is about 50%. One reported explanation is that few clients have employees to run the business in their absence. Respondents suggested that this problem could be addressed by delivering client training through digital channels, such as via regular telephones or mobile text messaging.

5. Summary and conclusion

The DBJ is one of many developing world institutions receiving EIB support to achieve impact through development finance. The EIB initiated the process by providing wholesale loans to the DBJ, which in turn retailed these loans to selected microfinance institutions. The microfinance institutions then on-lended to MSMEs to finance their businesses and improve their performance. This study sought to understand the potential impact of the DBJ's microfinance programme on both primary beneficiaries (microfinance institutions) and final beneficiaries (MSMEs).

To achieve the study's objectives, we collected two sets of data. The first data set was collected from MSMEs using telephone interviews because of pandemic-related restrictions. From a population of 4 600 MSMEs, a total of 420 interviews were successfully completed. After data cleaning, we obtained a sample of 211 MSMEs suitable for inclusion in econometric analysis. The second data set was collected from microfinance institutions using structured questionnaires sent by email. Of the microfinance institutions supported by the DBJ's microfinance programme, three were recommended for this study, of which two returned completed questionnaires (the third is not currently operating with the DBJ).

We analysed the effect of credit amount received on the MSMEs' financial performance using descriptive (graphs and univariate tables) and econometric analyses. To account for the potential endogeneity bias due to self-selection or reverse causality in the econometric analysis, we used the instrumental variable technique. Credit amount requested was used as the instrument for loan amount received. We also performed heterogeneity analyses across different groups by loan recency and the owner's age and sex. To assess the impact of DBJ operations on microfinance institutions, we used a qualitative analysis.

While acknowledging significant methodological limitations in our choice of instrument and the absence of a control group, our results generally indicate that the credit obtained from the DBJ's microfinance programme is positively associated with the performance of MSMEs and microfinance

institutions. This EIB-supported programme (under the Impact Financing Envelope) allows microfinance institutions to increase their client portfolios and offer more diverse products to clients. Our estimation showed that a 1% increase in the credit amount received is associated with a 0.226% increase in firm profits. The effect is lower for female-owned than for male-owned businesses and is significant only for MSMEs that most recently received credit at least one year ago. Several reasons may explain the difference across sex. First, although there were more female business owners in the sample, the amount of credit received was significantly lower for females than for males (Table A6). The maximum and minimum credit amounts also differed across the sexes, again favouring male owners. Second, the education level was relatively lower among females than males, which could hamper the effective use of credit received. For firms that received credit earlier, the positive association with financial performance could be explained by reaping the benefits of earlier investments that have had time to mature. We also found that the credit amount received only significantly affects the financial performance of firms with older owners (aged >40). This could be explained by older entrepreneurs having the advantage of experience, which enables them to make sound investments with the credit they receive. Our summary statistics show that the average age of an MSME owner in Jamaica is 36, most MSMEs operate in the trading sector, and 72% of them are female-owned.

MSME respondents also offered some ideas for improving their activities and engagement with microfinance institutions. These mostly concerned clients' perceived hindrances of loan operations. Their suggestions include extending the frequency of loan repayments, increasing the loan amount (especially for those who received less than they requested), expediting the loan application process, and reducing loan processing time.

In general, the study reveals that the Impact Financing Envelope credit line provided by the EIB to the DBJ has been beneficial to microfinance institutions and final beneficiaries. Most of the beneficiaries interviewed expressed that the credit received from the microfinance institutions improved their businesses. For some MSMEs, this was particularly helpful during the COVID-19 pandemic. Similarly, participating microfinance institutions clearly believed that credit from the DBJ has improved their portfolios and sustained their operations.

5.1. Limitations of the study

The study was limited in various ways. First, it did not identify and use an appropriate control group, which is desirable for any impact evaluation exercise. The study only relied on the treatment group to evaluate the impact of DBJ credit. Second, restrictions arising from the COVID-19 pandemic made it difficult to include firms that were not existing beneficiaries of DBJ funding, as most of these firms were adjusting to the difficulties of the crisis. Third, the pandemic restrictions also precluded face-to-face interviews, which were the preferred method for data collection. We therefore resorted to telephone interviews, which hindered the effectiveness of the survey. Finally, for the instrumental variable approach used in data analysis, identifying a perfect instrument from the data available was challenging. While we used various statistics to test the strength of our instruments, we believe an experimental approach would have completely removed bias from endogeneity. This issue should be considered in future efforts to evaluate interventions of this nature.

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Annex A: Additional Tables

Table A1: Summary statistics comparison: Complete vs. incomplete observations

Variable	Incomplete		Complete	
	N	Mean	N	Mean
Sex	260	0.708 (0.456)	161	0.745 (0.437)
Education				
No Education	-	-	161	0.012 (0.111)
Primary	258	0.190 (0.393)	161	0.124 (0.331)
Secondary	258	0.717 (0.451)	161	0.770 (0.422)
University	258	0.093 (0.291)	161	0.093 (0.292)
Activity				
Trading	261	0.487 (0.501)	161	0.547 (0.499)
Agriculture	261	0.207 (0.406)	161	0.230 (0.422)
Services	261	0.245 (0.431)	161	0.155 (0.363)
Other	261	0.061 (0.240)	161	0.068 (0.253)
Registration	260	0.423 (0.495)	161	0.435 (0.497)
Sales	117	46 019.684 (57 962.776)	161	40 490.422 (52 127.341)
Costs	108	28 555.296 (33 836.846)	161	29 024.981 (38 360.580)

Note: Standard deviations in parentheses.

Table A2: First-stage results for full sample

	(1) Sales	(2) Profit
Sex	-0.128** (0.057)	-0.160** (0.077)
Education (ref=None)		
Primary	-0.159 (0.301)	-0.145 (0.335)
Secondary	-0.169 (0.293)	-0.152 (0.325)
University	-0.117 (0.304)	-0.127 (0.340)
Main activity (ref=Trading)		
Agriculture	-0.030 (0.065)	-0.040 (0.091)
Services	-0.181*** (0.065)	-0.196** (0.085)
Other	-0.121 (0.121)	-0.127 (0.193)
Registered	0.102** (0.050)	0.073 (0.069)
Management assistance	0.117** (0.054)	0.125* (0.071)
Term of loan	0.007 (0.004)	0.009 (0.010)
Guarantee given	0.073 (0.048)	0.085 (0.066)
Amount of credit requested	0.951*** (0.029)	0.944*** (0.034)
Constant	0.549 (0.434)	0.640 (0.498)
N	151	100
R-squared	0.911	0.916
Adjusted R-squared	0.904	0.904

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: First-stage results (disaggregation by loan recency)

	Dep. Var.: Sales		Dep. Var.: Profit	
	(1) [< 1 year]	(2) [≥ 1 year]	(3) [< 1 year]	(4) [≥ 1 year]
Sex	-0.075 (0.068)	-0.199* (0.114)	-0.052 (0.086)	-0.464** (0.187)
Education (ref=None)				
Primary	- -	-0.197 (0.372)	- -	-0.123 (0.428)
Secondary	-0.024 (0.088)	-0.208 (0.345)	-0.005 (0.110)	-0.189 (0.396)
University	0.032 (0.136)	-0.111 (0.365)	-0.026 (0.197)	-0.053 (0.417)
Main activity (ref=Trading)				
Agriculture	-0.070 (0.073)	0.048 (0.141)	-0.062 (0.099)	-0.180 (0.251)
Services	-0.162* (0.085)	-0.206* (0.107)	-0.140 (0.103)	-0.255* (0.150)
Other	-0.052 (0.152)	-0.063 (0.213)	-0.124 (0.488)	-0.056 (0.275)
Registered	-0.016 (0.062)	0.243*** (0.088)	-0.057 (0.082)	0.208 (0.133)
Management assistance	0.131* (0.067)	0.108 (0.097)	0.126 (0.089)	0.114 (0.132)
Term of loan	0.006 (0.004)	0.002 (0.012)	0.014 (0.014)	-0.009 (0.025)
Guarantee given	0.025 (0.058)	0.129 (0.086)	0.027 (0.080)	0.157 (0.129)
Amount of credit requested	0.956*** (0.029)	0.954*** (0.092)	0.952*** (0.035)	0.951*** (0.130)
Constant	0.362 (0.360)	0.561 (1.019)	0.335 (0.429)	0.899 (1.365)
N	82	68	58	41
R-squared	0.950	0.845	0.954	0.822
Adjusted R-squared	0.942	0.811	0.943	0.746

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: First-stage results (disaggregation by age of entrepreneur)

	Dep. Var.: Sales		Dep. Var.: Profit	
	(1) [≤ 40 years]	(2) [> 40 years]	(3) [≤ 40 years]	(4) [> 40 years]
Sex	-0.101 (0.080)	-0.132* (0.076)	-0.164* (0.089)	-0.197* (0.105)
Education (ref=None)				
Primary	0.019 (0.246)	- -	0.021 (0.243)	- -
Secondary	-0.166 (0.224)	0.019 (0.090)	-0.146 (0.223)	0.021 (0.125)
University	-0.203 (0.257)	0.112 (0.139)	-0.342 (0.291)	0.107 (0.192)
Main activity (ref=Trading)				
Agriculture	0.054 (0.090)	-0.028 (0.085)	-0.011 (0.119)	-0.022 (0.114)
Services	-0.107 (0.084)	-0.187** (0.088)	-0.089 (0.088)	-0.204 (0.129)
Other	0.189 (0.212)	-0.149 (0.146)	-0.228 (0.587)	-0.149 (0.213)
Registered	-0.112 (0.075)	0.164** (0.065)	-0.189* (0.092)	0.171* (0.089)
Management assistance	0.113 (0.070)	0.156** (0.072)	0.111 (0.093)	0.142 (0.091)
Term of loan	0.013*** (0.004)	0.002 (0.008)	0.039 (0.025)	-0.001 (0.014)
Guarantee given	-0.024 (0.068)	0.104 (0.064)	0.003 (0.084)	0.097 (0.088)
Amount of credit requested	0.734*** (0.055)	0.994*** (0.035)	0.669*** (0.061)	0.989*** (0.040)
Constant	2.952*** (0.626)	-0.109 (0.415)	3.542*** (0.673)	0.039 (0.484)
N	50	100	34	65
R-squared	0.898	0.928	0.905	0.939
Adjusted R-squared	0.865	0.919	0.851	0.926

Source: Produced by the authors from survey data

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: First-stage results (disaggregation by sex of entrepreneur)

	Dep. Var.: Sales		Dep. Var.: Profit	
	(1) [Female]	(2) [Male]	(3) [Female]	(4) [Male]
Education (ref=None)				
Primary	-0.116 (0.274)	- -	-0.112 (0.280)	1.035 (0.597)
Secondary	-0.190 (0.265)	0.206 (0.222)	-0.163 (0.271)	1.417** (0.607)
University	-0.056 (0.278)	-0.093 (0.370)	-0.020 (0.286)	- -
Main activity (ref=Trading)				
Agriculture	0.027 (0.068)	-0.141 (0.199)	0.038 (0.092)	0.138 (0.292)
Services	-0.180** (0.073)	-0.249 (0.160)	-0.242*** (0.085)	-0.440* (0.233)
Other	-0.189 (0.129)	-0.065 (0.324)	-0.237 (0.184)	-0.551 (0.680)
Registered	0.077 (0.051)	0.196 (0.154)	0.012 (0.067)	0.549** (0.237)
Management assistance	0.125** (0.058)	0.267* (0.156)	0.140* (0.073)	0.363* (0.184)
Term of loan	0.008* (0.004)	0.013 (0.014)	0.016 (0.010)	0.031 (0.031)
Guarantee given	0.076 (0.052)	0.047 (0.153)	0.104 (0.064)	0.142 (0.221)
Amount of credit requested	0.965*** (0.029)	0.892*** (0.110)	0.969*** (0.031)	0.843** (0.131)
Constant	0.258 (0.409)	0.808 (1.263)	0.143 (0.432)	-0.140 (1.632)
N	113	38	74	26
R-squared	0.925	0.880	0.944	0.890
Adjusted R-squared	0.917	0.835	0.935	0.817

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Summary statistics on credit received (by sex)

Sex	N	Mean	SD	Min.	Max.
Female	285	97 070.916	66 687.069	60	500 000
Male	108	140 402.78	174 406.86	12 000	1 000 000

Table A7: Variable definitions

Variable	Definition
Sales	Average total amount of sales and earnings in a normal week (in Jamaican dollars)
Cost	Average total operating costs in a normal week (in Jamaican dollars)
Profit	Difference between sales and cost
Education	Highest level of education attained by owner
Sex	Sex of owner
Activity	Exact business activity loan was used for
Credit requested	Credit amount requested (in Jamaican dollars)
Credit received	Credit amount received (in Jamaican dollars)
Credit once	How many times did you receive credit? (=1 if 1; =0 if > 1)
Most recent credit	When did you receive the most recent credit? (=1 if received less than 12 months ago; =0 otherwise)
Credit assistance	Did you receive assistance from the microfinance institution in managing the credit received? (=1 if yes; =0 if no)
Registration	Is the firm formally registered? (=1 if yes; =0 if no)
Term of credit	How long is the term of the loan (in months)?
Guarantee	Did you give a guarantee (collateral) to obtain credit? (=1 if yes; =0 if no)

The impact of microfinance on business investment and outcomes in Haiti

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Summary

Microfinance institutions are a crucial lifeline for poorer people in Haiti. Most households and micro, small and medium-sized enterprises (MSMEs) cannot access credit through formal financial institutions such as commercial banks, partly because of their inability to meet the standards for loan approval (e.g. stable employment, good credit history, high-valued collateral). Microfinance institutions fill this gap by serving the financial needs of those excluded from the formal banking system and with limited access to informal means of financing (e.g. borrowing from friends or joining a savings scheme). For people on low incomes, microfinance institutions play an important role in not only providing access to collateral-free credit, but also facilitating their inclusion in the financial system.

Empirical studies report inconsistent findings on the impact of loans on MSMEs in the developing world. For every study suggesting that microfinance helps such businesses, there is another concluding that they get no benefit from microfinance. Furthermore, as most studies have been conducted in Southeast Asia and sub-Saharan Africa, we still have limited understanding of microfinance's role in other developing regions, particularly Latin America and the Caribbean.

To better understand the social impact of Haitian microfinance institutions, we present a deep dive report on the effects of microloans provided by a major Haitian microfinance institution, ACME, on the performance and development of its MSME clients. We specifically assess whether, after receiving microloans, entrepreneurs implemented changes in their businesses, invested in fixed assets, experienced changes in net revenue and profit, or changed their behaviour.

From July to August 2020, we collected primary data on ACME's clients through a comprehensive quantitative and qualitative survey. The questionnaire included both closed and open-ended questions. We collected sociodemographic, socioeconomic and business information on Haitian micro-entrepreneurs and asked them to report the occurrence or level of a series of outcome indicators at the enterprise level.

We use a novel non-experimental method of impact assessment to isolate the effects of receiving a microloan on a series of business outcomes. Our analysis compares the outcomes between an experimental group of veteran borrowers who have completed at least three loan cycles, and a control group of new entrants going through their first cycle.

Holding several factors constant, we conclude that receiving continuous loans from ACME had some positive effects on Haitian businesses. We find a positive impact on business expansion through various outcomes. Compared to new clients, firms that had completed at least three loan cycles had a higher probability of hiring new workers in 2018 and of increasing their merchandise stock. They also reported higher profits and savings.

The results also highlight the gender-differentiated impact of microloans on businesses. Although ACME loans are critical in helping women open new outlets, the outcomes of increasing stock and adding new services are found only among male-owned businesses. Likewise, receiving continuous loans had a significantly positive impact on estimated average monthly profit only for male entrepreneurs. For savings, female veteran borrowers fare worse than female new clients. Male veteran borrowers, on the other hand, were more likely to report a positive change in annual savings

compared to male new clients. Meanwhile, loans significantly increase the share of business income devoted to household spending only among women-led firms.

Finally, another important observation is the positive effect of receiving continuous microloans on the probability of owning a bank account. This result supports previous research in Haiti evidencing that microfinance can guide borrowers' behaviour by helping them adopt more formal business practices.

1. Introduction

One of the most significant challenges facing developing countries is the need to reduce the incidence and depth of poverty. Eradicating all forms of poverty is a global challenge and a critical requirement for sustainable development. Since the 1990s, microfinance has been considered an important development policy tool for achieving this goal (Helms, 2006); in many developing countries, microfinance is the best form of external financing available to micro, small and medium-sized enterprises (MSMEs).

The assumption is that low-income households and small firms granted microloans (e.g. dedicated to production) will in turn accumulate their own capital for further investment, thereby reducing poverty. Lack of finance is a major barrier to the growth of MSMEs. Therefore, the provision of finance is an important means of mobilising resources dedicated to production.

However, the impact of microfinance in the developing world is difficult to demonstrate and results are mixed. Microfinance as a development tool has been celebrated and criticised (Banerjee et al., 2015b). While some development practitioners have praised the provision of microloans for transforming lives in certain regions, many researchers have concluded that microfinance is no silver bullet in tackling poverty, and that most contemporary schemes have been less effective than expected (Hulme & Mosley, 1996).

In Haiti, as in other developing countries, microfinance institutions are a crucial lifeline for poorer people. Most households and MSMEs cannot access credit through formal financial institutions such as commercial banks, partly because they are unable to meet the standards for loan approval (e.g. stable employment, good credit history, high-valued collateral). Microfinance institutions fill the gap by providing small loans at full-cost interest rates to micro-entrepreneurs and small traders with few or no assets, thus eliminating the constraint of collateral. The demand for microcredit in Haiti is very high. It comes from a range of businesses – informal traders, small merchants and larger firms – that need working lines of credit for operations or investment projects. The microfinance landscape, particularly its non-cooperative aspect, is relatively diverse and reaches a large number of people. In recent years, the sector has grown rapidly and many microfinance institutions have been transformed into profitable, financially self-sustainable entities that can operate at a sufficient scale (independent of subsidies).

Microfinance institutions in Haiti are driven by not just profitability but also a social mission. One challenge these institutions face is how to reconcile the two. Dichter (1997) points out that as microfinance institutions grow and competition increases, there might be mission drift and loss of focus on alleviating poverty. Haiti's microfinance institutions mostly remain attached to social objectives – primarily reducing the level of poverty and providing much-needed support to small entrepreneurs. Many of these institutions are increasingly using sophisticated tools to define and measure progress towards their social goals. To improve understanding of the social impact of Haitian microfinance institutions, we present this deep dive report on the effect of the microloans provided by a major microfinance institution on the performance and development of its clients.

Our aim is to enrich the literature by providing further empirical evidence on the impact of microcredit on MSMEs' performance in the developing world. The few related studies to date have reported inconsistent findings. For every study suggesting that microfinance helps such businesses,

there is another concluding that they do not benefit at all from microfinance. Furthermore, most studies have been conducted in Southeast Asia and sub-Saharan Africa; we still have limited understanding of microfinance in other developing regions, particularly Latin America and the Caribbean. Our study will enable donors and practitioners in Haiti to understand what the data show as well as the causal factors underlying the success and failure of certain microfinance initiatives.

This report will examine the impact of small loans granted by ACME on MSMEs in Haiti. Established in Haiti in 1997, ACME is a microfinance institution that focuses on granting collateral-free loans to small entrepreneurs lacking access to conventional lending. ACME's main mission is to support the development of Haitian MSMEs by enabling entrepreneurs to access essential financial products and guiding them in the process of long-term business growth¹. ACME has a network of 32 interconnected agencies with a clientele of over 35 000 borrowers, 65% of whom are women. It offers various financial products, including traditional loans and loans targeting agricultural producers². As of 2018, the institution had more active loans than any other microfinance institution in Haiti.

This study has two main goals. First, we want to build a comprehensive profile of microfinance recipients in Haiti to identify who has access to microfinance. Second, we want to assess the impact of ACME loans on promoting the development of small Haitian enterprises. This will be measured by the level of investment made by loan recipients into their enterprises and by the benefits derived from these investments. Business investment indicates the stability and growth of an enterprise. Higher investment suggests greater empowerment of entrepreneurs to make choices to respond to market conditions, reduce risks and, consequently, increase profit. It can also lead to improvements in well-being at the household level as higher income lowers economic vulnerability. For a quasi-experimental impact assessment, a sample of veteran clients (at least three loan cycles completed) will serve as the treatment group to be compared to a control group of new clients (currently going through their first loan cycle). As well as discussing the aggregate results, we will also apply a gender lens to assess the differentiated impact of microfinance on microenterprises. This report is organised as follows. Section 2 reviews the literature on the impact of microfinance on business outcomes. Section 3 then presents our theory of change and discusses our research questions and hypotheses. Section 4 presents our data and profiles ACME clients based on the primary data collected. Section 5 discusses our model for non-experimental impact analysis and its results. Finally, section 6 concludes with a series of policy recommendations.

2. Literature review

2.1. Impact of microfinance on business outcomes

Extensive work has been conducted on the impact of microfinance on individuals and households in developing countries. Most of these studies examine the impact of receiving microcredit on socioeconomic outcomes such as income, wealth, health, education, housing and poverty status.

¹ To learn more about ACME and its mission, see www.acmehaiti.com.

² In 2017, the European Investment Bank provided a €3 million loan to ACME, with a seven-year term and two-year grace period. ACME is authorised to allocate the funds to microfinance loans in any eligible sectors (excluded sectors include, for example, tobacco).

Empirical findings on the general impact of microloans have been inconsistent³. While many studies have found positive socioeconomic effects on households and individuals (Barnes, 1996; Khandker, 2001; Afrane, 2002), others have shown mixed or even negative effects (Kabeer, 1998; Copestake, 2002; Bateman & Chang, 2009). The impact of microfinance on firms and MSMEs has not received widespread attention, but the number of studies has been growing in recent years. Such studies are important as small firms are the backbone of many developing economies. A dynamic MSME sector can stimulate capital accumulation and consequently foster the achievements of long-pursued development goals.

It is widely assumed that access to microfinance and external credit leads to increased sales and growth for MSMEs. Research in both developed and developing countries has demonstrated the importance of access to financing and the vital role of financial institutions in developing MSMEs (Niskanen & Niskanen, 2007; Brown et al., 2004; Kibet et al., 2015). There are a few theoretical explanations for the existence of microfinance institutions and firms' decisions to take out microloans for investment purposes. The rise of microfinance schemes could be a direct result of financial market inefficiencies due to asymmetric information, as posited by Stiglitz and Weiss (1981). Financial intermediaries are interested in not only the interest they derive from loans but also the level of associated risk. Given that banks have incomplete information about credit applicants, and considering the high cost of screening, credit rationing is consequently bound to occur as financial institutions will stop extending credit beyond a certain interest rate level with the goal of preserving the quality of their portfolio. Wahid (1994) sees borrowing as a strategy for poorer people to accumulate their own capital and improve their well-being using the income generated from investments. This happens because their income from other sources is so low that they cannot generate sufficient surpluses for investment. In instances where retained earnings are insufficient, firms will choose to finance their projects externally, rather than going bankrupt.

Similar to studies on households and individuals, research on the impact of microfinance on business outcomes offers mixed findings. Many studies conducted in developing countries have found a positive impact on clients and their businesses. In terms of business investment, for instance, Barnes, Gaile and Kibombo (2001) found that microfinance clients in Uganda were more likely to (1) add new products and services to their current businesses and (2) start a new business. Similarly, Dupas and Robinson (2008) found that clients were more likely to invest in cropland in Kenya and Uganda after receiving a loan. Quaye's (2011) research in Kenya shows a positive effect of loans on the growth of MSMEs in general. Waithanji's (2014) research, also conducted in Kenya, found a positive association between the granting of microfinance loans and MSMEs' business performance. In Tanzania, Madole (2013) also found a positive effect on business outcomes due to the credit obtained from a financial institution: businesses were able to increase profits, the number of employees, sales turnover, business capital and assets.

In terms of impact on revenue and profit, research in Uganda has shown a positive association between microfinance programme participation and business net revenue, as well as a significant difference between recipients and non-recipients in the proportion reporting increased business profit (Barnes, Gaile & Kibombo, 2001). Fauster (2014) and Awuah and Addaney (2016) found a positive impact on revenue, profit and asset turnover for firms that received microfinance services.

³ See Van Rooyen et al. (2012) and Copestake and Williams (2011) for systematic reviews of evidence on the effects of microfinance in developing countries.

There is also evidence that microfinance helps foster changes in the behaviour of entrepreneurs by pushing them to adopt more formal business practices. For instance, one study conducted in Haiti shows that receiving a microloan positively impacted the manner in which micro-entrepreneurs saved, although no significant difference was found in savings levels between recipients and non-recipients (Paul et al., 2011).

In some instances, however, positive results are inconsistent across different outcomes or subgroups. In Bangladesh, Ferdousi (2015) measured the impact of loans on entrepreneurship development and concluded that microloans contributed to higher income but with no effect on business innovation. Karlan and Zinman (2010) used a randomised control trial to study the impact of expanding a new lending programme in the Philippines. They found that the programme raised the business profits of male borrowers but did not significantly affect income or poverty. A study by de Mel, McKenzie and Woodruff (2009) gives some insights into the return on capital for small enterprises in Sri Lanka. The authors found that small grants were mostly invested in business expansion. Although in the case of the full sample the loans increased business profits by at least 68% per year, this effect was only significant for male business owners when the sample was disaggregated by sex.

A few other studies have found an insignificant or even negative impact of loans on clients' businesses. Banerjee et al. (2015a), in their first randomised control evaluation of group lending in India, assessed the impact of microlending on various measures including business outcomes. Although business profits were higher in neighbourhoods receiving the loans than in non-recipient neighbourhoods, this relationship was not statistically significant. The authors concluded that, contrary to many claims, microfinance is not a miracle solution, although they acknowledged its contribution to fostering entrepreneurship in developing countries. Also using a randomised control experiment, Angelucci et al. (2015) examined the impact of a group lending programme by the largest microlender in Mexico. They found no evidence of transformative effects across different domains, such as micro-entrepreneurship, income and labour supply. Barnes, Keogh and Nemarundwe (2001) examined a microfinance programme in Zimbabwe and found no impact on the value of fixed business assets. They also reported that microcredit had no significant impact on employment levels, which they attributed to political and socioeconomic unrest in the study region. In Indonesia's second largest city, Atmadja et al. (2016) found a negative relationship between microcredit and profits for women-owned enterprises, which they interpreted as indicating that higher debt might be detrimental to performance. In some other cases, a significantly positive effect on one outcome comes at the expense of another outcome. For instance, Karlan and Zinman (2010) found that a microfinance programme in the Philippines led to businesses reducing the number of paid employees but generating higher profits. In Peru, Copstake et al. (2005) studied the effect of a microfinance programme on a wide range of outcomes at the enterprise and household levels. They found no effects on business sales and profits but significantly positive effects on individual and household income.

2.2. Theory of change

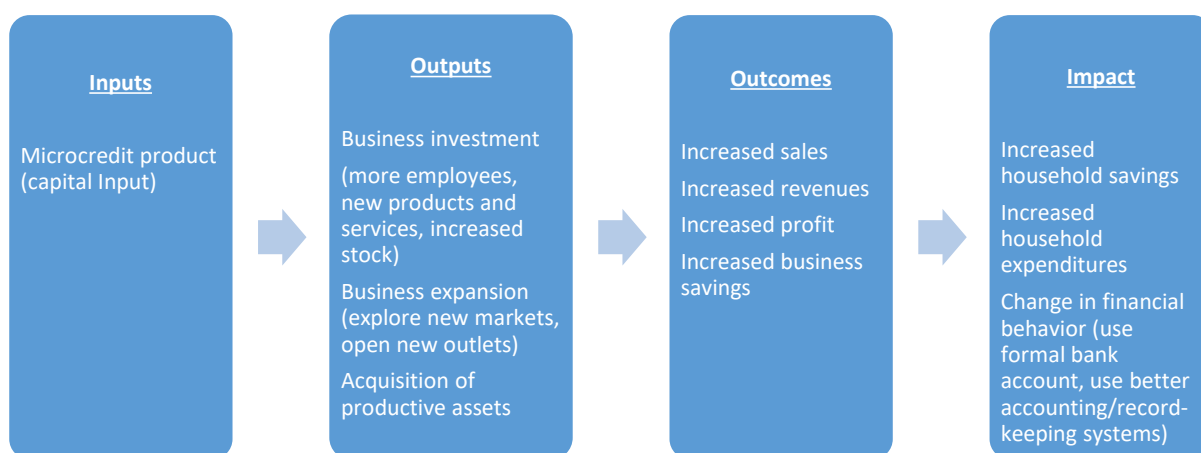
Figure 1 is an overview of the theory of change linking microloan provision to changes in business outcomes for Haitian micro-entrepreneurs. Our theory of change is grounded on three main assumptions: (i) continuous loans will lead to positive effects for businesses, (ii) entrepreneurship is a potential pathway out of poverty, and (iii) small-scale entrepreneurs have high returns on their investments. As an input, continuous loans from ACME will generate a series of outputs, including

greater business investment, business expansion, and acquisition of productive assets. Next, outputs are expected to generate positive changes in businesses, including increased sales, revenues and profits. These outcomes, in turn, have wider implications, potentially leading to changes in savings, household spending, financial behaviour and business practices.

In collaboration with ACME, we developed the following set of research questions to evaluate the contribution of microfinance loans to the overall development of Haitian MSMEs:

- How did the receipt of loans stimulate the expansion of Haitian MSMEs?
- Did it help Haitian microenterprises acquire more fixed assets?
- Did it have an impact on the revenue and profit of MSMEs?
- Did it foster changes in recipients' behaviour?

Figure 1: A theory of change for microcredit



We chose to assess the impact of loans for four groups of outcome variables (see Table 1)⁴. The first group of outcome variables measures changes implemented with the goal of increasing profits. Among these changes, we focus on the addition of new products, investment in a new location, and reduction of costs by buying products/inputs in greater volume. These types of transactional patterns indicate greater flexibility and empowerment of entrepreneurs to make choices they deem necessary to achieve higher profitability.

The second set of outcome variables evaluates entrepreneurs' investment in fixed assets. As fixed assets represent a form of wealth, investing in them indicates the growth of a microenterprise (Barnes, Keogh & Nemarundwe, 2001b). Respondents were asked to list the major fixed assets they purchased after receiving their first loan from ACME, the values of these assets at the time of purchase, and the dates of purchase. Notably, some evidence in the literature suggests that purchasing fixed assets is seldom the best use of a microfinance loan. In India, for example, Hulme et al. (2009) found that the dominant source of investment in fixed assets was savings, not microloans. In Haiti, however, a recent report from FONKOZE⁵ (2019) clearly indicates that Haitian entrepreneurs use part of their microloans

⁴ See Table A5 for the average values of these outcome variables.

⁵ FONKOZE is a microfinance institution similar in size to ACME.

to grow their businesses through purchasing additional operating equipment. The impact of microloans on fixed assets investment is worth exploring in the case of ACME.

The third set of outcome variables evaluates whether investment decisions yielded positive returns (in terms of earnings, profit and savings)⁶. The fourth set of outcome variables assesses the impact of loans on clients' behaviour. The survey included a series of questions to assess any changes in entrepreneurs' behaviour after receiving a loan, focusing specifically on their approach to tracking business income and expenses and on the efficiency of their savings practices.

Based on our theory of change, we hypothesise that the injection of continuous loans from ACME will lead to more capital and labour investment. We also expect greater investment in fixed assets. Furthermore, we predict that these investments will yield positive outcomes in terms of higher revenues and greater profitability. Lastly, we expect the acquisition of loans to lead to changes in clients' business practices.

Table 1: Sets of outcome variables

	Key indicators
Group 1: Business expansion	<ul style="list-style-type: none"> • Added new employees • Added new products and services • Opened another branch/outlet • Sold in new market locations • Bought in greater volumes • Increased stock
Group 2: Investment in fixed assets	<ul style="list-style-type: none"> • Expenditure on business fixed assets
Group 3: Earnings and profit	<ul style="list-style-type: none"> • Changes in household conditions • Sales levels • Cost levels • Profit levels • Changes in savings
Group 4: Change in behaviour	<ul style="list-style-type: none"> • Use of a formal bank account • Use of accounting/record-keeping systems

3. Microfinance in Haiti

Given Haiti's low gross domestic product (GDP) growth and lack of formal employment, the country's economy is dominated by the informal sector, which provides a living for an estimated 41% of the population (ECVMAS, 2012). Many small entrepreneurs and informal traders have no access to formal financial systems and are considered "unbankable" by most financial institutions, based on their lack of stable employment, poor credit history and limited assets. The Haitian banking system is also very shallow as banks are reluctant to issue loans. In 2014, private credit as a percentage of GDP was estimated at just 17.2%, a level significantly below the 40% average of other Caribbean nations (Bebczuk et al., 2017). To finance their projects, Haitian small enterprises often resort to informal

⁶ To minimise recall bias, we asked respondents to estimate their average monthly sales, costs and profits during both "off-peak" and "peak" months for a given year. We take the midpoint between the peak and off-peak values as the average monthly estimates in this report.

means, such as borrowing from relatives and friends or joining a rotating savings scheme⁷. Those with limited access to these informal avenues often seek microfinance loans.

The difficulty in getting a loan from formal institutions in Haiti attests to the bigger problem of overall financial inclusion. It is estimated that 46% of Haitians are excluded from the financial system (FinScope, 2018); in rural areas, the majority (53%) remain underserved financially⁸. Haitian microfinance institutions play an important role by not just providing access to collateral-free credit to people on low incomes, but also facilitating their inclusion in the financial system. To that end, we must also acknowledge a series of measures recently implemented by the Haitian authorities in collaboration with microfinance institutions to boost financial inclusion. The government has adopted a national strategy for financial inclusion, which aims to increase the proportion of Haitians with a formal bank account. The strategy also aims to improve access to credit and financial capability through financial education and better consumer protection. Furthermore, a recent presidential decree has finally put Haiti's microfinance institutions under the regulatory control of the central bank of Haiti; they had previously been classified as credit institutions, which excluded them from central bank programmes. International partners are also providing support in combating financial exclusion. For instance, the United States Agency for International Development/Haiti Finance Inclusion project finances research to identify key players in the financial sector and foster the development of appropriate products and services.

Microfinance institutions are present in most regions of the country. Rural areas are served by savings and credit cooperatives (known by their French acronym CECs) that provide access to savings and other financial products. CEC members are also owners of their cooperatives, which differentiates CECs from other microfinance institutions. By contrast, non-cooperative microfinance institutions, such as ACME, grant credit using funds borrowed from the formal financial system, international organisations, or donors. They serve the needs of poorer people living in urban areas who are excluded from the formal banking system and reside far from CECs. Although cooperative microfinance institutions outnumber their non-cooperative equivalents, non-cooperative microfinance institutions have greater financial assets and reach more people.

The Haitian microfinance sector has been recovering after its first financial crisis in the early 2000s, where a pyramid scheme led to massive losses (Paul et al., 2002). The sector overall, and non-cooperative institutions in particular, has grown rapidly, especially between 2008 and 2015. According to the latest census of the microfinance industry in Haiti, the number of MSMEs that benefit from microcredit was estimated at 281 263 in 2017, compared to 239 000 in 2009 (United States Agency for International Development & DAI, 2018). Women now receive a more equitable share of the portfolio (41.2%). Although sector diversity in loan allocation is still lacking, with 53% of portfolio lending to the trade and retail sector and only 15% to enterprises involved in production (agriculture and manufacturing), this has been improving recently⁹.

⁷ One widely used scheme is *susu* (known as *sòl* in Haiti), where people contribute an equal amount each month to a savings pool that is rotated among different members, based on an agreed schedule.

⁸ Over 60% of all commercial branches are in metropolitan Port-au-Prince; of the eight commercial banks, only three have operations outside the metropolitan area (FONKOZE, 2008).

⁹ The agricultural production sector remains gravely underfunded, despite agriculture representing over 25% of Haiti's GDP.

Over the past decade, Haitian microfinance institutions have become efficient and profitable, with a significant improvement in operational capacity. At the end of fiscal year 2017, the operational sufficiency of credit unions and cooperatives was estimated at 1.4 – above the acceptability threshold and higher than the global standard of 1.34. Thus, the entire system is functional in its ability to cover expenses from operating revenues. For CECs, the return on assets is estimated at 4.9% and the return on equity at 18.2%, which surpasses the inflation rate over the last three years (United States Agency for International Development & DAI, 2018). Operational efficiency was 18% in 2017, while net income from interest increased by 100% (65% in real terms) from 2013 to 2017. There have been efforts to introduce and assimilate information and communications technology within microfinance institutions, which would contribute greatly to more efficient operations (United States Agency for International Development & DAI, 2018).

Nevertheless, the key barriers to full development of the microfinance sector remain economic. Haiti is a fragile economy with a low human development index and high levels of poverty and inequality. Recent decades have been characterised by slow economic growth (far below the population growth), a concentrated production base, fiscal imbalance and accelerating inflation. Macroeconomic conditions have worsened in recent years due to an ongoing political crisis, lack of external funding, and poor conditions for agriculture. The years 2018 and 2019 were particularly difficult for businesses as large-scale demonstrations triggered a series of nationwide lockdowns, known as *peyi lòk*, which completely paralysed economic activities for weeks. MSMEs were especially affected during this period. The crisis discouraged investment and forced several firms to suspend or cease operations, resulting in massive job losses and employee furloughs. Compounding this situation, at the beginning of 2020, the COVID-19 pandemic triggered a global recession with devastating effects on small economies like Haiti. In fiscal years 2019 and 2020, the Haitian economy is estimated to have contracted by 1.2% and 3.7%, respectively (International Monetary Fund, 2021).

4. Methodology

4.1. Data and sampling

We collected primary data on ACME's clients through a comprehensive survey that sought quantitative and qualitative information: the questionnaire included both closed and open-ended questions. We aimed to assess whether entrepreneurs that received a microloan subsequently implemented changes in their businesses, invested in fixed assets, experienced changes in net revenue and profit, or adjusted their behaviour. Micro-entrepreneurs were asked to report the occurrence or level of these outcome indicators at the enterprise level. We also collected sociodemographic, socioeconomic and business information on the owner.

With the objective of performing a quasi-experimental impact assessment, we collected the same information from two separate subsamples: a treatment group and a control group. For our treatment group, a random sample was selected from the membership list of entrepreneurs who have completed at least three ACME loan cycles¹⁰. A loan cycle is the period between getting the loan (disbursement) and full repayment, and averages six months for ACME clients; therefore, clients who

¹⁰ The treatment-group cut-off of three loan cycles was chosen in collaboration with ACME. Data collected by ACME and internal studies show that the effects of continuous loans on the average small business only start to appear after the third cycle.

have completed at least three loan cycles have been with ACME for at least 18 months. The control group was intended to include enterprises that have been approved and are awaiting disbursement and clients in their first loan cycle. However, it was difficult to sample individuals who have been approved but not yet received the loan, given that the time between approval and disbursement of funds is less than three days. Therefore, only clients in their first cycle were chosen to form the control group. Other non-experimental impact evaluations of microfinance programmes have used new entrants as a control group (Karlan, 2007; Kondo et al., 2008; Swain & Varghese, 2009), affirming this as a reliable and inexpensive method (Samer et al., 2015).

Respondents reported the occurrences or levels of outcomes in 2019. It was crucial to have the same reference period for both control and treatment groups. For enterprises in the control group, 2019 counts as the pretreatment period: only firms that received their first ACME loan from January 2020 onwards were included in the control group. For enterprises in the treatment group, 2019 coincided with at least their second ACME loan cycle, assuming no interruption. In theory then, enterprises in the control group represent the pretreatment state of those in the treatment group.

The COVID-19 pandemic altered our data collection as it became impossible to conduct face-to-face interviews. On 19 March 2020, the government of Haiti announced the first two cases of the novel coronavirus in the country and consequently declared a national state of emergency. Several measures were imposed to attempt to contain the spread of the disease, such as airport closures, curfews and strict social distancing protocols. The interviews were, therefore, conducted via telephone over a span of 60 days (July and August 2020) with the help of a local firm specialising in social science research. ACME gave us a list of over 29 000 clients. Using a margin of error of 4% and a 95% confidence interval, we drew a representative sample of 626 clients for the treatment group (at least three loan cycles completed)¹¹. For the control group, we randomly selected 207 clients (about one-third of the number in the treatment group) with one loan cycle. In total, 833 clients were interviewed for this study.

Considering that clients may own more than one business, the survey gathered information on the business for which the loan was disbursed. In addition, businesses that had existed for less than one year were excluded from our sample. During the analysis phase, we removed duplicate observations, individuals who were not business owners (e.g. those who took loans for education), those who did not have a current loan with ACME, and those whose loan-receiving business was created after August 2018. The final sample was reduced to 695 clients for analysis. Table 2 shows the gender and geographic distributions of the final sample.

¹¹ The sample size was determined using the following formula:
$$n = \frac{\frac{z^2 s^2}{E^2}}{\left(1 + \frac{z^2 s^2}{E^2} \times \frac{1}{N}\right)}$$

Table 2: Sample distribution (ACME clients)

Location ¹²	Total			Control			Treatment		
	Women	Men	Total	Women	Men	Total	Women	Men	Total
Northern departments	198	117	315	35	23	58	109	67	176
Southern departments	83	52	135	20	19	39	42	20	62
West department	153	92	245	27	18	45	81	53	134
Total	434	261	695	82	60	142	232	140	372

Northern departments: North, Artibonite and Centre.
Southern departments: South, Grand'Anse and Nippes.

4.2. Descriptive findings: ACME client profiles

This section presents comprehensive profiles of ACME clients based on the primary data collected (Table A1)¹³. Most borrowers from ACME are women (62.5%). There is no difference in the gender distribution between veteran borrowers and new clients. The average client is 41 years old, and there is no significant difference in age between men and women borrowers. However, there is a significant age difference between new clients and veteran borrowers: those who have completed at least three loan cycles are four years older, on average, than new clients. Most clients are married (44%) or live in a consensual union (30.2%); about 18% of them have never been married. These figures closely mirror general statistics at the national level, with the exception of the proportion of never-married individuals. According to the latest national household survey, 33.1% of household heads are married, 40.9% live in a consensual union, and 6.7% have never been married (ECVMAS, 2012). Regarding educational attainment, a significant proportion of ACME clients have completed secondary school (48.9%) and 33.2% have finished primary school; close to 10.3% have completed post-secondary studies¹⁴. The educational differences across gender lines are striking. While a significantly higher percentage of male entrepreneurs have completed secondary and post-secondary studies, a significantly higher percentage of female entrepreneurs have only completed primary education or did not attend school at all. We find no statistical difference in educational attainment between veteran borrowers and new clients for most schooling levels.

The average household size is five people, which is fairly similar to the national average of 4.3 (United Nations, 2019). In the average household there are 2.38 dependent children and 0.9 other individuals who are economically active. Most borrowers own their homes (62.4%), while 31.3% are renters. At the national level, homeownership rates are higher (80% of heads of household own their house) and the percentage of renters is lower (20% of heads of household are renters or in the process of paying the property down) (ECVMAS, 2012). Regarding borrowers' regional location, most clients live in northern departments (45.3%), close to 35% in the West department (where the capital is located), and 19.4% in southern departments¹⁵. Comparison reveals that new clients are statistically

¹² Haiti is divided administratively into ten departments.

¹³ See the Annex for a comparison of the client profiles for ACME with those for FONKOZE, another major microfinance institution in Haiti.

¹⁴ ACME clients have higher educational attainment than the overall population. At the national level, 16.2% of the population have completed secondary school, 16.6% have completed primary school, and 6.7% have completed tertiary studies (ECVMAS, 2012).

¹⁵ The distribution of clients by region is not different from the estimated regional household distribution. According to the latest household survey (ECVMAS 2012), 33.2% of households are in northern departments, 35.5% in the West department, and 14.7% in southern departments, as classified in Table 2.

more likely than veteran borrowers to live in southern departments. Most households (58.5%) reported having received remittances; of these clients, 64.8% said they use some of this income in their businesses. Over 40% of households also reported receiving income from other economic activities, although a gender difference was observed here too, with 54.4% of men reporting such additional income sources but only 32.2% of women. Among those reporting other sources of incomes, 77.6% used some of the money in their businesses.

The average client has one business with an average age of ten years. Women-owned businesses are significantly older than those owned by men, as are businesses owned by veteran borrowers compared to those owned by new clients. Considering business characteristics, most ACME clients are involved in petty trade (70.9%), while 21.8% are wholesalers¹⁶. Clients involved in manufacture, agricultural production and service provision constitute the rest of the sample. In terms of size, enterprises have an average of 0.83 full-time employees¹⁷, but men-owned businesses employ significantly more workers than women-owned businesses (1.37 vs. 0.50)¹⁸.

Focusing on the characteristics of loans received, the average number of loan cycles is six overall and nine for the subsample of veteran borrowers. For loan tenor, as expected, the average business borrows for a duration of seven months. The average tenor is longer for men than for women, and longer for veteran borrowers than for new clients. The average client received the local equivalent of \$1 737 in their last disbursement¹⁹, although men received significantly more than women (\$2 159 vs. \$1 487). We also find a significant difference between veteran borrowers and new clients: veteran borrowers received close to two times more. The average interest rate charged (5.8% overall) also differs across gender lines: 6.6% for men vs. 5.4% for women. New entrants are also charged more compared to veteran borrowers (6.3% vs. 5.7%), although the difference is not statistically significant.

We also explore whether businesses have access to additional financing sources. Most businesses reported that they had never borrowed from another microfinance institution (91.2%) or from a commercial bank (97.4%). These statistics highlight ACME's contribution to financial inclusion in Haiti, as over 90% of its clients were previously unbanked.

4.3. Impact of microfinance on business outcomes: Multivariate analysis

Evaluating the impact of a microfinance programme entails a comparison between an experimental group of individuals who received a loan versus a control group of individuals who did not. The statistical difference in a particular outcome between the two groups should indicate whether there is an impact.

The best, although not always feasible, method to achieve unbiased estimates of such an impact is through a randomised programme placement. Randomisation allows researchers to disentangle causation from correlation by minimising selection bias, which can be a source of confoundedness.

¹⁶ A national survey conducted in 2018 shows that 29% of MSMEs were involved in the service sector, and 30% in agriculture and manufacturing. The average MSME employed nine full-time workers and 41% of MSMEs were aged between five and ten years (Centre de Facilitation des Investissements, 2018).

¹⁷ Of the 695 enterprises considered in this study, 694 (99.9%) had fewer than ten full-time employees.

¹⁸ A chi-square test shows a significant difference between the number of full-time employees and type of business. Manufacturing enterprises have the highest average number of full-time employees (3.6), followed by firms involved in agricultural production (1.6), restaurants/hotels (0.93), wholesale trade (0.5) and petty trade (0.49).

¹⁹ This value is calculated using the following exchange rate: \$1 = 63 Haitian gourdes, as of 2 October 2020.

When a randomised control experiment is not plausible, empirical studies that aim to assess the direct impact of microfinance loans often resort to a non-experimental comparison between treatment and control groups. Such studies, however, often suffer from the usual issues of selection bias. Where the sample of borrowers has dissimilar characteristics to the control group, it is difficult to isolate the effects of participation. As participation in microfinance is not a random event, entrepreneurs could have higher outcomes regardless of participation due to confounding factors such as higher levels of human capital and advantageous opportunities.

One way to address confoundedness is to use an instrumental variable approach, often through a two-stage linear probability model (see Godquin, 2004). However, this method must be used with extreme caution, particularly given the practical problems encountered in identifying valid instrumental variables (Crown et al., 2011). More rigorous studies use the statistical techniques of matching (Silva, 2012) and difference-in-difference (Lyngdoh & Pati, 2013). Propensity score matching allows researchers to simulate balanced treatment and control groups using weights from a propensity score model, while difference-in-difference compares the average change over time in the outcome variable between the treatment and control groups. However, these methods also have potential drawbacks, such as omitted variable bias and reverse causality issues. Inverse probability weights based on propensity scores can also be used to address endogeneity concerns. Known as propensity score reweighting, this technique allows researchers to create balanced treatment and control groups that simulate a random allocation of subjects (similar to propensity score matching) to estimate the treatment effect. Propensity score reweighting has a major advantage over propensity score matching: it retains all the observations, which helps maintain statistical power to detect a treatment effect (Stone & Tang, 2013)²⁰.

One goal of this report is to estimate the impact of microfinance on a series of key business outcomes for micro-entrepreneurs. We intend to assess differences in this series of outcomes between veteran borrowers and new clients. Under certain assumptions, such as no major change in the behaviour of new clients, we can successfully integrate a sample of new entrants as a control group, given that they have often received little or no treatment (Swain & Varghese, 2009).

To deal with selection bias and endogeneity, we use a covariate balancing propensity score – a novel propensity score reweighting methodology proposed by Imai and Ratkovic (2014) – to produce estimates of the impact of receiving a microfinance loan. The covariate balancing propensity score is a significant improvement over propensity score matching and standard propensity score reweighting, given its robustness to misspecification of the propensity score model. This nascent method has been used in various applied disciplines to address confoundedness when assessing causal effects in observational data (see Ehnthal et al., 2016; Vandecandelaere et al., 2016; Albanese et al., 2017).

Our first goal is to make the two groups similar, and thus comparable, over a series of control variables. Then, given that the average treatment effect is of interest, we can weigh the control group observations (new clients) such that their weighted covariate distribution matches that of the treatment group (veteran borrowers). The covariate balancing propensity score optimises the covariate balance while modelling the treatment assignment, enabling a near-perfect covariate

²⁰ Although the difference-in-difference method has the advantage of accounting for unobservable bias, it requires the use of panel data to measure the difference between treatment and control.

balance between the treatment and control groups. Using the covariate balancing propensity score, the average treatment effect can be obtained through these steps:

Step 1: A discrete choice model (logit) is run:

$$\text{Prob}(tvar = 1 | X) = \text{invlogit}(X * b),$$

where *tvar* is the treatment variable (having completed at least three loan cycles), *X* is a matrix of control variables, and *b* is a vector of coefficients to be estimated. Unlike other propensity score methods, the covariate balancing propensity score yields the logit coefficients (*b*) that produce the best balance on matching variables as the treatment assignment is modelled.

Step 2: Weights are constructed as follows:

Weights for treatment group: $1/p$,

Weights for control group: $1/(1-p)$,

where *p* is the predicted value (propensity score) based on the model in step 1.

Step 3: We regress the outcome variable, using the weights, on the treatment variable for evidence of impact:

$$Y = tvar * b,$$

where *Y* is the outcome variable and *b* is the average treatment effect (the effect of completing at least three loan cycles on a particular outcome). One limitation of this model is its inability to directly eliminate selection bias due to unobservable differences across the treatment and control groups. Our model relies on the assumptions that these unobservable factors are independent of the observable covariates and play no significant role in treatment assignment. In other words, we assume that the unobservable factors do not threaten the internal validity of the estimated treatment effects. Nonetheless, we run Rosenbaum's (2002) test to assess the sensitivity of our non-experimental findings: specifically, we check the extent to which a significant association between participation in microfinance and a particular outcome could be due to unobservable variables. Suppose a value Γ as the level of hidden bias or degree of departure from similarity that may lead to hidden bias. If $\Gamma = 1$, the study is free of bias: the chance that a unit receives a treatment is the sole function of observed covariates. If $\Gamma = 2$, for instance, one subject has twice the odds of receiving treatment than another subject due to hidden differences. The Rosenbaum test determines what magnitude of hidden biases (i.e. value of Γ) would render the results insignificant. After calculating the difference in the outcome variable between treatment and control cases, the Wilcoxon signed-rank test is then conducted to yield upper and lower bound estimates of p-values at different levels of gammas (Swain & Floro, 2012)²¹.

The propensity score reweighting method we use requires an evaluation over a series of covariates or control variables. These types of non-experimental impact assessment rely on the assumption that if we can control for the variables that matter most, any post-reweighting difference in outcomes

²¹ We use the STATA command "mhbounds" to compute sensitivity bounds for categorical outcome variables and "rbounds" for continuous variables. See Rosenbaum (2002) for more details on the statistical computation of sensitivity bounds.

between the two samples is a fair estimator of the average treatment effect – in our case, the impact of receiving microloans on the outcome being assessed. As such, we included a series of variables in the model that are determinants of the probability of receiving microfinance. The choice of these variables was informed by a review of the literature and the strength of their relationship with the outcome of interest (receiving microfinance loans). We first consider the entrepreneur’s gender, as there is evidence that men and women do not have equal access to financial institutions. This is certainly the case in Haiti, where men are less likely to be excluded from the financial system (FinScope, 2018). We also include the entrepreneur’s age to control for the effect of experience, as prior evidence shows that age is a significant determinant of entrepreneurs’ participation in microfinance (Anjugam & Ramasamy, 2007; Hemtanon & Gan, 2020). We also control for the entrepreneur’s marital status, specifically whether he or she is single, married, in a consensual union, or separated (widowed or divorced).

The entrepreneur’s level of education is also captured using a categorical variable for educational attainment. Household structure is considered and balanced across samples to adjust for measured confounding. Specifically, the model includes the number of dependent children, the number of working household members, and the regional location of the household (West department, northern departments, or southern departments). Haiti has regional disparities in economic opportunities. The West department has lower poverty and inequality compared to the rest of the country (Pokhriyal et al., 2020). We include a series of enterprise variables in the model to control for the type of business, size of the enterprise (measured by the number of workers), age of the business, and the number of businesses owned by the entrepreneur. Finally, we control for whether the household receives remittances and income from other activities.

5. Results

Table A6 shows the average treatment effect coefficients using covariate balancing propensity score reweighting. Respondents were asked to evaluate the occurrences or levels of these outcomes (impact variables) in 2019. Therefore, respondents in the control group estimated outcomes when they did not have microfinance, while respondents in the treatment group estimated outcomes when they had completed at least three loan cycles. For enterprises in the treatment group, the first injection (first cycle) must have happened in the second quarter of 2018 at the latest. One of our hypotheses is that microfinance will foster continued business expansion; therefore, any evidence of impact should be observed in 2019.

- The results show no difference between veteran borrowers and new clients in the incidence of adding new products/services in 2018 and 2019, after controlling for a series of observables.
- **Compared to new clients, veteran borrowers were more likely to hire new workers in 2018, but not in 2019.** The second finding could be a direct consequence of the sociopolitical crisis that arose in 2019, when a series of protests, turbulence and lockdowns throughout the year negatively impacted all businesses.
- **We find a significant difference between veteran borrowers and new clients in the propensity for expansion (opening new outlets), but only among woman-led firms.** Among male-owned firms, this association was insignificant.

- Statistically, veteran borrowers were no more likely than new clients to expand their business by buying in greater volume in 2019 compared to 2018, or in 2018 compared to 2017.
- **However, veteran borrowers were more likely than new clients to report that their merchandise stock (or number of services offered) had increased in 2018 compared to 2017.** This result was significant among male-owned firms, but not among female-owned firms.
- We also hypothesised that business investments due to receiving continuous loans would yield higher revenue and greater profitability. In terms of business revenue, the results show no statistical difference between veteran borrowers and new clients for 2018 and 2019. **However, we find a significant difference in reported average monthly profit, estimated as gross monthly revenue minus spending. Specifically, veteran borrowers reported higher average monthly profit levels compared to new clients for 2018 and 2019.** Disaggregated by gender, this result was significant only among male-owned firms²².
- **We also find that, compared to new clients, veteran borrowers allocated a significantly higher share of business revenues to family spending (rent, school fees, etc.).** This result was statistically significant among female borrowers but not male borrowers.
- **When asked to compare the amount saved in 2019 to that saved in 2018, the results show that male veteran borrowers were more likely to report a positive change in savings than male new clients,** whereas female veteran borrowers were less likely to report a positive change in savings than female new clients in 2019. When asked to compare the amount saved in 2020 to that saved in 2019, male veteran borrowers were again more likely to report a positive change in savings compared to male new clients. There was no difference between female veteran borrowers and female new clients in the propensity to report a positive change in savings in 2020.
- **Consistent with our hypothesis, the receipt of loans is associated with greater investment in fixed assets: veteran borrowers reported a significantly higher number of fixed assets purchased and higher average values of these assets compared to new clients.** This result was significant for both male-owned and female-owned firms.
- **Regarding the impact of continuous loans on entrepreneurs' behaviour, we find that veteran borrowers were more likely than new clients to own a formal business account at a commercial bank.** However, we find no difference between the two groups in the use of accounting/record-keeping systems for their business.

We limit the Rosenbaum (2002) sensitivity analyses to average treatment effects found to be significant in our covariate balancing propensity score impact assessment. In Table A7, we turn our attention to the upper bound significance levels for various levels of Γ . For most outcomes, we find Γ thresholds ranging from 1.2 to 1.7, meaning that the unobserved effect will need to increase the odds of treatment by a factor of 1.3 (in most cases) before the statistical inference of average treatment effects can change. For continuous outcomes, such as the number of fixed assets and average value of

²² For the multivariate analysis, the revenue, spending and profit variables were log-transformed using the inverse hyperbolic sine (arcsine) function to improve normality. Unlike the natural log transformation, arcsine allows us to retain negative values while easing the influence of outliers (see Grabka et al., 2013). Figure A1 reports the kernel distributions of estimated average monthly profit.

fixed assets, the Γ values surpass 3. While we are confident that the model is insensitive to hidden bias for these continuous outcomes, the relatively small Γ values for the other outcome variables indicate a degree of sensitivity to unobserved confounding variables. Yet, as Becker and Caliendo (2007) point out, these sensitivity results are worst-case scenarios and do not necessarily indicate the existence of unobserved heterogeneity or no effect of treatment on an outcome variable. In fact, as observational studies in social science are usually highly sensitive to hidden bias, most such studies examining causal inference report Γ values between 1.1 and 2.0 (Watson, 2005). Some studies assessing the impact of microfinance programmes have used low increments in Γ to check robustness and concluded that a level of $\Gamma = 1.5$ is sufficiently high for a model to be considered insensitive to hidden bias (Swain & Floro, 2012; Ely et al., 2019). Nonetheless, we recommend caution in interpreting the results for which the value of Γ is below 1.5.

6. Conclusion

This report explored the impact of microfinance loans on the business performance of MSMEs in Haiti. We used a novel method of non-experimental impact assessment to isolate the effect of receiving microloans on a series of business outcomes. Our analysis compared the differences in these outcomes between an experimental group of veteran borrowers, who have completed at least three loan cycles, and a control group of new clients currently going through their first cycle. Overall, holding several factors constant, we conclude that receiving continuous loans from the microfinance institution ACME had positive effects on Haitian businesses. Compared to new clients, veteran borrowers had a higher probability of hiring new workers in 2018 and a higher likelihood of increasing their merchandise stock as a way of expanding their business. These results were not significant for 2019 because that year was characterised by degenerating macroeconomic conditions and a risky sociopolitical climate that negatively impacted most Haitian businesses. Disregarding 2019, these findings mirror those of Barnes, Gaile and Kibombo (2001), Barnes, Keogh and Nemarundwe (2001) and Foster (2014), who all showed a positive impact of microfinance on business investment and expansion in developing settings. Veteran borrowers also reported higher levels of average monthly profit and were more likely to report a positive change in savings from 2019 to 2020 compared to new clients. Although we find no significant impact of loans on revenue reported by respondents, we do find that veteran borrowers allocated a higher share of business revenue to family spending compared to new clients. This supports prior research in Haiti reporting a positive association between receipt of a microfinance loan and food consumption (Paul et al., 2011).

The results therefore highlight that microfinance institutions can play an important role in helping Haitian enterprises achieve their business goals. For microfinance institutions to meet their full potential, further improvements are needed, mainly in financial inclusion and allowing greater access to financial products. Both product lines and activities financed require greater diversification. Microfinance should also transcend the provision of access to credit by embracing a wider range of financial services such as savings, insurance, training, and funds transfer. Haitian small business owners who lack access to credit need various financial products (not just loans) to help them grow and sustain their enterprises. For instance, microinsurance can help small businesses withstand unforeseen hazards and provide entrepreneurs with an opportunity to revamp their businesses after a shock. Moreover, microsavings seems a promising avenue for increasing financial inclusion while helping low-income households to improve their financial planning and build long-term income.

This study also confirms the hypothesis that loans, even continuous ones, are often invested in fixed assets. Compared to new clients, veteran borrowers reported a higher number and average value of fixed assets purchased after receiving their last loan. In fact, the average amount spent on fixed assets by ACME clients represents 26% of the average amount received in their last disbursement. Although research in other countries reports little (if any) impact of microfinance on the level of business fixed assets (Hulme et al., 2009), our findings are consistent with FONKOZE's (2019) recent report that Haitian entrepreneurs devote part of their microloans to growing their businesses by purchasing additional operating equipment.

With such a significant allocation to fixed assets among ACME clients, asset-based financing might be worth exploring, considering the need for Haitian microfinance institutions to adopt a wider range of financial services and contractual innovations. Asset-based financing is the disbursement of loans to low-income borrowers for the purchase of specific assets, as opposed to traditional cash-based financing disbursed to finance projects. In this model, microfinance institutions finance an entrepreneur's purchase of an asset that can increase his or her business productivity. The lending is, however, conditional on the purchase of the asset, which also serves as collateral for the loan. The client is required to buy the asset over a fixed period and pay a small rental fee for its use. Similar programmes are already in place in countries such as Pakistan (Bari et al., 2021) and Kenya (Bhargava, 2016), where they have been shown to be successful. Considering the high cost of traditional microfinance products and the associated problems of enforcement and moral hazard, asset-based financing might represent a viable complement, if not an alternative, to current financial products offered in Haiti.

Our results also highlight the gender-differentiated impact of microfinance loans on Haitian businesses. Although ACME loans are critical in helping women to physically expand their businesses (opening new outlets), only male-owned businesses benefited through increased stock or the addition of new services after receiving loans. This reflects the reality of female entrepreneurship in Haiti. While the advance of microfinance has contributed to an expansion of small women-owned enterprises over the years, women remain concentrated in low-budget, homogenous economic activities with few growth prospects (Mauconduit et al., 2013). Our data show that women dominate the petty trade sector, whereas men dominate sectors with high growth potential, such as agriculture and manufacturing. For the average woman, while additional loans could help increase her presence in a specific market, they would not enable greater innovation or a change in her business model. Also noteworthy is the gender-differentiated impact on profit. The results show that receiving continuous loans had a significant impact on average monthly profit only for male entrepreneurs. In terms of savings, female veteran borrowers fared worse than female new clients. Male veteran borrowers, on the other hand, were more likely to report a positive change in annual savings compared to male new clients. It is, however, unsurprising that loans to women entrepreneurs did not positively affect their profits and savings. These findings reiterate women's high concentration in low-growth sectors, greater aversion to risk (Jianakoplos & Bernasek, 1998; Benmansour et al., 2006), lower loan disbursements, and higher cost of borrowing²³. For instance, although Haitian women constitute the majority of ACME's clientele, they receive significantly less in disbursements and at a higher interest

²³ There is evidence that women tend to be more risk averse than men in investing and making financial decisions (Jianakoplos & Bernasek, 1998; Benmansour et al., 2006). Gender differences in investing and risk-taking might be due to the institutional barriers that contribute to gender disparities and/or differences in individual preferences. For a more in-depth discussion on the topic, see Bajtelsmit and Bernasek (1996).

rate (Table A1). The results also show that loans significantly increase the share of business income devoted to household spending by women-led firms, but not men-led firms. This finding could be due to the greater share of home responsibilities borne by female household heads as their businesses expand. Generally, in developing countries like Haiti, female-headed households have more dependents and a higher non-worker to worker ratio compared to other types of household (Buvinić & Gupta, 1997).

These results are striking and highlight that, despite major strides towards improving women's access to microcredit, more must be done to allow female business owners to reap the full economic benefits of microfinance. One prominent obstacle is the gender-specific barriers that prevent women's full participation and subsequent empowerment. These barriers can take the form of societal gender biases, the consequences of such biases, or weak commitment from microfinance institutions to eliminating all forms of gender discrimination in lending. It is important for microfinance institutions to continue targeting women in the design of microfinance products, while also addressing the specific barriers and risks that women face. There is a need for more programmes and products specifically tailored to women and their enterprises, considering their needs and assets. Microfinance institutions should explore programmes with special incentives for women to invest in high-growth sectors (e.g. providing more loans on flexible repayment terms to women-led firms that want to invest in agriculture or manufacturing). They should also design financing programmes to encourage the creation of more women-led start-ups. Women entrepreneurs could benefit from capacity building programmes, for instance in the form of financial literacy training, which could help shrink the gender information gap. It is also important for microfinance institutions to collect gender-disaggregated data on loan impacts while tracking women empowerment indicators. This would help improve the execution of current programmes and the design of future ones.

Another important finding of this study is the positive effect of receiving continuous microloans on the probability of owning a bank account. This result supports the previous finding in Haiti that microfinance can affect borrowers' behaviour by helping them adopt more formal business practices. Paul et al. (2011) show that receipt of a loan has contributed significantly to the financialisation of savings in Haiti, with a significant proportion of microfinance clients having changed their savings method from non-monetary to monetary accumulation. Considering our result, we recommend that loans be accompanied by proper business skills training to ensure their proper utilisation. Client training is not necessarily a non-productive investment, as business training can lead to more successful and sustainable microfinance institutions. In the Dominican Republic, Drexler et al. (2014) show that financial literacy and accounting training for business owners resulted in increased revenues for businesses and better management practices. Training will allow microfinance institutions to maximise their potential to help enterprises improve business practices. This training could cover a wide range of subjects from financial literacy to entrepreneurship, providing a good starting point for changing business practices and helping clients to develop adequate planning and improve their creditworthiness for future borrowing.

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Annex A: Additional tables, figures and explanations

Note 1: FONKOZE client profiles

The Annex compares our primary data on ACME clients with existing data on clients of FONKOZE, another major microfinance institution in Haiti with over 53 000 clients (as of September 2019). Our goal is to draw a comprehensive profile of microfinance recipients in Haiti. This comparison will deepen our understanding of which enterprises access microfinance and, consequently, the potential factors hindering access. It will also enrich our understanding of the microfinance sector in Haiti, especially its challenges and opportunities.

FONKOZE was created 25 years ago with the mission of bringing financial inclusion and development services to Haiti's poorer populations. Since 2015, FONKOZE has been collecting important information on clients from the time they receive their first loan up to their ninth loan cycle. These data allow the organisation to directly observe how its clients' lives are affected and to keep track of its overall social goals. FONKOZE also collects information on its clients' interaction with service providers and clients' level of satisfaction.

We find that, similar to ACME, the majority of clients are women (55%). Regarding age, the average borrower is 39 years old, women are significantly older than men (by 2.65 years on average), and veteran borrowers are significantly older than new clients. Overall, 62.9% of FONKOZE's borrowers are literate, but there is a significant difference across gender lines with women less likely to be literate than men. The likelihood of literacy is also higher among new clients than veteran borrowers. Similar to ACME, the average household size is four. The average FONKOZE client's household has 1.36 dependent children, with male-headed households having significantly more dependent children compared to female-headed households (1.48 vs. 1.26). Households headed by veteran borrowers also have more dependent children on average than those headed by new clients, but this difference is not significant. The average household has 1.72 members, with male-headed households having more working members on average than female-headed households (1.91 vs. 1.58). Households headed by veteran borrowers also have a significantly higher number of working people than those headed by new clients. Most clients live in northern departments (56%); only 14% are located in the West department, while the other 30% live in southern departments. There is a clear difference along gender lines here too: while women are more likely to live in northern departments, men are more likely to reside in southern departments. Similarly, veteran borrowers are more likely to reside in northern departments or the West department, whereas new clients are more likely to live in southern departments.

Regarding business characteristics, the results show that 96% of FONKOZE clients are involved in trade (petty trade or wholesale). There is no gender difference, but new clients are more likely to be involved in the trade sector compared to veteran borrowers. The average number of loan cycles is two overall and five for the subsample of veteran borrowers. We also compared the highest amount spent on the business in the last three months. The overall average was \$393, while women-owned businesses outspent male-owned business, and veteran borrowers tended to outspend new clients.

Similar to ACME's clients, the majority of households in the FONKOZE sample reported receiving remittances from abroad (53.7%). Women entrepreneurs were more likely to receive remittances

than male entrepreneurs (58% vs. 48%), and new clients reported a higher probability of receiving remittances compared to veteran borrowers (55% vs. 51%).

We also analysed borrowers' household conditions, focusing specifically on food insecurity and poverty. We find that 74.4% of households can be classified as food insecure, with a higher likelihood of food insecurity in households headed by male (vs. female) entrepreneurs and by new clients (vs. veteran borrowers). As to poverty status, we find an average probability of 46%; male-headed households were more likely to be in poverty than female-headed households, and poverty was more likely in veteran borrower households than in those headed by new clients (Table A2)²⁴.

Note 2: Comparing ACME to FONKOZE

We find some similarities between the clients of these two major microfinance institutions. The majority of borrowers are women with an average age close to 40. In Tables A3 and A4, our regression results reveal that age is a significant factor explaining continued participation in a microfinance programme, as older entrepreneurs have a higher probability of being veteran borrowers rather than new clients for both institutions. The average household size is four. Most of the clients of both institutions reside in northern departments. The regression results show that borrowers in southern departments were least likely to receive continued access to microfinance. We also find that microfinance institutions mostly cater to small-scale traders and have few clients involved in goods production or service provision. The regressions reveal that wholesalers have a higher probability of being continuing clients than petty traders. For both institutions, the majority of households receive remittances from abroad. The regressions show that, compared to non-recipients, those who received remittances had greater access to microfinance as they were more likely to be continuing borrowers.

We also find some dissimilarities between the client profiles of ACME and FONKOZE. A significant proportion of ACME clients have completed primary or secondary education, whereas a high percentage of FONKOZE clients are illiterate. The regression results show a positive association between education and continued access to microfinance. For ACME, educated borrowers had a higher probability of completing at least three loan cycles than clients with no schooling, although this result was significant only for male borrowers. For FONKOZE, literate clients were no more likely than illiterate clients to be veteran borrowers. ACME clients also had a higher number of dependent children in their care compared to FONKOZE clients, and had received a higher number of loan cycles. For ACME clients, the number of dependent children was associated with a higher probability of being a veteran borrower, particularly for women borrowers. The dissimilarities between these two sets of clients can be explained by the differing missions of the largest microfinance institutions in Haiti. While ACME aims to support Haitian MSMEs by giving them access to essential financial products and accompanying them in long-term business development, FONKOZE's goal is to serve the poor and the ultra-poor (primarily rural women) by empowering them with financial services to lift themselves out of poverty.

²⁴ The poverty headcount is based on the Poverty Probability Index using the national poverty line.

Table A1: Characteristics of clients (ACME)

	Total (Mean)	Men (Mean)	Women (Mean)	<i>p</i>	Control (Mean)	Treatment (Mean)	<i>p</i>
<i>Age and gender</i>							
Woman (yes/no)	0.625	-	-	-	0.578	0.624	0.33
Man (yes/no)	0.376	-	-	-	0.423	0.376	0.33
Age (years)	41.3	41.6	41.1	0.60	38.38	42.89	0.00
<i>Marital status</i>							
Single/Never married	0.181	0.195	0.173	0.45	0.176	0.167	0.80
Married	0.44	0.483	0.415	0.08	0.348	0.497	0.00
In consensual union	0.302	0.318	0.293	0.48	0.430	0.261	0.00
Widowed/Divorced	0.076	0.004	0.119	0.00	0.056	0.075	0.45
<i>Education</i>							
No formal schooling	0.057	0.015	0.082	0.00	0.042	0.067	0.28
Primary school	0.332	0.2835	0.361	0.03	0.288	0.373	0.07
Secondary school	0.489	0.547	0.453	0.01	0.521	0.451	0.15
University	0.103	0.130	0.087	0.07	0.126	0.094	0.27
Technical school	0.0173	0.023	0.013	0.36	0.021	0.013	0.53
<i>Household structure</i>							
Household size	4.57	4.37	4.70	0.02	4.13	4.77	0.00
# dependent children	2.383	2.448	2.343	0.430	2.007	2.532	0.002
# working people	0.901	0.866	0.922	0.433	0.831	0.927	0.251
<i>Housing tenure</i>							
Own	0.624	0.601	0.638	0.33	0.493	0.647	0.00
Rent	0.313	0.352	0.290	0.08	0.452	0.298	0.00
Live with family	0.061	0.046	0.071	0.17	0.084	0.053	0.19
<i>Location</i>							
West department	0.352	0.352	0.352	0.99	0.316	0.360	0.35
Northern departments	0.453	0.448	0.456	0.83	0.408	0.473	0.18
Southern departments	0.194	0.199	0.191	0.79	0.274	0.166	0.01
<i>Type of business</i>							
Petty trade	0.709	0.678	0.728	0.16	0.78	0.67	0.01
Wholesale	0.218	0.226	0.214	0.71	0.147	0.233	0.03
Manufacture	0.007	0.019	0.000	0.00	0.00	0.010	0.21
Agricultural production	0.021	0.042	0.009	0.00	0.014	0.032	0.25
Restaurant/Construction/ Services	0.028	0.037	0.027	0.38	0.049	0.045	0.86

Table A1: Characteristics of clients (ACME) (Continued)

	Total (Mean)	Men (Mean)	Women (Mean)	p	Control (Mean)	Treatment (Mean)	p
Enterprise size (# workers)	0.832	1.372	0.507	0.000	0.739	0.914	0.136
Number of businesses	1.17	1.20	1.15	0.23	1.11	1.18	0.18
Age of business	10.83	10.19	11.21	0.07	8.30	12.08	0.00
Number of cycles received	6.463	6.219	6.611	0.320	1.000	9.270	0.000
Loan tenor (# months)	7.24	7.52	7.08	0.00	6.53	7.39	0.00
Amount of loans received (Haitian gourdes)	109 451.20	136 024.10	93 743.32	0.01	46 589.16	130 261.00	0.00
Interest rate charged	5.83	6.59	5.37	0.00	6.29	5.70	0.23
Borrowed from other microfinance institution (yes/no)	0.087	0.088	0.087	0.98	-	-	-
Borrowed from bank (yes/no)	0.019	0.030	0.025	0.385	-	-	-
Receive remittances (yes/no)	0.588	0.597	0.582	0.702	0.542	0.604	0.19
Income from other activities (yes/no)	0.405	0.544	0.322	0.000	0.408	0.397	0.826

Table A2: Characteristics of clients (FONKOZE)

	Total (Mean)	Men (Mean)	Women (Mean)	<i>p</i>	Control (Mean)	Treatment (Mean)	<i>p</i>
<i>Sociodemographics</i>							
Woman (yes/no)	0.55	-	-	-	0.55	0.55	0.88
Man (yes/no)	0.45	-	-	-	0.45	0.45	0.88
Age (years)	39.25	37.87	40.45	0.00	37.87	40.89	0.00
Literate (yes/no)	0.629	0.693	0.576	0.00	0.673	0.609	0.01
<i>Household structure</i>							
Household size	4.46	4.86	4.13	0.00	4.43	4.58	0.15
# dependent children	1.36	1.48	1.26	0.00	1.33	1.42	0.16
# working people	1.72	1.91	1.58	0.00	1.70	1.84	0.02
<i>Location</i>							
West department	0.14	0.15	0.13	0.31	0.12	0.19	0.00
Northern departments	0.56	0.54	0.57	0.08	0.52	0.56	0.03
Southern departments	0.30	0.33	0.28	0.01	0.37	0.25	0.00
<i>Type of business</i>							
Trade	0.96	0.97	0.96	0.38	0.97	0.93	0.00
Wholesale	0.009	0.01	0.008	0.63	0.005	0.020	0.00
Manufacture/Manual work	0.02	0.02	0.02	0.71	0.014	0.034	0.00
Other	0.01	0.011	0.008	0.48	0.008	0.011	0.66
<i>Other characteristics</i>							
Number of cycles received	2.39	2.41	2.35	0.39	1.00	5.12	0.00
Highest amount spent in last three months	23 871.89	22 750.45	24 795.21	0.06	21 090.01	28 272.47	0.00
Receive remittances (yes/no)	0.54	0.48	0.58	0.00	0.55	0.51	0.85
Food insecure (yes/no)	0.744	0.769	0.722	0.01	0.76	0.69	0.00
Mobile banking (yes/no)	0.35	0.33	0.38	0.01	0.41	0.37	0.06
Probability of being poor	0.46	0.51	0.42	0.00	0.41	0.50	0.00

Table A3: Probit regression (probability of treatment = 1) (ACME)

	Total	Men	Women
<i>Age and gender</i>			
Woman (yes/no)	-	-	-
Man (yes/no)	-0.15		
Age (years)	0.10***	0.09	0.08
Age squared	-0.00**	-0.00	-0.00
<i>Marital status</i>			
Single/Never married	-	-	-
Married	-0.11	0.24	-0.20
In consensual union	-0.56***	-0.58*	-0.52*
Widowed/Divorced	-0.15		-0.18
<i>Education</i>			
No formal schooling	-	-	-
Primary school	0.24	1.26*	0.09
Secondary school	-0.02	1.23*	-0.26
University	0.01	1.28*	0.08
Technical school	-0.13	0.72	
<i>Household structure</i>			
# dependent children	0.08**	0.02	0.15**
# working people	0.06	0.04	0.12
<i>Location</i>			
West department	-	-	-
Northern departments	0.02	-0.02	0.20
Southern departments	-0.46**	-0.67**	-0.21
<i>Type of business</i>			
Petty trade	-	-	-
Wholesale	0.35**	0.00	0.92***
Manufacture	-	-	
Agricultural production	0.15	0.44	0.25
Restaurant/Construction/Services	-0.31	-0.49	-0.35

Table A3: Probit regression (probability of treatment = 1) (ACME) (Continued)

	Total	Men	Women
Enterprise size (# workers)	0.06	0.19*	-0.10
Number of businesses	0.14	0.07	0.05
Age of business	0.04***	0.06**	0.03*
Receive remittances (yes/no)	0.29**	-0.26	0.53***
Income from other activities (yes/no)	-0.04	0.12	-0.05
Constant	-2.68***	-3.12**	-2.62**
N	510	196	311
pseudo R-squared	0.139	0.199	0.196
*** p<0.01, ** p<0.05, * p<0.1			

Table A4: Probit regression (probability of treatment = 1) (FONKOZE)

	Total	Men	Women
<i>Sociodemographics</i>			
Woman (yes/no)	-	-	-
Man (yes/no)	0.09	-	-
Age (years)	0.06***	0.07**	0.05*
Age squared	-0.00**	-0.00	-0.00
Literate (yes/no)	-0.10	-0.12	-0.08
<i>Household structure</i>			
# dependent children	0.01	0.02	-0.01
# working people	-0.02	0.03	-0.06
<i>Location</i>			
West department	-	-	-
Northern departments	-0.14	-0.05	-0.22
Southern departments	-0.46***	-0.37**	-0.54***
<i>Type of business</i>			
Trade	-	-	-
Wholesale	0.59*	0.64	0.41
Manufacture/Manual work	0.25	0.26	0.21
Other	-0.08	0.00	-0.18
<i>Type of loan</i>			
Type A	-	-	-
Type B	0.58***	0.57***	0.61***
Type C	1.01*	1.30*	0.66
Type D	-1.39***	-1.57***	-1.25***
Receive remittances (yes/no)	0.05**	0.09**	0.03
Mobile banking (yes/no)	-0.16**	-0.13	-0.20*
Constant	-1.84***	-2.34***	-1.36**
N	1 643	741	902
pseudo R-squared	0.121	0.134	0.117
*** p<0.01, ** p<0.05, * p<0.1			

Table A5: Outcome variables: mean

Outcomes	Total	Men	Women
1. Business expansion			
Did you add a new product/service in 2018?	0.19	0.21	0.17
Did you add a new product/service in 2019?	0.12	0.14	0.10
Did you hire new workers in 2018?	0.02	0.01	0.02
Did you hire new workers in 2019?	0.01	0.01	0.01
Did you open a new branch in 2018?	0.06	0.07	0.06
Did you open a new branch in 2019?	0.04	0.05	0.02
Did you buy in greater volume in 2018 compared to 2017?	0.22	0.23	0.21
Did you buy in greater volume in 2019 compared to 2018?	0.19	0.21	0.17
Did your merchandise stock increase from 2018 to 2019?	0.35	0.42	0.28
Did your merchandise stock increase from 2019 to 2020?	0.17	0.20	0.14
2. Earnings and profit			
Gross monthly revenue during peak months in 2018	110 240.40	72 775.03	145 461.30
Gross monthly revenue during off-peak months in 2018	58 446.27	40 834.46	75 003.00
Gross monthly revenue during peak months in 2019	109 880.00	77 073.53	140 721.20
Gross monthly revenue during off-peak months in 2019	66 969.79	49 149.51	83 722.49
Estimated average monthly profit in 2018	-22 556.12	-18 995.85	-25 903.11
Estimated average monthly profit in 2019	-12 525.49	-8 385.16	-16 417.79
Amount per month to family spending in 2018	20 432.00	19 608.50	21 206.18
Amount per month to family spending in 2019	20 896.91	18 736.03	22 928.34
Saved more in 2019 compared to 2018? (yes/no)	0.43	0.58	0.28
Saved more in 2020 compared to 2019? (yes/no)	0.24	0.35	0.14

Table A5: Outcome variables: mean (Continued)

Outcomes	Total	Men	Women
3. Investment in fixed assets			
Number of fixed assets purchased after most recent loan	0.57	0.76	0.40
Average value of fixed assets purchased after most recent loan	3 609.86	14 237.55	2 594.89
4. Change in behaviour			
Do you have a bank account for the business?	0.21	0.19	0.23
Do you use an accounting/recording system for the business?	0.10	0.10	0.10
*** p<0.01, ** p<0.05, * p<0.1			

Table A6: Multivariate analysis of the impact of microfinance on business outcomes: Average treatment effects (ACME)

Outcomes	Total	Men	Women
1. Business expansion			
Did you add a new product/service in 2018?	0.04	-0.08	0.04
Did you add a new product/service in 2019?	0.05	0.03	0.06
Did you hire new workers in 2018?	0.01*	0.01	0.01
Did you hire new workers in 2019?	0.00	-0.01	0.00
Did you open a new branch in 2018?	0.01	-0.06	0.05*
Did you open a new branch in 2019?	-0.00	-0.05	0.03**
Did you buy in greater volume in 2018 compared to 2017?	-0.01	-0.05	-0.01
Did you buy in greater volume in 2019 compared to 2018?	0.00	0.10	-0.06
Did your merchandise stock increase from 2018 to 2019?	0.12**	0.18**	0.06
Did your merchandise stock increase from 2019 to 2020?	0.03	0.06	-0.04
2. Earnings and profit			
Gross monthly revenue during peak months in 2018	0.12	-0.12	0.17
Gross monthly revenue during off-peak months in 2018	0.19	-0.12	0.34
Gross monthly revenue during peak months in 2019	0.01	-0.14	0.05
Gross monthly revenue during off-peak months in 2019	0.03	-0.02	0.04
Estimated average monthly profit in 2018	2.86*	5.42**	1.67
Estimated average monthly profit in 2019	2.87*	5.50**	0.77
Amount per month to family spending in 2018	0.30***	0.14	0.33**
Amount per month to family spending in 2019	0.29***	0.13	0.33*
Saved more in 2019 compared to 2018? (yes/no)	0.02	0.24**	-0.18**
Saved more in 2020 compared to 2019? (yes/no)	0.12***	0.30***	-0.03

Table A6: Multivariate analysis of the impact of microfinance on business outcomes: Average treatment effects (ACME) (Continued)

Outcomes	Total	Men	Women
3. Investment in fixed assets			
Number of fixed assets purchased after most recent loan	0.62***	0.79***	0.40***
Average value of fixed assets purchased after most recent loan	2.40***	1.95***	2.02***
4. Change in behaviour			
Do you have a bank account for the business?	0.13***	0.09*	0.11*
Do you use an accounting/recording system for the business	0.03	0.00	0.03
*** p<0.01, ** p<0.05, * p<0.1 Covariates used in the model: age, age squared, gender, marital status, education, # dependent children, # working household members, location, type of business, enterprise size, number of businesses, age of business, receipt of remittances, incidence of income from other activities.			

Figure A1: Kernel density estimates: Estimated average monthly profit

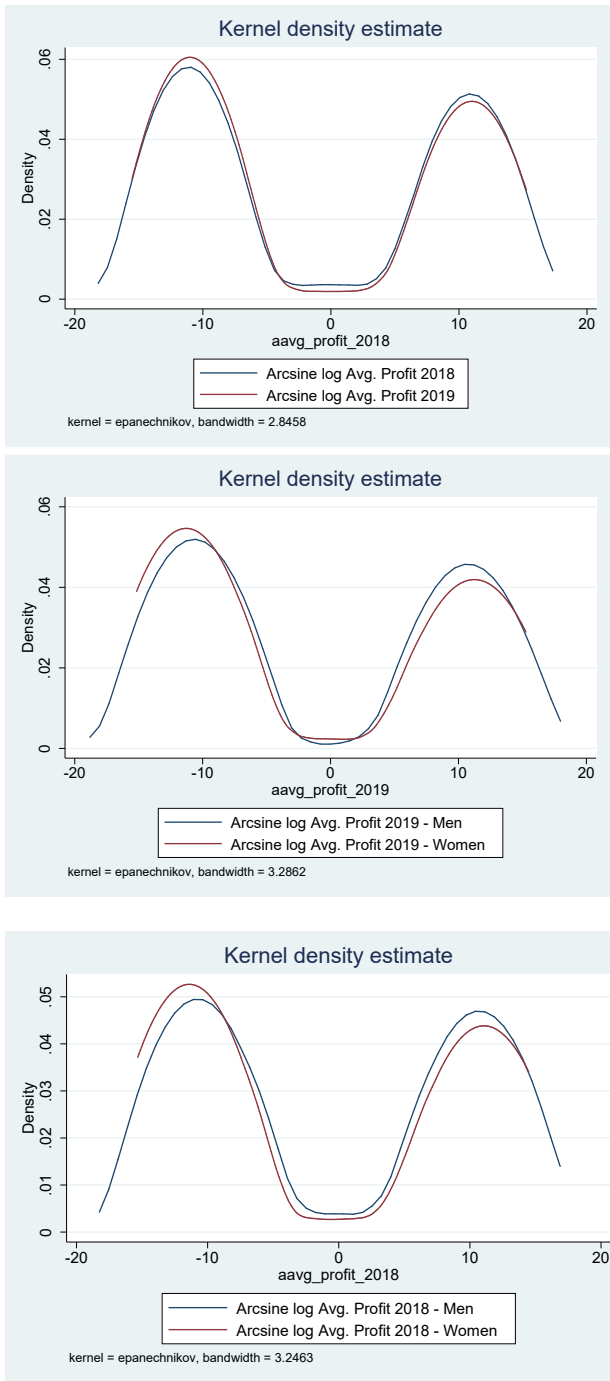


Table A7: Sensitivity analysis – Rosenbaum sensitivity bounds

Outcomes		Gammas																				
		1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Merchandise stock increase from 2018 to 2019?	p_mh +	0.00	0.01	0.04	0.07	0.13	0.21	0.30	0.40	0.50	0.50	0.41	0.33	0.26	0.20	0.15	0.11	0.08	0.06	0.04	0.03	0.02
	p_mh -	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Estimated average monthly profit in 2018	sig +	0.00	0.00	0.01	0.05	0.13	0.26	0.42	0.59	0.73	0.84	0.91	0.95	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	sig -	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Estimated average monthly profit in 2019	sig +	0.00	0.00	0.01	0.04	0.11	0.23	0.38	0.55	0.69	0.81	0.89	0.94	0.97	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	sig -	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amount per month to family spending in 2018	sig +	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.13	0.23	0.36	0.49	0.63	0.74	0.83	0.89	0.94	0.96	0.98	0.99	0.99
	sig -	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amount per month to family spending in 2019	sig +	0.00	0.00	0.01	0.04	0.12	0.26	0.44	0.61	0.76	0.87	0.93	0.97	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	sig -	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saved more in 2020 compared to 2019?	p_mh +	0.01	0.03	0.07	0.11	0.18	0.25	0.34	0.42	0.51	0.52	0.45	0.38	0.32	0.26	0.21	0.17	0.14	0.11	0.09	0.07	0.05
	p_mh -	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A7: Sensitivity analysis – Rosenbaum sensitivity bounds (Continued)

Outcomes		Gammas																				
		1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Number of fixed assets purchased after most recent loan	sig +	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	sig –	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average value of fixed assets purchased after most recent loan	sig +	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
	sig –	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Do you have a bank account for the business?	P_mh +	0.00	0.01	0.01	0.02	0.04	0.06	0.09	0.13	0.17	0.21	0.26	0.31	0.37	0.42	0.47	0.52	0.56	0.52	0.47	0.43	0.39
	p_mh +	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Covariate balancing propensity score weights are used in the propensity score matching calculations.

Gamma: odds of differential assignment due to unobserved factors.

P_mh+: Mantel-Haenszel statistical significance level (assumption: overestimation of treatment effect).

P_mh-: Mantel-Haenszel statistical significance level (assumption: underestimation of treatment effect).

Sig +: Hodges-Lehmann upper bound significance level.

Sig -: Hodges-Lehmann lower bound significance level.

The impact of digital distribution on the small retail sector in Nigeria: The case of the ShopTopUp platform

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Abstract

This study investigates the impact of ShopTopUp, a digital retail distribution platform, on the market for consumer goods and the business operations of small retailers in Nigeria. Cluster sampling was applied to generate a geographically concentrated sample of 479 small retail stores in Lagos, comprising 124 stores in the control group (non-users of ShopTopUp) and 355 stores in the treatment group (ShopTopUp users). A telephone survey of this sample was then administered, with questions focused on the purchase and sales prices of key products; the frequency of product stock-outs; sale volumes and profitability; and employment. The survey data were analysed through multivariate regressions and propensity score matching (calculating the average treatment effect on the treated) to estimate the effects of using ShopTopUp. The most notable finding is that ShopTopUp users experience shorter average stock-out periods (1.7 days) than non-users (3.4 days).

1. Introduction

This study investigates the impact of ShopTopUp, a digital retail distribution platform, on the market for consumer goods and the business operations of small retailers in Nigeria. Unlike the more traditional route-to-market approaches, ShopTopUp uses a hyperlocal marketplace allowing retailers to (1) view up-to-date product price and discount information for their area and (2) via a central scheduling system, have their orders reliably delivered at the best prices. By 2020, ShopTopUp was fully operational in Lagos and Abuja and partially operational in other major cities in Nigeria, connecting over 22 000 small retailers directly with manufacturers and distributors.

The potential benefits offered by the ShopTopUp platform are important in the context of the Nigerian economy and retail sector, which section 2 describes. The retail sector is a major contributor to national gross domestic product (GDP) and employment, especially for women (providing 5.1% of formal female employment in 2018). Small retailers form the largest component of the sector (National Bureau of Statistics, 2020). However, the retail sector has been under pressure due to slow economic growth and high inflation rates, with four consecutive years of reduced real output from 2016 to 2019 (National Bureau of Statistics, 2021). Moreover, households allocate a large proportion of their consumption spending to food items, which makes many households vulnerable to food price inflation.

Within this context, it is important to realise efficiency gains in the retail sector. Specifically, ShopTopUp aims to correct certain key problems in the wholesale link in the supply chain between manufacturers/distributors and small retailers. Section 3 details the specific problems that ShopTopUp addresses. First, the typical practice is for wholesalers to receive goods from manufacturers and distributors on credit, which is expensive and difficult to secure, and then pass on these costs to retailers. Second, most wholesalers fail to pass on any product discounts and promotions from manufacturers and distributors to small retailers. Third, many new and popular goods fail to reach small retail stores promptly. Lastly, most wholesalers operate inefficient product order-delivery systems that contribute to higher product prices and longer stock-outs.

Section 4 details the methodology applied to estimate the impact of ShopTopUp on small retailers, then reports the results. The first step was to apply cluster sampling to generate a geographically concentrated sample of 479 small retail stores in Lagos, comprising 124 stores in the control group (non-users of ShopTopUp) and 355 stores in the treatment group (ShopTopUp users). These stores participated in a telephone survey with questions focused on the purchase and sales prices of key products; the frequency of product stock-outs; sale volumes and profitability; and employment. Multivariate regression analysis and propensity score matching – calculating the average treatment effect on the treated – were then applied to the survey data to estimate the effects of using ShopTopUp. The most important findings are that ShopTopUp users experience shorter stock-out periods and are able to internalise lower supply prices to reduce consumer prices for selected products.

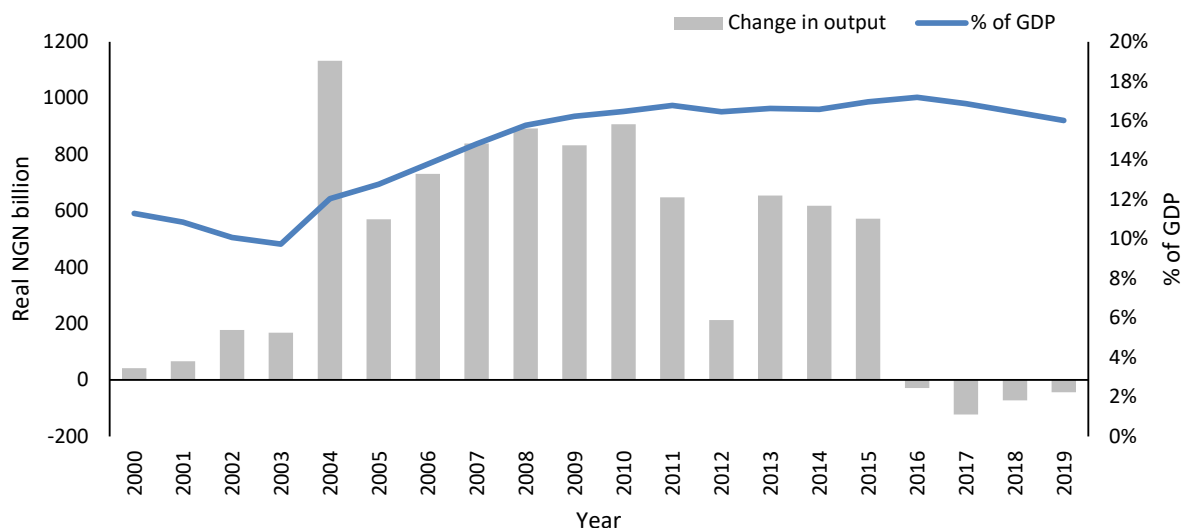
2. Key characteristics of the Nigerian retail sector

2.1. Size and structure of the retail sector

Trade (retail and wholesale) has consistently comprised a large proportion of Nigeria's GDP. Figure 1 shows that trade's contribution to GDP was 16.0% in 2019 and averaged 14.7% from 2000 to 2019.

Retail trade is an important sector in the Nigerian economy but has experienced declining levels of real output since 2016. Retail sector output fell in real terms by NGN 43.2 billion in 2019, with a cumulative reduction in real output of NGN 267.0 billion from 2016 to 2019. This compares poorly against most other sectors and the general economy, which declined in real terms by 1.6% in 2016 but then grew by 0.8% in 2017, 1.9% in 2018, and 2.2% in 2019 (International Monetary Fund, 2021a). The size and recent negative performance of the retail sector, particularly in contrast to the overall economy, intensifies the need to realise potential productivity gains within the sector.

Figure 1: Contribution of trade (retail and wholesale) to Nigerian GDP, 2000-2019

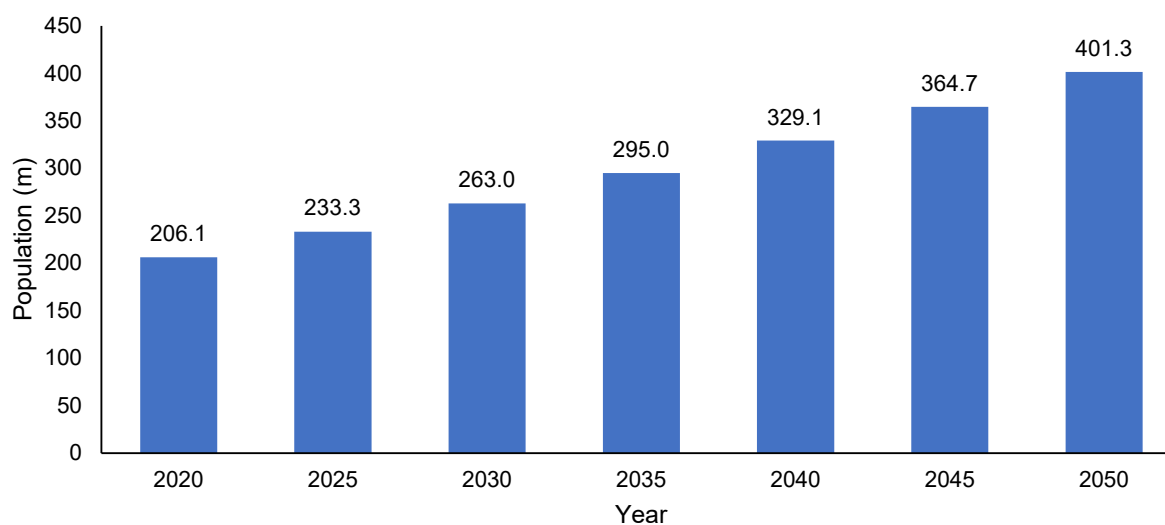


Source: National Bureau of Statistics (2021)

The Nigerian retail sector is dominated by small and informal retailers. Approximately 62% of consumer spending in 2015 occurred in open-air markets, while a further 12% occurred in kiosks (Nielsen, 2015). Larger retailers such as hypermarkets and supermarkets accounted for the remaining 26% of consumer spending. Thus, the majority of household consumption is facilitated by small retailers.

2.2. Consumer base and prices

Nigeria has a large demand base for retail goods: as Figure 2 shows, the country's population was 206.1 million in 2020. This large consumer demand base is set to grow to 401.3 million people by 2050, making Nigeria the third most populous country globally (World Bank, 2020). This significant demand base is expected to be relatively wealthier over the medium term, despite the impact of COVID-19, with the International Monetary Fund (2021a) forecasting that GDP per capita will rise by 76% from \$2 080 in 2020 to \$3 660 in 2025. Consequently, the number of middle-class consumers – a main driver of retail spending – is forecast to grow over the medium term (Oxford Business Group, 2019).

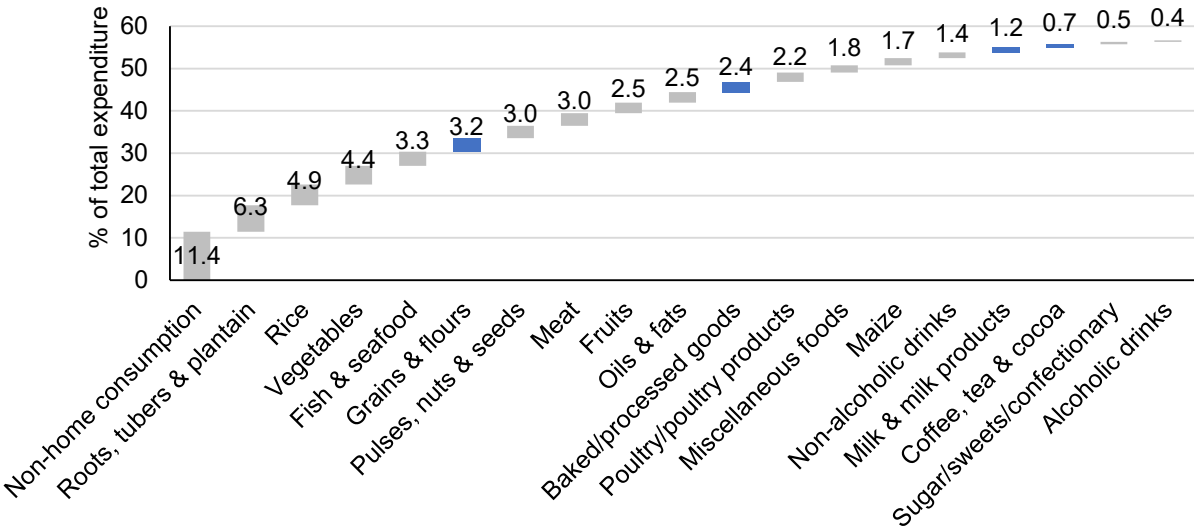
Figure 2: Nigerian population, 2020-2050

Source: World Bank (2020)

However, approximately 83 million people (40% of the total population) lived below the poverty line of NGN 137 430 (\$381.80) per year in 2019 (National Bureau of Statistics, 2020). This large impoverished subpopulation is a vulnerable consumer group especially sensitive to changes in food prices. The 2018 Nigeria Living Standards Survey reported that 11.7% of households reduced their food consumption to cope with higher food prices, with a further 4% of households lowering their non-food consumption (National Bureau of Statistics, 2020). Price inflation from inefficiencies in the distribution system thus poses a loss of potential value within the retail sector.

Consumer sensitivity to food prices is further supported by Figure 3, which highlights the large proportion of food spending in total household consumption spending. Food was the main spending group in 2019, comprising 56.7% of total household consumption spending. The food groups sampled in this study (grains and flours; baked and processed goods; milk and milk products; and coffee, tea and cocoa beverages) accounted for 7.5% of total household consumption spending and 13.3% of total food spending.

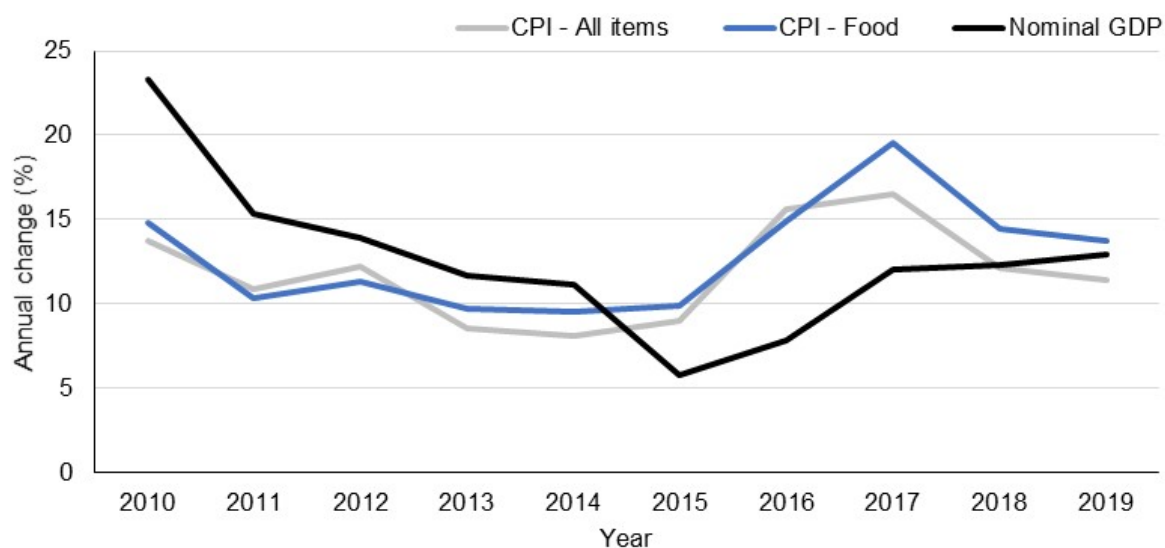
Figure 3: Food items as a percentage of total household consumption spending in Nigeria, 2019



Source: National Bureau of Statistics (2021)

Given these statistics, it is problematic that food price inflation has mostly outpaced growth in both the total consumer price index and nominal GDP since 2014 (Figure 4). This situation has worsened since the COVID-19 pandemic, with inflation reaching a 33-month high in November 2020 as lockdowns and import restrictions created supply shortages (International Monetary Fund, 2021b). Nielsen’s (2017) survey revealed that Nigerian consumers were increasingly price conscious due to high rates of inflation and relatively subdued economic growth. Of the surveyed shoppers, 70% were aware of the prices for standard grocery store items, with around 95% of those noticing price changes; 60% were cutting back on luxury groceries and buying only essential items, with 23% buying in bulk and 17% switching to cheaper products; and 76% reported being influenced by promotions, with 21% saying they would switch to stores offering price promotions. These findings demonstrate the potential negative impact on household disposable income and retail sales from inefficiencies that limit the availability of product and price information for consumers and raise food prices.

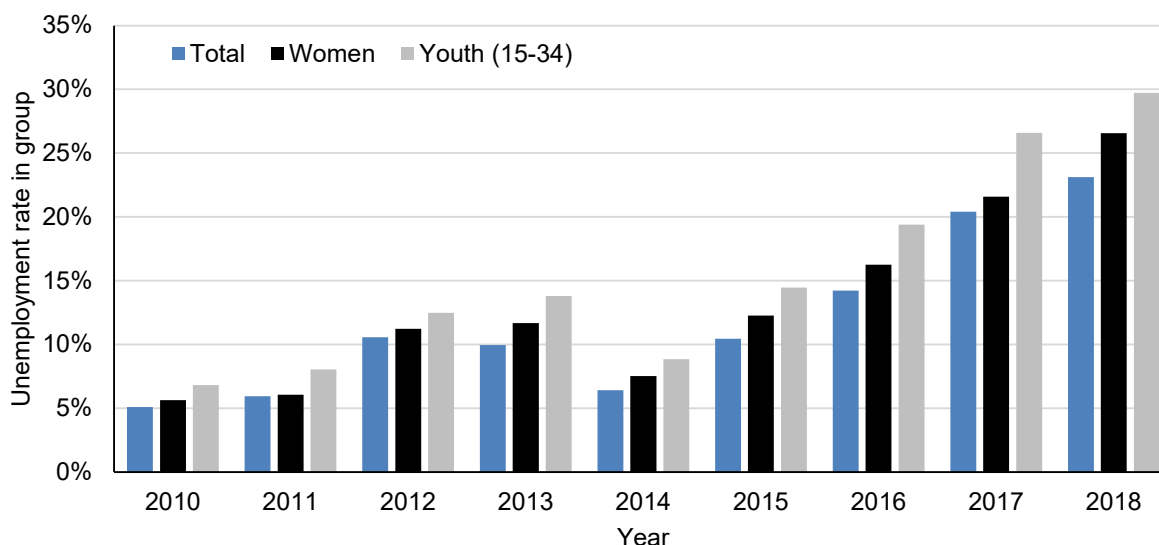
Figure 4: Food price inflation versus consumer price inflation (CPI) and nominal GDP growth in Nigeria, 2010-2019



Source: Central Bank of Nigeria (2021)

2.3. Employment

Unemployment is increasingly becoming a national crisis in Nigeria. Figure 5 demonstrates that the national unemployment rate rose from just 5.1% in 2010 to 23.1% in 2018, with the 2020 Q2 data indicating a further increase to 27.1%. Moreover, the unemployment rates among young people (aged 15-34) and women were 29.7% and 26.6%, respectively, in 2018. Within this context of high and increasing unemployment rates, especially among women, it is important to note the significant role of the retail sector. According to the 2018 Nigeria Living Standards Survey, 4.7% of males and 5.1% of females employed nationally were working in the trade sector (National Bureau of Statistics, 2020). The retail sector is, therefore, an important current and potential source of employment.

Figure 5: Unemployment rates in Nigeria, 2010-2018

Source: National Bureau of Statistics (2021)

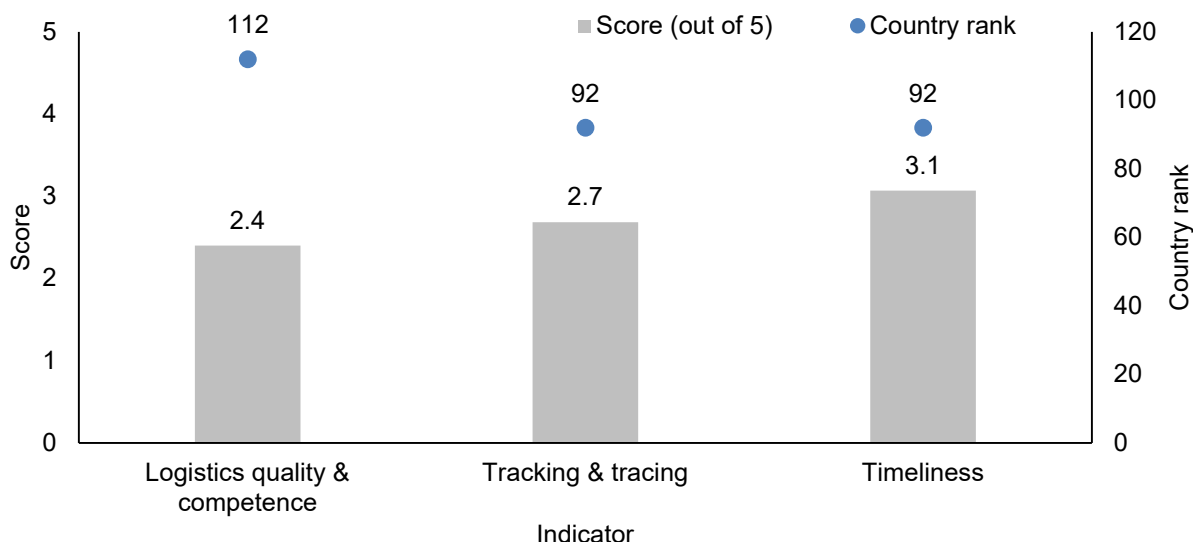
3. Barriers to the growth of small retailers

Approximately 70% of Nigeria's small retailers in 2018 were supplied by wholesalers, rather than directly by manufacturers or distributors (TradeDepot, 2020). This additional wholesale link in the supply chain between manufacturers/distributors and small retailers often introduces four main problems that affect the price of goods and constrain growth among small retailers:

- Wholesalers receive goods from manufacturers and distributors on credit. This limits the working capital available to manufacturers and distributors. Also, due to rigorous and lengthy credit processes, high interest rates and cumbersome collateral requirements, small retailers pay a higher price for goods than they would otherwise pay if supplied directly by manufacturers and distributors (OECD, 2021).
- Most wholesalers fail to pass on any product discounts and promotions from manufacturers and distributors to small retailers. This issue arises because there is no direct communication channel between manufacturers/distributors and small retailers. Consequently, the benefits from product promotions often remain with the wholesalers, rather than reaching small retailers and consumers (TradeDepot, 2020).
- Linked to this missing communication channel is the problem that new and popular goods fail to reach small retail stores promptly. Nielsen (2015) analysed a range of new products in Nigeria over a six-month period and found that the highest-selling new product measured by the Nielsen Retail Index was available in 65% of stores, while the next nine best-selling products were available in just 30% of stores. This mismatch between demand and supply may constrain potential sales growth.
- Most wholesalers operate inefficient product order-delivery systems. The poor logistics performance outcomes are detailed in Figure 6, which reports three key logistics indicators for 2018: logistics quality and competence; tracking and tracing; and timeliness. The three scores are all markedly below the best possible score of 5, with Nigeria ranking between 92nd and 112th globally. Besides poor road infrastructure and other issues, delivery vans in Nigeria often carry too

much or too little inventory, which leads to higher transport costs being passed on to retailers or unfulfilled demand and stock-outs (TradeDepot, 2020). The risk of stock-outs is heightened by too many small retailers having limited or no storage space, and thus only holding inventory they can display (Nielsen, 2015).

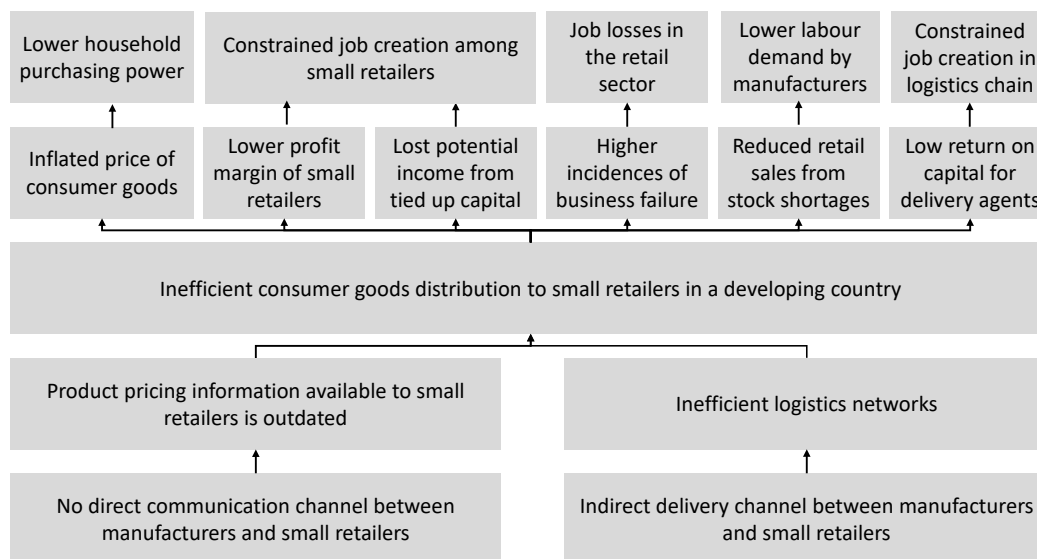
Figure 6: World Bank's Logistics Performance Index, 2018



Source: World Bank (2021)

As shown in Figure 7, these problems within the consumer goods distribution system result in various stakeholder and societal effects. At the stakeholder level, small retailers are negatively affected by paying higher prices for goods, leading to either lower profit margins on sales or higher prices for consumers. Lower profit margins constrain job creation by small retailers, whereas higher consumer prices reduce household purchasing power. Higher supply prices likely raise the incidence of business failure among small retailers, leading to job losses in the sector. Sales of goods may also be lost where inefficient delivery systems lead to stock-outs, thereby decreasing demand for these goods and lowering the required production volumes, which may in turn dampen manufacturers' labour demand. Inefficient delivery systems also negatively affect the return on capital for delivery agents, and ultimately the sector's growth and job creation.

Figure 7: Problem tree



4. Potential efficiency gains from digital retail distribution: Case study of TradeDepot

4.1. Company profile and services

TradeDepot (2020) operates a business-to-business digital retail distribution platform called ShopTopUp that connects small retailers directly with local manufacturers and distributors. This allows small retailers to order directly from manufacturers and distributors, thereby negating the problems associated with the wholesale link in the logistics chain (Figure 8).

Unlike more traditional route-to-market approaches, ShopTopUp uses a hyperlocal marketplace to provide small retailers with reliable product supply at the best prices. The hyperlocal product discovery system ensures that each retailer only sees products available for their specific location, listed at the applicable local currency prices. The platform gives retailers a real time view of the prices and discounts available from every major brand, which they can then order and have delivered from the nearest depots. During this process, manufacturers have oversight of their distribution, which they can leverage to optimise deliveries to distributors, improve pricing, and deal directly with small retailers. Producers could also use ShopTopUp to alter their prices in response to the offer prices of other producers, although this is not a purpose of the platform.

ShopTopUp's central scheduling system takes the order list, identifies distributor locations, assesses each driver's available van capacity, and automatically schedules delivery routes for each driver. This scheduling optimisation benefits distributors by reducing their workload and enabling them to deliver considerably more stock per day with the same number of vans. Several major distributors have already integrated with the digital platform, including Nigeria's leading logistics provider, MDS Logistics, which has 50 depots across the country.

Small retailers pay cash for the products on delivery, which is then deposited into the relevant manufacturer's or distributor's bank account. TradeDepot generates revenue from this service by charging a markup of typically 2-5% on the price of the goods.

ShopTopUp serves many local manufacturers in Nigeria. Among the registered packaged goods companies are Unilever, PZ Cussons, Kellogg's, Arla, IndoMie, Promasidor, Nestlé, Flour Mills Nigeria Plc and Guinness Nigeria Plc. Accordingly, ShopTopUp covers a wide variety of products, including toiletries, provisions, cleaning and laundry, baby, health and beauty, tea and beverages, snacks, food items, household, and wine and liquor. The set of available products is area and time specific, with standardised product prices within each area.

Since its inception in 2015, TradeDepot has grown the network of ShopTopUp users to over 22 000 retailers across Nigeria as of 2019. Partech (2018) notes that there are approximately 1.2 million small retailers in Nigeria, which means that approximately 1.8% of the country's small retailers are registered ShopTopUp customers. There is a positive growth trend, with a new retailer signing up to ShopTopUp every three minutes as of November 2019. ShopTopUp had full operations in Lagos and Abuja in 2019, with partial operations in other major Nigerian cities. TradeDepot also extended its operations to Ghana and South Africa in 2019, with active pilot studies in both countries.

4.2. Study approach

4.2.1. Research questions

This study aimed to investigate the following research questions, through the survey tool described in Section 4.2.3 and presented in full in Annex A:

1. Does the ShopTopUp platform contribute to the sustainability of small retailers?
2. What impact has the ShopTopUp platform had on retail sales and consumer prices?
3. Has the ShopTopUp platform led to job creation among small retailers?
4. Has the ShopTopUp platform led to empowerment of female entrepreneurs?

4.2.2. Sample selection and characteristics

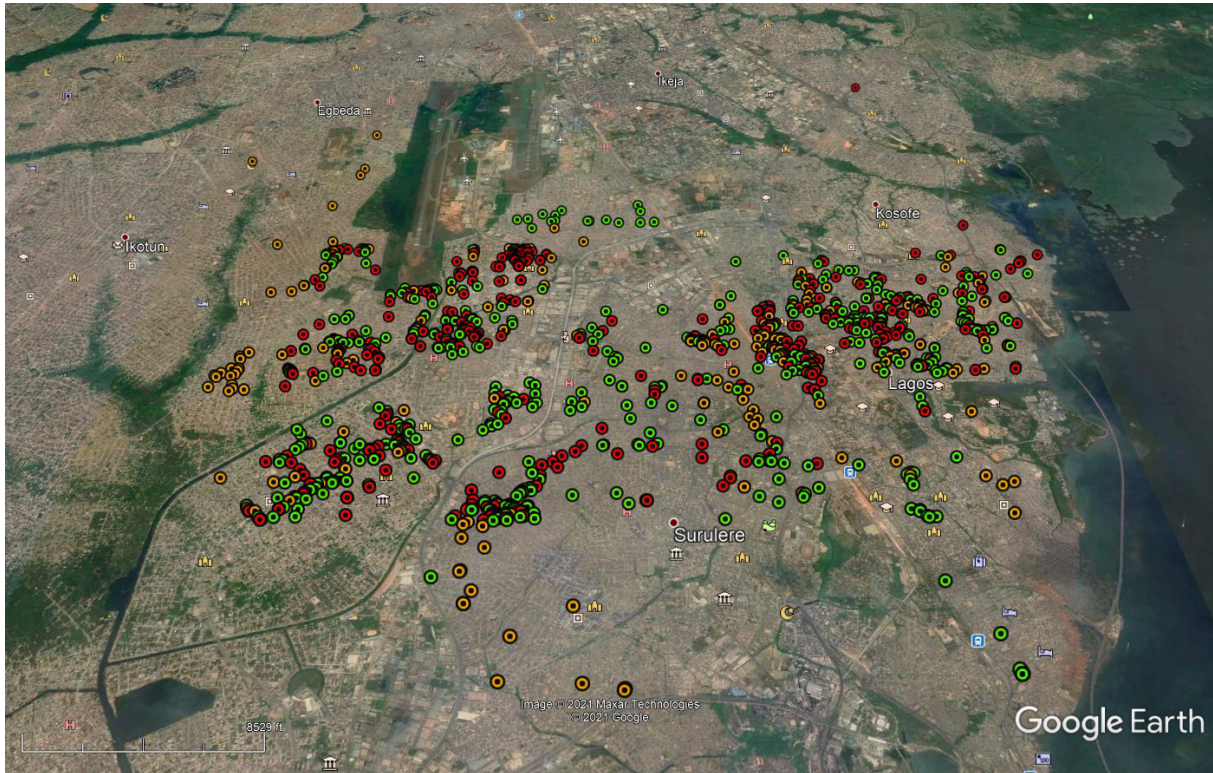
The study focused on small retailers in Lagos, an urban centre with 14.8 million residents. Lagos was chosen as the study site for two key reasons. First, it is the base of operations for ShopTopUp. As such, the city has the highest number of and the longest standing ShopTopUp users. Second, the retail market in Lagos is very competitive with a high number of small retailers.

As the first step, we identified the following three groups of ShopTopUp users: active retail stores that had ordered from ShopTopUp within the last 90 days; inactive retail stores that were registered with ShopTopUp but had not used the platform within the last 90 days; and inactive retail stores that were not yet registered with ShopTopUp. The group of active retail stores is the study's treatment group, while the two groups of inactive retail stores form the control group.

The second step was to apply a cluster sampling method, dividing the population of retail stores across Lagos into geographically concentrated clusters then randomly selecting among these clusters to form the sample. This approach was chosen to negate the vast regional diversities across Lagos by clustering the sample of stores within geographic zones sharing many basic characteristics (consumers, distance to depots, density of retail stores, etc.). To facilitate this task, TradeDepot used their store

database to generate a random sample of 500 active (green) and 500 inactive (red) ShopTopUp users in the same (or if not then the adjacent) 1.1 km x 1.1 km grids. The original sample of 500 inactive stores had to be increased by 227 stores (orange) because of low survey response rates, which is discussed further in section 4.2.3. The larger sample necessarily extended the area over which the stores are located. The sample's geographic distribution is depicted in Figure 8.

Figure 8: Geographic information system quadrants and the sample of small retail stores in Lagos



4.2.3. Survey

The survey tool (Annex A) was administered to the sample of retail stores shown in Figure 9. The COVID-19 outbreak changed the survey approach from the planned face-to-face interviews to telephone interviews, which were conducted by an independent survey company. Response rates were low, especially amongst the control group. Consequently, the target of 400 stores for each of the control and treatment groups was not reached. A total of 479 interviews were successfully completed, comprising 355 stores in the treatment group and 124 stores in the control group. The final sample is summarised in Table 1.

Table 1: Sample characteristics

	Control group	Treatment group
Sample size	124	355
<i>Sex of retail store owner</i>	(N=124)	(N=355)
Male	16.9%	19.9%
Female	83.1%	80.1%
<i>Age group</i>	(N=21)	(N=299)
18–35 years	9.5%	25.4%
36–50 years	71.4%	58.5%
>50 years	19.0%	16.1%
<i>Highest level of education</i>	(N=112)	(N=323)
None	6.3%	1.9%
Primary school	17.0%	8.0%
Secondary school	40.2%	40.9%
Tertiary	0.0%	7.7%
University	34.8%	38.7%
Vocational training	1.8%	2.8%
<i>Store owner has other businesses</i>	(N=123)	(N=352)
Yes	28.5%	32.1%
No	71.5%	67.9%

Despite extending the sample of inactive stores by 227 to account for the lower-than-expected response rates, the control group remained limited and unbalanced in relation to the treatment group. Another noteworthy issue was the poor response to particular questions in the survey. The problematic questions concerned culturally sensitive age and employment statistics and financial information. These survey design issues were identified during the pilot phase and corrected by streamlining the survey and replacing values with ranges. However, data gaps persisted as respondents remained hesitant to answer certain questions.

The sample characteristics detailed in Table 1 reveal some interesting findings. First, it is important to note that stores in the treatment group had been using ShopTopUp for an average of 24.2 months – long enough for established trends to have developed. The average period that the stores had been in business was also relatively high in both the treatment group (12 years) and control group (11 years).

Consistent with the industry trend, retail stores in the treatment (80.1%) and control (83.1%) groups were predominantly female-owned. These data reveal only a marginal difference in sex distribution between the control and treatment groups, signalling no sex bias between the groups. In line with the expectation that technology diffusion is highest among young people, the proportion of youths (18-35 years old) was higher in the treatment group (25.4%) than in the control group (9.5%). Reflecting the high costs of owning a retail store, ownership was concentrated among 36- to 50-year-olds. Completing secondary school was the highest level of education achieved by the largest proportion of owners in the treatment group (40.9%) and control group (40.1%), but only the treatment group contained owners with tertiary level education. Lastly, a moderate proportion of owners in the treatment (32.1%) and control groups (28.5%) owned other businesses.

4.2.4. Impact estimation strategy

Two methods were applied to estimate the impact on retailers of using ShopTopUp: multivariate regression analysis and propensity score matching.

4.2.4.1. Multiple regression analysis

The regression model is specified as follows:

$$Y_i = \alpha_i + \beta_1 Status_i + \beta_2 Educ_i + \beta_3 BusAge_i + \beta_4 Sex_i + \beta_5 AgeCat_i + e_i . \quad (1)$$

In equation (1), Y is the impact variable measured in terms of price levels, profit margin and duration of stock-outs; $Status$ is a dummy variable that takes the value of 1 if the retail store actively uses ShopTopUp, or 0 if not. $Educ$ is the education level of the retail store owner. Education level was divided into two categories: tertiary (post-secondary) and non-tertiary education. Small-scale retail businesses owned by well-educated people are expected to be more profitable compared to those owned by lowly educated people. This is even more relevant in businesses requiring knowledge of recent technologies like the internet and mobile phone apps.

$BusAge$ is the number of years that the business has been operating. This variable is expected to be positively correlated with business performance. Well-established businesses tend to be more profitable as entrepreneurial acumen develops over time and goodwill is accumulated in relationships with suppliers and customers.

Sex is the retail store owner's sex. This is a dummy variable that takes the value of 1 if the owner is male or 0 if female. Male-owned businesses are expected to perform better than female-owned businesses. Chirwa (2008) attributes the relatively poor performance of women-operated enterprises to the inaccessibility of credit from the formal financial system, lack of capital and an inadequate institutional framework.

$AgeCat$ is the age category of the retail store owner. The age of business owners is divided into two categories: young people (≤ 35 years) and older generations (≥ 36 years). This dummy variable takes the value of 1 for young people or 0 for older generations. Existing literature has shown that businesses run by relatively young people are likely to be more successful than those run by relatively older people (Sinha, 1996).

Finally, e_i is the error term in Equation (1).

4.2.4.2. Propensity score matching

Impact estimation literature has devised several methodological approaches that are suitable for various circumstances. The typically ideal approach is randomised control trials, in which subjects are randomly assigned to treatment and control groups. Random assignment minimises bias and confounding factors, enabling the effect of treatment to be estimated by comparing outcomes directly between treatment and control groups (Austin, 2011). Considering the high cost and the impracticality of randomised control trials in some circumstances, quasi-experimental and non-experimental methods are also used. Quasi-experimental methods include, for example, propensity score matching, regression discontinuity design, and difference-in-difference. But the regression discontinuity design and difference-in-difference methods require data collection at two points in time. Given the demands

and challenges of using randomised control trials and other quasi-experimental methods, we applied propensity score matching. This involves using statistical techniques to construct control groups by matching each treated unit with a non-treated unit or units of similar characteristics. In propensity score matching, an individual is not matched on every single observable characteristic but on their propensity score – the likelihood that the individual will participate in the intervention given their observable characteristics (Rosebaum & Rubin, 1983; Heinrich et al., 2010). Thus, propensity score matching ensures that the average characteristics of the treatment and control groups are similar, which is sufficient to get an unbiased impact estimate (White & Sabarwal, 2014). The creation of comparable groups aims to address the challenge of non-random assignment of subjects to treatment and control groups, which leads to bias due to confounding factors.

The specific propensity score matching method we used is nearest neighbour matching. This matching approach also served as a robustness test for checking the sample balance to ensure the treatment and control groups have comparable characteristics.

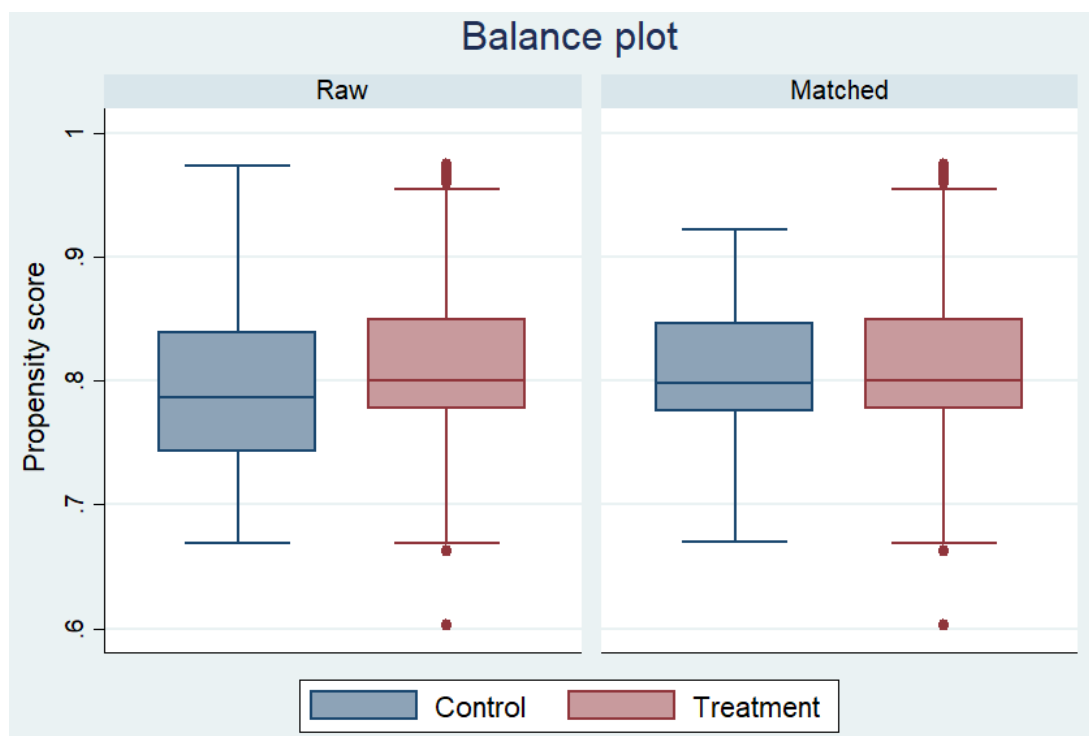
To estimate the average treatment effect on the treated, let Y_{1i} denote the potential outcome of retailer i if they were to use ShopTopUp, and Y_{0i} the potential outcome if retailer i chose not to use ShopTopUp. The use of ShopTopUp is denoted by the dummy variable D_i . For each retailer, we observe $Y_i = Y_{0i} + D_i(Y_{1i} - Y_{0i})$; that is, we observe Y_{1i} for ShopTopUp users and Y_{0i} for non-users. The average treatment effect on the treated can be written as $E[Y_{1i} - Y_{0i} | D_i = 1]$ and then rewritten as follows:

$$E[Y_{1i} - Y_{0i} | D_i = 1] = E[Y_{1i} | D_i = 1] - E[Y_{0i} | D_i = 1] \quad (2)$$

where the first term measures the outcome of retailers using ShopTopUp and the second term measures the outcome of retailers not using ShopTopUp.

A logistic model was used to predict each retailer's propensity score, using the following covariates: business age (*BusAge*), education level of the owner (*Educ*), sex of the owner (*Sex*) and the owner's age category (*OwnerAge*). One-to-one matching to the nearest neighbour was used. This involved matching a retailer in the treatment group to the nearest neighbour in the control group. Checking the balance of the covariates is vital before interpreting the results (Rubin, 2008). We tested the balance of the covariates using the covariance balance box proposed by Austin (2009), which compares the propensity scores for the two groups before and after matching. Figure 9 shows that the treated and untreated (control) samples are largely well-balanced as the box plots for the matched sample are similar.

Figure 9: Covariate balance test results



4.3. Results

4.3.1. Business operations

The vast majority of retailers in the treatment group reported positive changes since using ShopTopUp, especially in terms of the diversity of products sold, volume of orders placed (purchases) and volume of sales. Table 2 summarises the experience of ShopTopUp users since they began stocking their store using the platform.

Table 2: Business changes since using ShopTopUp

Criterion	Increased	Decreased	No Change
Diversity/range of products	84.5%	11.5%	4.0%
Volume of purchases	83.8%	11.9%	4.3%
Volume of sales	89.6%	6.6%	3.8%
Supply price of products	64.5%	20.4%	15.0%
Sales price of products	66.3%	14.4%	19.2%
Shop trading hours	13.8%	10.7%	75.5%
Store size	49.1%	2.8%	48.2%

4.3.2. Product stock-outs

The results presented in Table 3 suggest that ShopTopUp has not reduced the frequency of product stock-outs. In fact, a higher proportion of stores in the control group (35.7%) relative to the treatment group (31.5%) reported that they never experienced stock-outs. The high degree of stock-outs, with 64.3% of stores in the control group and 68.5% in the treatment group experiencing stock-outs of

varying durations, is partly due to a combination of inefficient distribution and a lack of working capital among small retailers.

Table 3: Frequency of product stock-outs

How often stores experienced stock-outs	Control (N=115)	Treatment (N=349)
Never	35.7%	31.5%
Daily	22.6%	24.9%
Weekly	23.5%	26.9%
Monthly	7.8%	8.3%
Other	10.4%	8.3%

However, as Table 4 shows, the average stock-out duration was longer in the control group (3.4 days) than in the treatment group (1.7 days). This suggests that using the digital platform affects retailers' ability to quickly restock. ShopTopUp users can place orders on the platform online or over the phone and have deliveries made over a shorter time period. Non-users rely on making several trips to the wholesalers to procure goods and calling multiple suppliers for delivery of products to restock their shops, which increases the duration of stock-outs. The regression results reported in Table 5 indicate that using ShopTopUp reduced the duration of stock-outs. This finding is confirmed by the matching approach results shown in Table 6.

Table 4: Average duration of product stock-outs

	Control (N=106)	Treatment (N=330)	p-value
How long does the average stock-out last? (in days)	3.4	1.7	0.00

Table 5: Ordinary least squares regression results: Impact of ShopTopUp use on product stock-out duration

Independent variable	Dependent variable: Stock-out duration
<i>Status</i>	-1.661*** (0.455)
<i>BusAge</i>	-0.00122 (0.0223)
<i>Educ</i>	0.145 (0.402)
<i>Sex</i>	-0.281 (0.490)
<i>OwnerAge</i>	0.225 (0.551)
Constant	3.369*** (0.503)

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

Table 6: Nearest neighbour matching results: Impact of ShopTopUp use on product stock-out duration

	Duration of stock-outs
Average treatment effect on the treated (treated vs. untreated)	-1.040** (0.466)

4.3.3. Consumer product prices

Table 7 shows that retailers in the control and treatment groups sold their products at relatively similar prices, with the largest price difference being for Three Crown Evaporated Milk (10.1% higher in the treatment group). Although the selling prices of retailers in the treatment group were lower for three of the five top-selling products, the differences were not statistically significant. The treatment group's slightly lower selling prices may be attributed to efficiency gains through lower delivery costs.

Table 7: Average sales prices of the five top-selling food products

Product	Unit	Selling price (NGN)		Mean comparison (p-value)
		Control	Treatment	
Milo	20 g sachet	44.0	42.9	0.12
Golden Penny Spaghetti	500 g sachet	222	216	0.03
Three Crown Evaporated Milk	170 g	174.7	192.4	0.20
Nasco Cornflakes	35 g sachet	152.9	153.1	0.90
Peak Milk Powder	16 g sachet	46.9	46.3	0.22

The regression analysis results in Table 8 indicate that using ShopTopUp significantly reduced the selling price of Golden Penny Spaghetti and Peak Milk. While using ShopTopUp was also associated with a reduction in the sales prices of Milo and Nasco Cornflakes, these results were not statistically significant.

Table 8: Ordinary least squares regression results: Impact of ShopTopUp use on product sales prices

Independent variable	Dependent variable: Product sale prices				
	Milo	Golden Penny Spaghetti	Three Crown Evaporated Milk	Nasco Cornflakes	Peak Milk
<i>Status</i>	-1.145 (0.711)	-6.186** (3.075)	1.627 (2.285)	-2.651 (5.395)	-0.837* (0.472)
<i>BusAge</i>	0.0434 (0.0332)	0.0450 (0.137)	-0.0564 (0.0905)	0.326 (0.237)	-0.0265 (0.0212)
<i>Educ</i>	0.0466 (0.602)	4.461* (2.471)	-1.632 (1.550)	8.527** (4.144)	-0.0948 (0.385)
<i>Sex</i>	3.370*** (0.767)	7.165** (3.066)	-0.483 (1.909)	11.28** (5.131)	0.609 (0.469)
<i>OwnerAge</i>	0.273 (0.755)	0.981 (3.021)	2.106 (1.821)	-3.933 (5.272)	0.766 (0.474)
Constant	42.91*** (0.777)	219.3*** (3.274)	153.9*** (2.460)	44.06*** (6.040)	47.28*** (0.521)

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

The average treatment effect on the treated results reported in Table 9 confirm the findings from the regression analysis that using ShopTopUp was significantly associated with reduced selling prices for Golden Penny Spaghetti and Peak Milk.

Table 9: Nearest neighbour matching results: Impact of ShopTopUp use on product sales prices

	Average treatment effect on the treated				
	Milo	Golden Penny Spaghetti	Three Crown Evaporated Milk	Nasco Cornflakes	Peak Milk
Treated vs. Untreated	-1.209 (1.240)	-7.404* (4.156)	1.351 (3.563)	-1.239 (3.603)	-1.119* (0.628)

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

4.3.4. Product supply prices

Analysis of the supply prices of the five most frequently traded food products reveals that retailers in the treatment and control groups pay relatively similar prices. Table 10 compares the respective average supply prices for retailers in the control and treatment groups.

Table 10: Average supply prices of the five most frequently trade food products

Product	Unit	Purchase price (NGN)		Mean comparison
		Control	Treatment	p-value
Milo	240 x 20 g	9 069.2	9 074.8	0.81
Golden Penny Spaghetti	20 x 500 g	4 079.4	4 033.6	0.15
Three Crown Evaporated Milk	24 x 170 g	6 704.7	6 738.1	0.75
Nasco Cornflakes Sachet	36 x 35 g	1 607.1	1 545.6	0.32
Peak Milk Powder Sachet	210 x 16 g	9 015.3	8 903.2	0.03

The regression analysis results in Table 11 show that, contrary to our expectation, using ShopTopUp led to an increase in the supply price of Three Crown Evaporated Milk. Although using ShopTopUp was negatively associated with the supply prices of the other four products, the results were not statistically significant.

Table 11: Ordinary least squares regression results: Impact of ShopTopUp use on product supply prices

Independent variable	Dependent variable: Product supply prices				
	Milo	Golden Penny Spaghetti	Three Crown Evaporated Milk	Nasco Cornflakes	Peak Milk
<i>Status</i>	-0.0165	-3.162	3.800***	-0.298	-0.397
	(0.0671)	(2.775)	(1.129)	(0.438)	(0.291)
<i>BusAge</i>	0.00454	-0.0493	-0.0674	0.0142	-0.00221
	(0.00290)	(0.112)	(0.0450)	(0.0193)	(0.0134)
<i>Educ</i>	-0.00327	-0.779	0.440	0.284	0.175
	(0.0534)	(2.083)	(0.774)	(0.333)	(0.241)
<i>Sex</i>	0.0473	1.198	0.537	0.0313	-0.0290
	(0.0688)	(2.684)	(0.926)	(0.421)	(0.289)
<i>OwnerAge</i>	0.0725	2.111	-0.531	0.395	-0.338
	(0.0655)	(2.570)	(0.904)	(0.445)	(0.308)
Constant	37.72***	204.5***	136.9***	42.72***	42.82***
	(0.0740)	(2.966)	(1.220)	(0.499)	(0.327)

The average treatment effect on the treated results presented in Table 12 are similar to the findings from the regression analysis. Specifically, the impact of using ShopTopUp on four product supply prices was negative but only significantly for Peak Milk. The impact on the supply price of Three Crown Evaporated Milk was again positive but, unlike in the regression analysis, is not statistically significant.

Table 12: Nearest neighbour matching results: Impact of ShopTopUp use on product supply prices

	Average treatment effect on the treated				
	Milo	Golden Penny Spaghetti	Three Crown Evaporated Milk	Nasco Cornflakes	Peak Milk
Treated vs. Untreated	-0.0809 (0.123)	-1.957 (1.570)	2.323 (1.596)	-0.333 (0.296)	-0.405* (0.209)

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

4.3.5. Value of sales

Table 13 shows that the average monthly value of sales made by retailers was higher among users of ShopTopUp than among non-users of the platform.

Table 13: Average monthly value of sales

Sales value (NGN)	Control (%) (N=91)	Treatment (%) (N=133)
0–100 000	28.6	9.0
100 001–500 000	42.9	33.8
500 001–1 000 000	20.9	25.6
1 000 001–5 000 000	6.6	25.6
Over 5 000 001	1.1	6.0

We also analysed the impact of using ShopTopUp on the gross profit margin for selected commodities using a regression analysis. Profit margin was measured as the difference between the selling and buying prices. Using ShopTopUp did not statistically impact on the gross profit margin of Milo, Three Crown Evaporated Milk, Peak Milk or Nasco Cornflakes, but the gross product margin of Golden Penny Spaghetti was lowered. The regression results are shown in Table 14.

Table 14: Ordinary least squares regression results: Impact of ShopTopUp use on product gross profit margin

Independent variable	Dependent variable: Product gross profit margin				
	Milo	Golden Penny Spaghetti	Three Crown Evaporated Milk	Peak Milk	Nasco Cornflakes
Status	-0.782	-2.502**	-1.517	-1.137	-1.516
	(1.487)	(1.234)	(1.396)	(1.097)	(1.396)
BusAge	0.0808	0.0650	0.0427	-0.0951*	0.426
	(0.0653)	(0.0495)	(0.0557)	(0.0492)	(0.055)
Educ	-0.168	0.486	-0.724	-0.903	-0.724
	(1.182)	(0.922)	(0.960)	(0.914)	(0.959)
Sex	7.461***	2.601**	-0.755	1.341	0.754
	(1.526)	(1.178)	(1.167)	(1.078)	(1.166)
OwnerAge	0.0416	-0.548	1.497	1.501	1.496
	(1.445)	(1.140)	(1.122)	(1.132)	1.122
Constant	8.745***	6.807***	10.32***	9.727***	10.32
	(1.651)	(1.306)	(1.505)	(1.226)	(1.505)
R ²	0.32	0.33	0.39	0.08	0.01
Number of observations	360	458	824	184	222

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

The average treatment effect on the treated results did not indicate any statistically significant effects of using ShopTopUp on gross profit margin for the five focal products.

Table 15: Nearest neighbour matching results: Impact of ShopTopUp use on product gross profit margin

	Average treatment effect on the treated				
	Milo	Golden Penny Spaghetti	Three Crown Evaporated Milk	Nasco Cornflakes	Peak Milk
Treated vs. Untreated	-1.938	-2.382	-0.453	-0.453	0.324
	(1.635)	(1.492)	(2.226)	(2.226)	(1.210)

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

4.3.6. Employment

Table 16 reveals extensive reliance on non-remunerated staff to operate retail stores: 54.9% of stores in the treatment group had non-remunerated staff, such as family members, compared to 45.9% in the control group. However, the percentage of stores with full-time employees was higher in the treatment group than in the control group (38% vs. 27.1%). This suggests that ShopTopUp supports existing jobs, and perhaps job creation, within the retail sector.

Table 16: Percentage of retailers with at least one staff member in each of three employment categories

Staff type	Control (N=85)	Treatment (N=71)
Full-time employees	27.1%	38.0%
Part-time employees	4.5%	2.8%
Non-remunerated staff	45.9%	54.9%

4.3.7. Pricing mechanism

As Table 17 reports, 89.7% of stores in the control group and 87.2% in the treatment group applied cost plus markup pricing to determine sales prices charged to customers. Most of the remaining stores referred to prices charged by other retailers; only a very few stores referred to their own past prices.

Table 17: Pricing mechanism applied by retail stores

Pricing mechanism	Control (N=116)	Treatment (N=345)
Cost plus markup	89.7%	87.2%
Reference to other traders	9.5%	11.6%
Reference to own past prices	0.9%	1.2%

We also assessed the impact of using ShopTopUp on small retailers' access to loans. The percentage of retailers reporting that they had accessed loans in the past 12 months was slightly higher in the treatment group (N=347) than in the control group (N=117), at 19.7% vs. 16.7%.

5. Discussion of findings

Using ShopTopUp has a statistically significant impact on supply chain performance as measured by the duration of stock-outs. This positive effect is in line with our expectation and prior literature. The stock-out duration of ShopTopUp users was 1.7 days shorter than that of non-users. This result is similar to a finding by Hsin and Papazafeiropoulou (2008): in their study, small-scale enterprises that used e-purchasing experienced an improvement of 68.49% in response time for purchasing orders, which shortened on average from 4.38 days to 1.38 days. ShopTopUp provides an efficient way of moving products from manufacturers directly to traders, eliminating the inefficiencies and costs of going through the wholesale system. These efficiency gains minimise retailers' stock-out periods, thus reducing the associated loss of revenue. These gains are expected to improve business profitability.

By contrast, the results showed that using ShopTopUp had no statistically significant impact on the gross profit margin of four of the five top-selling products. Moreover, the statistically significant impact on the other product was negative (i.e. the profit margin was smaller for ShopTopUp users than for non-users). These findings are contrary to prior expectations and the results of previous studies on the impact of information and communications technology (ICT) on the profitability of small-scale businesses in Nigeria. The literature shows that using ICT improves small-scale business profitability within Nigeria (Adewoye & Akanbi, 2012; Rufai, 2014; Afolayan, 2015) and elsewhere. For example, Esselaar et al. (2008) reported a positive impact of ICT use on small-scale enterprise profitability in 13 African countries. ShopTopUp, as a form of ICT innovation used by small-scale retail businesses, was therefore expected to improve business profitability.

The contrary results may be explained by our use of product-specific profit margin, rather than the enterprise's overall profitability as measured by return on capital employed or return on equity, among other holistic variables. ShopTopUp users may experience increased net profit through reduced overhead costs related to improved stock-procurement logistics, and reduced revenue losses as stock-outs become shorter and less frequent. In the descriptive analysis, 83.6% of ShopTopUp users reported an increased volume of sales since they started using the platform, while 31.6% of users

recorded sales of over NGN 1 million, compared to only 6% of non-users. In combination, these factors point to increased levels of profitability of users of the ShopTopUp platform. Similarly, Nyangarika and Ngassa (2020) found that the use of ICT by small-scale businesses in Tanzania increased their volume of sales and, subsequently, their profitability.

Focusing on the drivers of gross profit margin, namely the supply and selling prices of products, this study showed that using ShopTopUp led to a decline in the selling price of certain products. However, the impact on supply prices was largely not statistically significant except for two products with mixed results. The ability of ShopTopUp users to sell at lower prices, despite facing similar supply processes to non-users, can be attributed to supply chain cost savings. The reduction of supply chain-related costs is the most important positive impact of ICT adoption for small-scale enterprises (Kmarc, 2005; Rufai, 2014).

6. Conclusion

This study examined the impact of using the ShopTopUp digital retail distribution platform on small-scale retailer performance in Nigeria. It used a quasi-experimental method involving a telephone survey of users and non-users of ShopTopUp. The study also sought to understand the age and sex characteristics of small-scale retail business owners. Business performance was mainly measured by profit margin, ability to pass on lower prices to consumers, duration of stock-outs and the value of sales. Effects were estimated using regression analysis and a matching approach. Descriptive analysis showed that the owners of small-scale retail businesses were mostly women of middle age. Using ShopTopUp was associated with a higher value of sales and lower selling prices. The results of the impact estimation were mixed. Against expectations, using ShopTopUp had no impact on profit margin. However, ShopTopUp users experienced a statistically significant reduction in the duration of stock-outs, in line with prior expectations and prior literature.

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Annex A: ShopTopUp survey tool

B	Respondent identification number	
C	Date of interview	dd-mm-yyyy
D	Survey start time	hr:min
E	Research assistant's name	
F	State	
G	Street name	
H	GPS location	
I	Store name	

Introduction

Hello, can I speak to [customer name]? My name is [interviewer name] and I am calling from a company called 60 Decibels. I am conducting research on behalf of ShopTopUp Nigeria. We are speaking with customers of ShopTopUp (like yourself) to better understand how customers are utilising the platform and its overall impact, specifically in terms of supporting shop owners and reducing costs. This interview is voluntary and will not affect the service you receive from ShopTopUp but if you have the time we value your feedback so ShopTopUp can identify opportunities for improving.

Firstly, could I speak with the owner of this business? (If absent) Could I speak with an employee who knows the business well?

Respondent's role:	Owner	Employee
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(Repeat introduction)

Do you have 25 minutes to talk to me?	Yes	No Could I call back at another time that is more convenient for you?
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Great, before we start, I will just read out how the information you give us in this conversation will be shared and used.

- The information you share will only be seen by my team and the researchers working on this project concerning ShopTopUp.
- We will ask you at the end of the interview, once you know what you have shared with us, whether you would prefer to be kept anonymous or if you would be happy for us to share your name with ShopTopUp. No problem if you would like to be anonymous, but note that ShopTopUp will not be able to respond directly to any complaints or problems you may share.
- We sent you an SMS on [day] to provide you with the name, address and phone number of 60 Decibels and ShopTopUp. If you would like me to read any of this out to you, just ask. You can call the number in your SMS if you would like to access or correct any of your personal information.
- Thanks so much for being patient – I know that was a lot of information, but we would love to get onto the fun part of the conversation.

Thank you. Firstly, I just wanted to ask a couple of questions about [yourself/owner of the business].					
1.	(If speaking with employee, ask this question): What is the sex of the owner of the retail business?	Male	Female	Other	Rather not say
2.	If speaking with owner: Would you mind sharing your age with us? If speaking with employee: Would you mind sharing the owner's age with us? (If necessary, estimate the age)	18–25 years	26–35 years	36–50 years	>50 years
3.	If speaking with owner: What is your highest level of education?	None (Never enrolled/completed primary school)	Completed primary school	Completed secondary education	
	If speaking with employee: What is the owner's highest level of education?	University/training beyond high school	Vocational education	Other:	
4.	If speaking with owner: How many years have you been running this retail business? If speaking with employee: How many years has the owner been running this retail business?				
5.	If speaking with owner: Do you own other retail shops or other business activities? If speaking with employee: Does the owner own other	Yes		No (Go to Q14)	

	retail shops or other business activities?		
Now I am going to ask you specific questions about your usage of the ShopTopUp app.			
6.	Do you use the ShopTopUp app to order goods?	Yes	No (Go to Q11)
7.	How long have you been using the ShopTopUp app? (in months)		
8.	When was the last time you used the ShopTopUp app to order goods? (days ago)		
9.	On a scale of 0–10, how likely is it that you would recommend the ShopTopUp app to a friend, where 0 is not at all likely and 10 is extremely likely?	0	1 2 3 4 5 6 7 8 9 10
10.	<p>[If 0–6:] What actions could ShopTopUp take to make you more likely to recommend it to a friend or family member?</p> <p>[If 7–8:] What specifically about ShopTopUp caused you to give it the score that you did?</p> <p>[If 9–10:] What specifically about ShopTopUp would cause you to recommend it to a friend or family member?</p>	“ ”	
11.	How would you rate the cost of ShopTopUp products compared to alternative suppliers?	Very inexpensive	Inexpensive Similar Expensive Very expensive
12.	Since the owner started trading products via ShopTopUp, to what extent have the following		Increased No change Decreased
		Diversity/range of products	

	changed? (Tick all that apply)	Volume of purchases					
		Volume of sales					
		Supply price of products					
		Sales price of products					
		Shop trading hours					
		Store size					
13.	To what extent did these changes happen due to ShopTopUp?	ShopTopUp was the only reason	To a large extent	To some extent	Not at all due to ShopTopUp		
Now I am going to ask you some questions regarding specific ShopTopUp products.							
14–18.	I will first mention the product and then would like you to answer specific questions regarding that particular product.	Product	Purchase unit	Do you trade this good? (Y/N)	Current purchase price of good (NGN)	Current sales unit (e.g. kg, litre)	Current sales price (NGN)
		Milo Sachet	240 x 20 g				
		Golden Penny Spaghetti	500 g				
		Three Crown Evaporated Milk	24 x 170 g				
		Nasco Cornflakes Sachet	36 x 35 g				
		Peak Milk Powder Sachet	16 g				
Now I would like to learn more about your stock-outs, loans and other retail enterprise information.							
19.	How often do you experience stock-outs?	Never	Daily	Monthly	Quarterly	Less frequently than quarterly	
20.	If you use ShopTopUp, how often did you experience stock-outs before using the ShopTopUp platform?	Never	Daily	Monthly	Quarterly	Less frequently than quarterly	
21.	How long does the average stock-out last? (in days)						

22.	What is the average value of your sales per month? (NGN)	0–100 000	100 001–500 000	500 001–1 000 000	1 000 001–5 000 000	> 5 000 001
23.	How many employees do you have for this retail outlet?	Full-time		Part-time		Non-remunerated
24.	Since using ShopTopUp, has the remuneration you pay your workers in naira:	Increased		Not changed		Decreased
25.	To what extent did these changes in remuneration happen due to ShopTopUp?	ShopTopUp was the only reason	To a large extent	To some extent	Not at all due to ShopTopUp	
26.	Did you get any loans in the past 12 months?	Yes			No	
Now I am going to ask you some final questions regarding your business.						
27.	How many retail stores in this area do you think directly compete with your business?					
28.	How do you set the sales price of products?	Cost plus	Government instructions	Reference to past prices	Reference to other traders	Other:
29.	Great, that's it! At the beginning of the call I said we would keep your name and details private. Now that you know what you have shared with me today, are you happy for me to share your name and this information with ShopTopUp, or would you prefer to remain anonymous?	Yes	<p style="text-align: center;">No</p> <p style="text-align: center;">No problem. We confirm we will keep your identifying details anonymous, but please note that [ShopTopUp] will not be able to respond directly to you on any complaints or problems. We will share this information from all respondents more broadly though.</p> <p style="text-align: center;">[End interview]</p>			

30.	Could we use some of your answers and your name in marketing materials?	Yes, you may use them	No, please do not use them
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End interview:

Thank you very much for your time. We will use this information to inform ShopTopUp how they can improve their service to you and future customers. Have a great day!

L	Sex of respondent	Male	Female
M	Survey end time	hr:min	
N	Language used for interview		

The impact of Rensource solar energy on merchant subscribers in selected Nigerian markets

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Abstract

This study examines the impact of Rensource solar energy on subscribers in selected markets in the Nigerian states of Lagos, Kano and Ondo. It also explores the drivers of merchants' decision to subscribe to Rensource solar energy. Data were collected during July and August 2020 from 300 subscribers and 400 non-subscribers. A probit regression model was used to determine what drives merchants to subscribe to Rensource solar energy. We then calculated the average treatment effect and average treatment effect on the treated using propensity score matching to reveal how using Rensource solar energy affects merchants' monthly earnings, sales volumes and profits. The results reveal a positive impact on all three outcomes. In addition, by subscribing to Rensource solar energy, merchants using the national grid and standby generators can reduce their average monthly electricity expenditure by 36.64%. The decision to subscribe hinges on a complex set of factors including the merchant's personal, business and product characteristics, as well as the supplier's characteristics and features of the electricity supply. By taking into account the identified merchant, business and product characteristics, the future business strategies, models and communications can be designed to substantially increase subscriptions to Rensource solar energy by merchants and individuals. The study's findings support the need to raise broader awareness of how Rensource solar energy benefits the private sector in Nigeria.

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Summary

In Nigeria the lack of a reliable, affordable power supply is a major problem facing micro, small and medium-sized enterprises (MSMEs), resulting in reliance on diesel generators. Using generators is costly and also harmful to health and the environment through noise and air pollution. The irregular supply of electricity has been cited as one reason for (i) high production costs, (ii) loss of investors from the domestic economy, (iii) escalating unemployment as companies exit, and (iv) increasing reliance on alternative power sources such as generators, as well as various associated problems in the domestic economy. To address the deficiency in electricity supply, a number of policies and actions have been undertaken by the government and its partners. There has been a shift from predominantly central electricity generation towards embedded generation, defined as power production technology integrated within distribution systems close to the point of use. Moreover, as Nigeria boasts an abundant supply of solar energy, solar technologies can be used to drive electrification.

One of the relatively new private operators in the energy sector is Rensource. Founded in 2015, Rensource's mission is to make Nigeria the world's first country to rely predominantly on distributed renewables-based power generation. Currently, though, there is limited empirical evidence on how Rensource customers benefit from its services. Addressing this gap can reveal the features of Rensource's clients and further help the firm uncover gaps in its customer outreach strategies. This study addresses three research questions:

- i) What is the profile of Rensource's customer base?
- ii) What drives merchants to subscribe to Rensource solar energy?
- iii) How do Rensource customers benefit from its services?

A total of 300 Rensource subscribers (treatment group) and 400 non-subscribers (control group) were sampled from Sabon Gari (Kano), Iponri (Lagos), and Isikan, Nepa 1 and Nepa 2 (Ondo).

Most of the merchants surveyed have at least secondary school education. Over 80% of both subscribers and non-subscribers operate in rented shops and run their businesses as sole proprietorships. Business owners' average age is 44, while the average age of businesses is 13 years for Rensource users and 12 years for non-users. A significant proportion of subscribers' and non-subscribers' household income emanates from trading. Overall, supply reliability is ranked as the most important characteristic influencing the choice of a given source of electricity.

In terms of fuel cost, Rensource subscribers who were only using generators prior to subscription saved an average of NGN 5 744 per month, while subscribers who were previously using national grid electricity and standby generators saved an average of NGN 8 896 per month. Controlling for merchant and business characteristics such as gender, state and type of product sold, empirical findings from propensity score matching suggest that subscription to Rensource solar energy has a positive impact on monthly earnings. Comparing sales volumes and profits before and after subscription to Rensource revealed increases in both outcomes for subscribing merchants. These impacts occurred through lighting of shops to enhance product visibility and attract customers, creating a more comfortable and friendly environment for customers, testing of electrical appliances to ensure trust and customer confidence in products, facilitating more working hours and days, and refrigerating perishable goods to avoid spoilage and loss.

This research further reveals strategies that Rensource can use to increase the number of subscriptions to its solar energy services. For instance, Rensource can target more merchants through merchant/market associations, and adopt a product-specific strategy targeting merchants that sell products with a high need for reliable electricity (e.g. those trading food products, running beauty salons or selling cosmetics). Other factors affecting subscription to Rensource solar energy include access to credit and experience of a fire outbreak. Furthermore, the reliability of an energy source is an important driver of merchants' subscription decision. Considering the benefits of subscription to Rensource solar energy, it seems important to raise broader awareness of these benefits among private sector merchants, thereby encouraging more to subscribe.

List of acronyms

ATE	Average treatment effect
ATT	Average treatment effect on the treated
GDN	Global Development Network
MSME	Micro, small and medium-sized enterprise
NGN	Nigerian naira
PSM	Propensity score matching
PHCN	Power Holding Company of Nigeria
REA	Rural Electrification Agency

1. Introduction

Electricity is Nigeria's most used energy source (Oyedepo 2012). The country's electricity system has long been centred on the Power Holding Company of Nigeria (PHCN), which accounts for about 98% of total electricity generation. PHCN mainly relies on hydropower and thermal power stations. Thermal/fossil energy is the main source of electricity, accounting for about 86% of Nigeria's energy, while the remainder is generated from hydropower sources (Sambo et al., 2010; Oyewo et al., 2018). Aside from PHCN, power is also generated by other agencies, such as the Nigerian Electricity Supply Company, which uses thermal power stations.

Centralised power generation has not been able to meet the demand in Nigeria. As Aremu (2019) reports, the country suffers large power deficits and, thus, frequent power outages because of rationing and higher power costs. Aremu (2019) also notes that irregular electricity supply has led to high production costs, investors suffering losses in the domestic economy, escalating unemployment as companies exit due to power costs, increasing customer discontentment with the electricity distributor, as well as noise and air pollution from generator use. According to the cited estimate of Akuru and Okoro (2014a, 2014b), the average power backup to minimise the cost of expected power outages is usually three times the cost of publicly supplied electricity. They further add that persistent power outages coupled with expensive power backups have resulted in some businesses closing in Nigeria. Some users run generators to meet their power needs (Ferrero, 2018), but this often results in noise pollution and the required fuel is expensive (Akin & Adejumobi, 2017).

The country's power supply problem can be solved through a mix of energy source alternatives.

Afa and Anireh (2013) suggest that Nigeria has the resources to follow the global trend of focusing on a cleaner, more diverse and sustainable mix of electricity sources.

Solar energy stands out because solar photovoltaic technology supplies electricity without pollution and requires less maintenance as nothing is consumed or worn out during its operation (Yohanna & Umogbai, 2010). Additionally, off-grid solutions have emerged as a cheaper alternative for electricity provision in urban, semi-urban and rural areas (Nigeria Electricity Hub, 2019). These solutions offer a lucrative opportunity to rapidly increase electrification in rural areas, where about 55% of the population still lacks electricity access (Nigeria Electricity Hub, 2019). The potential of off-grid solutions is also very clear in urban areas, where some households and businesses are still awaiting access to reliable electricity. The Federal Government's Rural Electrification Agency (REA) has adopted solar mini-grids as the primary rural electrification resource to provide clean, affordable electricity to underserved and unserved households and businesses (Nigeria Electricity Hub, 2019). The REA is partnering with private sector off-grid energy developers to implement electrification projects across Nigeria; one of these developers is Rensource.

These alternatives pose their own sets of challenges. For example, the initial costs of solar installations are sometimes prohibitively high (Oghogho, 2014). Having initially relied on centrally generated electricity, the energy sector has recently shifted towards embedded generation, defined by Oladipo et al. (2018) as any electric power production technology that is integrated within distribution systems close to the point of use. They further add that embedded generation reduces the cost of the on-grid electric power supply.

Rensource's mission is to make Nigeria the world's first country to rely predominantly on distributed renewables-based power generation. Founded in 2015, Rensource has over 100 employees and about 1 500 customers, to which it provides power-as-a-service with open-ended payment plans. The company has subscription-based power-as-a-service models¹ using solar hybrid systems installed at the user's premises but maintained and serviced by the company. Rensource started with a household-powering model, but since 2018 has moved on to a model targeting MSMEs by supplying solar energy to markets. Nonetheless, the company still provides routine maintenance and services to existing household clients. The rollout to new markets under the current business model is prescribed by the REA. These new markets either have no access to electricity or rely on petrol/diesel generators.

While some merchants adopt solar energy as soon as it becomes available, others in the same markets take up the service after seeing how it works. Personal, socioeconomic, institutional and product characteristics influence merchants' decision to subscribe to solar energy. Rensource seeks to understand what drives merchants to subscribe to its solar power and how they benefit from doing so: such insights can be channelled into better managing the rollout. In some instances, Rensource extends its services to other parts of the same market. However, there is little empirical evidence on the drivers of why and when merchants decide to subscribe. With Rensource's power provision plan, merchants are expected to benefit from reliable and cheaper solar energy in several ways. However, there is no documented evidence on how Rensource customers benefit from its solar energy. Therefore, this study aims to answer the following research questions:

1. What is the profile of Rensource's customer base?
2. What drives merchants to subscribe to Rensource solar energy?
3. How do Rensource customers benefit from its services?

Addressing these gaps can elucidate some features of Rensource's customers, in turn helping the firm improve its products and customer outreach strategies. This research generates evidence on the benefits attained by merchants who have subscribed to Rensource solar energy. Insights from the study have policy implications and will help Rensource to continue improving to meet subscribers' needs. The findings should enable better-informed decision-making and greater sustainability of Rensource solar energy. Finally, this research contributes to the body of scientific evidence on how solar mini-grids can affect MSME performance.

2. Literature review

This section reviews relevant literature on the factors that hinder or enhance the usage of solar energy and its impact on individuals and MSMEs.

2.1. Factors that influence subscription to solar energy

Literature on the use of solar energy in Africa is dominated by studies on domestic uses, although a few brief mentions highlight small-scale commercial uses, such as in street lighting and at community centres (Ondraczek, 2013; Karakaya & Sriwannawit, 2015). Karytsas et al. (2019) highlight commercial use of solar power as an area that needs further attention in the research literature. Therefore, the literature reviewed here focuses mainly on the household adoption of solar energy. Nonetheless, the domestic uses of solar highlighted in these studies, such as in lighting and running small appliances

¹ The company provides both B2C and B2B services, and its models are solar- and battery-based.

(Khandker et al., 2014), are often similar to the uses by MSMEs, especially in areas yet to be connected to the national grid.

In exploring the adoption of solar energy, we note that the decision to subscribe is taken at the micro level by MSME owners based on several factors. One factor is membership of market associations. Grossman (2020) notes that private groups can provide institutions that support contractual trade. Group membership also connects actors to networks, and De Janvry et al. (2017) observe that networks transmit information and affect respondents' willingness to pay. Social learning facilitates the spread of information and the updating of beliefs (Carattini et al., 2018). Reed et al. (2010) define social learning as a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions within networks. Hogset (2005) maintains that social networks may interact with technology adoption decisions through (i) a social learning environment, (ii) informal finance, which may relax the actor's credit or risk tolerance constraints, and (iii) facilitation of collective action where technological externalities necessitate coordinated adoption. Miguel and Kremer (2003) nonetheless caution that individual adoption behaviour may reflect group priorities.

Gender may also affect the adoption of renewable energy, and gender-related challenges may impede the adoption of solar power. For example, Energia (2011) notes that in off-grid areas, female-headed households are poorer than male-headed households and have less access to electricity. Danielsen (2012) also observes that women generally face difficulties in benefiting from energy services. For example, they lack income, which limits investment in technology to improve productivity; they lack access to credit, which limits their ability to pay the upfront costs of improved energy technology or the fees for connecting to the electricity grid; and they have limited access to education. Such limitations suggest the likelihood of a gendered difference in solar technology adoption, even among merchants. Despite these limitations, Devine-Wright et al. (2007) indicate that women are more willing to pay for renewable energy technologies than men. Moreover, Winther et al. (2018) argue that because men tend to own their houses, have a higher income and make major decisions, women have little agency in systems with fixed connections and high subscription fees, whereas decentralised systems of supply, such as solar power systems, can ease these gendered restrictions.

Both higher education and income level are correlated with the adoption of solar power systems (Barau et al., 2020; Qureshi et al., 2017). Guta (2018) analysed what factors drive a household's decision on adopting solar energy technology in Ethiopia, finding that adoption is more likely in wealthy than in poorer households. Khandker et al. (2010) also demonstrate that high-income households tend to use clean, renewable and convenient energy sources, such as solar and electricity. Wealthier households are better equipped to meet the high initial cost of solar power equipment. Indeed, Qureshi et al. (2017) suggest that higher income is directly related to adoption as it may help in overcoming the cost barrier.

Education's influence on the likelihood of adoption probably comes via the positive effect on income (Lay et al., 2013). This argument is supported by Rahut et al. (2018), who argue that a high level of education is associated with higher household earning capacity, which generates sufficient income to invest in solar energy equipment. Additionally, skills and knowledge gained from environmental education help change human behaviour towards the environment (Desa et al., 2012), while skills

development particularly supports the uptake of innovative technologies. Amankwah-Amoah (2015) suggests the need for research and development, education and training to develop the skills of local people to support economic growth and foster innovation across Africa.

The availability of solar equipment is also a key determinant of adoption; where equipment is not readily available, adoption is likely to be low. Akinboro et al. (2012) note that solar equipment is not manufactured in Nigeria and so must be imported. Gulaliyev et al. (2020) argue that it is very expensive to install solar power systems in this situation.

The number of nearby installations affects social inclinations to install solar power (Mezic, 2018). Bollinger and Gillingham (2012) note that social interaction (peer) effects are a potentially important factor in the diffusion of new products. They report that an additional installation increases the probability of adoption in the same postcode by 0.78 percentage points. Brugger and Henry (2019) explain that peer effects work through various mechanisms, such as exertion of social influence on non-adopters and the provision of new information about the true costs and benefits of solar through active communication with adopters. In the context of electricity outages, reliance on generators and the resulting occurrence of fire outbreaks in markets (Ogeah & Omofonmwan, 2014), adopters are likely to assert some form of influence on non-adopters. Ogeah and Omofonmwan (2014) also suggest that because markets are a source of livelihood for many people, there is a need for more sustainable and reliable electricity with a lower risk of fire outbreaks.

Lack of financial resources for upfront investment in acquiring and installing new equipment can seriously impede the adoption of solar energy technologies (Karakaya & Sriwannawit, 2015). Installation costs, in particular, can dissuade entrepreneurs from adopting these technologies. Alrashoud and Tokimatsu (2019) argue that installation costs are the most significant barrier to adopting residential solar power systems. Amankwah-Amoah (2015) cites Bradford's (2006) estimate that over 90% of the lifetime cost of a solar power system is paid upfront at the time of installation – an outlay beyond the reach of most people in Africa. There may also be other initial requirements, such as changing existing appliances (Barau et al., 2020). Lee and Callaway (2018) argue that, following installation, the reliability and weekly/monthly fees of the installed power system are crucial determinants of the decision to adopt. They also observe that, in both West and East Africa, decentralised solar power systems are competing with grid systems in terms of reliability and tariff features. Kariuki (2018) adds that the lack of spare parts and adequate skills in repairing and servicing leads to equipment failures that halt the supply of energy and lower customer confidence in some renewable energy technologies, therefore hindering adoption.

Knowledge and awareness can generally boost user uptake of solar energy. Qureshi et al. (2017) observe that limited awareness in developing countries could add to misinformation among potential adopters. Despite its importance, awareness of solar energy as a source of power is still very low in Nigeria. According to Akinwale et al. (2014) and Akinboro et al. (2012), most users believe that solar energy can only power a few watts of lighting. There is also a common perception that solar energy offers a temporary solution pending connection to grid power (Kumar et al., 2019). Also, with erratic electricity supply, users are likely to perceive solar power systems as a complementary source, rather than a substitute for the national grid.

2.2. Impact of solar energy on MSMEs

The adoption of solar power systems is likely to have an impact on users, especially MSMEs, and one likely area of impact is business profitability. Adewuyi and Emmanuel (2018) observe that electricity outages result in significant business losses, including through the costs of independently generating power or of bribing electricity officials to mitigate such outages. Babajide and Brito (2020) suggest that adopting solar power systems opens possibilities for additional income generation and results in savings on both fuel and environmental costs. The adoption of Rensource solar technology can thus improve businesses' profitability.

Solar power systems can drive profitability by increasing the number of productive working hours for merchants within markets. Furthermore, Booth et al. (2018) note that the productive use of renewable micro-grid systems positively influences local economic activity and gender equality. Barman et al. (2017) suggest that extra income can be generated from conducting business or processing agricultural products in the evening thanks to the availability of better quality lighting.

Solar power adoption is also likely to impact employment; Dinkelman (2011) found that South Africa's post-apartheid rural electrification programme led to a 13.5% increase in female employment, as access to electricity enabled new businesses to produce local goods and services that were previously imported at higher cost. Lyke (2015) argues that electricity consumption is a fundamental driver of economic growth in Nigeria, while Yadav et al. (2019) reveal that users' positive experiences of solar power offer opportunities for solar power businesses to address unmet energy demand and further grow the market in rural communities. Furthermore, jobs created by productive uses of solar energy can have a multiplier effect as workers spend part of their income in the local economy, resulting in positive externalities through the creation of additional jobs.

Despite the potential benefits of adopting solar power systems, there has been very little empirical research on what factors affect adoption and the impact of adoption. Therefore, our study of Rensource solar-based micro-utilities will add value by highlighting the factors affecting adoption and the possible impact of solar power adoption in Nigeria.

3. Theory of change

A theory of change explains how activities are understood to produce a series of outcomes that contribute to achieving the final intended impact (Rogers, 2014). It can also help companies improve their strategy, measurements, communication and partnerships (Harries et al., 2014). The impact pathways and beneficiaries in the focal case are illustrated in Figure 1, showing the intermediate outcomes required for project outputs to bring real benefits (purpose and goals). The primary beneficiaries of Rensource solar technology are MSME owners (merchants, shopkeepers) who use solar energy in their operations. A number of enablers influence usage or adoption of Rensource solar-based micro-utilities by users. While internal enablers are within the organisation or its immediate control, external enablers lie beyond, including social, cultural, economic and political factors, laws and regulations, and other organisations (Harries et al., 2014).

The willingness of MSMEs to adopt renewable energy technologies can be influenced by other businesses in the same markets (Adepoju & Akinwale, 2019). Ugulu (2016, p. 147) notes that:

“Knowledge is a key problem because people do not believe it works. They must see that it works before they will accept the technology. That was why we installed it to convince people that it works. When they see you using it, they realise it is not just that you want to make a sale, but that it actually works.”

Additionally, peer influence is important and the decision to adopt a technology is affected by others’ decisions, either through information sharing in the process of social learning or through the perceived utility of conspicuous consumption of an environmentally friendly good (Bollinger & Gillingham, 2012).

Institutional factors also influence the adoption of technology. For instance, government subsidies to conventional power suppliers can make traditional sources cheaper for consumers than solar power sources, thus creating competition in the energy sector (Ohunakin et al., 2014). At the macro level, factors such as gross domestic product growth, financial development and trade openness have a long-term relationship with renewable energy technology adoption (Saibu & Omoju, 2016). Socioeconomic factors also affect the adoption of solar energy by MSMEs (Bada, 2011), while characteristics such as age, education status, occupation and average income are likely to influence households’ choice of energy source (Baiyegunhi & Hassan, 2014), in turn feeding into MSMEs’ energy choices.

3.1. Output

The provision of reliable electricity through the solar energy system is the key output from Rensource.

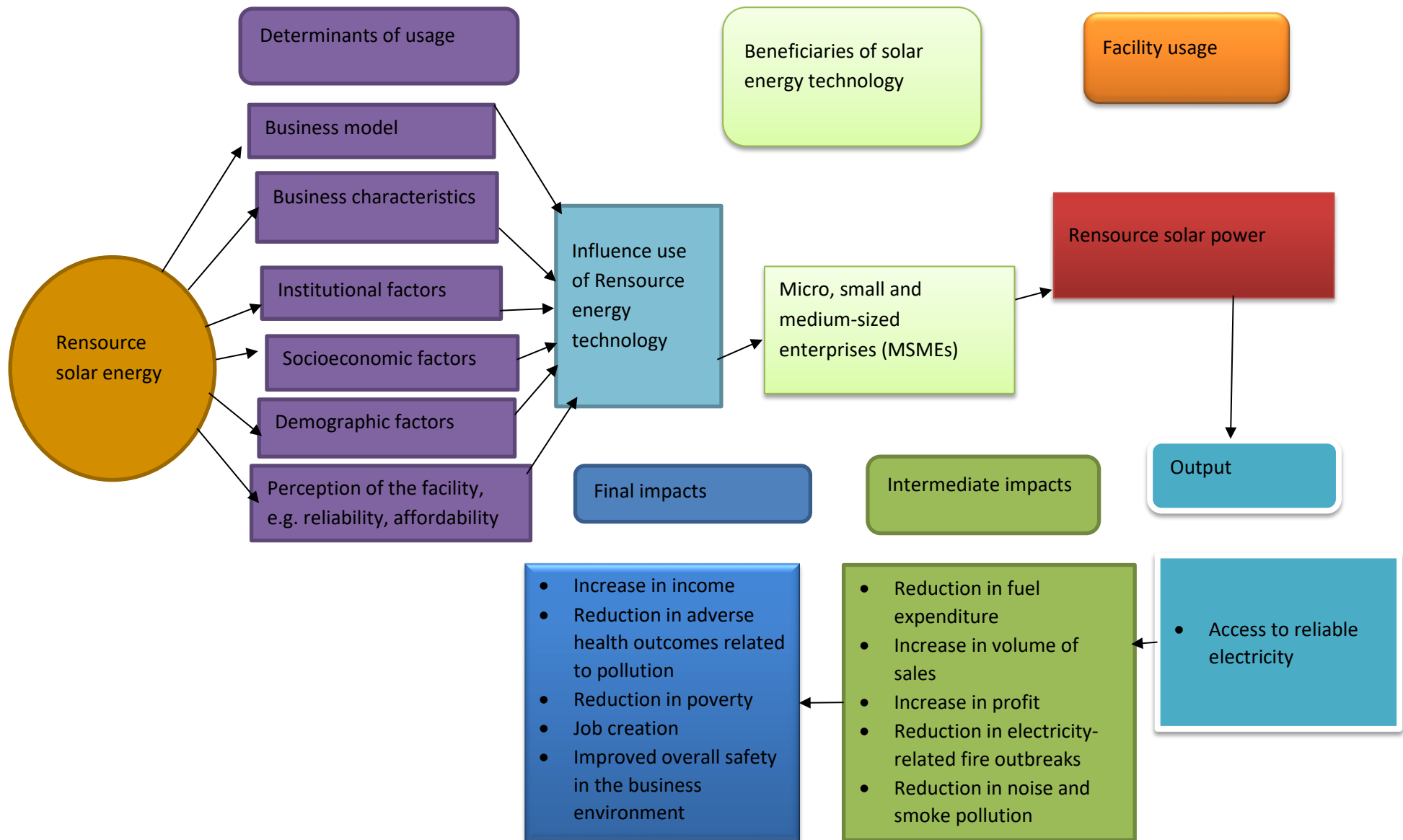
3.2. Intermediate impacts

There are several intermediate impacts. Merchants can increase their sales volume, leading to increased profit, through better lighting of shops to make products more visible and attractive to customers; creating a more comfortable and friendly environment for customers; testing electrical appliances to build trust and customer confidence in products; being able to work longer hours and on more days; and refrigerating perishable goods to avoid spoilage and loss. Users can benefit from reduced expenditure on fuel for backup generators, while decreased reliance on generators also lowers the risk of fires. Another intermediate impact is the reduction in noise and smoke pollution mainly caused by using standby generators during power outages.

3.3. Final impacts

In the long term, broader changes in society can result from using the solar-based micro-utility model. Incomes can rise due to increases in sales and profits as well as the expansion of businesses to provide services that require electricity. Business expansion can also lead to job creation and the employment of more personnel. The lowering of exposure to noise and smoke pollution can reduce adverse health outcomes. Furthermore, the reduction in electricity- or generator-related fires can improve overall safety within the physical business environment. These outcomes, as well as the intermediate impacts, are directly linked to poverty reduction.

Figure 1: Theory of change



4. Research methodology

4.1. Sampling and data collection

This study focuses on business subscriptions to Rensource solar energy, as the company's current model targets markets rather than individual households. The focal population includes all merchants in the markets where Rensource operates. The research sample includes both subscribers to Rensource solar energy and non-subscribers in selected markets in the selected states.

Multistage sampling was adopted to capture the targeted population. In the first stage we purposively selected the states of Lagos, Kano and Ondo as areas where Rensource is currently operating. We selected the Sabon Gari market in Kano, the Iponri market in Lagos, and the Isikan, Nepa 1 and Nepa 2 markets in Ondo. Rensource itself provided sampling frames of subscribers in the selected states, from which we randomly sampled 180, 75 and 45 subscribers from Sabon Gari, Iponri and Isikan, Nepa 1 and Nepa 2, respectively. The different sample sizes were proportional to the total number of subscribers in the various markets. The 300 selected subscribers (the treatment group) were drawn from a total of 400 merchants in the sample frames. To gain insights into the causal impact of Rensource solar energy, non-subscribers were also sampled from different sections of the same markets, forming a control group. The aim was to target potential clients to whom Rensource plan to roll out in the near future. Rensource did not have a REA-recommended potential market at the time of the survey, so the sample frame for the control group of non-subscribers was drawn from the same markets as the treatment group (Sabon Gari (Kano), Iponri (Lagos) and Isikan, Nepa 1 and Nepa 2 (Ondo)). The 400 selected non-subscribers were drawn from a total of 600 merchants in these sample frames. The overall sample thus comprised 700 merchants.

Table 1: Respondents by state and market

State	Market	Users	Non-users	Total
Kano	Sabon Gari	180	250	430
Lagos	Iponri	75	100	175
Ondo	Isikan	26	26	95
	Nepa 1	15	16	
	Nepa 2	5	7	
Total		300	400	700

Data were collected in July and August 2020. Both qualitative and quantitative data were collected.

This combination helps overcome weaknesses in using only one type of data, thus producing stronger evidence for conclusions and better-informed decision-making (Creswell & Clark, 2007). The structured questionnaire collected data on the socioeconomic characteristics of subscribers and non-subscribers in the selected markets; the social, economic, demographic, institutional and technological factors that influence the use of Rensource solar energy; respondents' sales, income and expenditure on diesel, petrol and electricity; and the benefits associated with the use of solar energy.

Due to the COVID-19 pandemic, we contracted a local data collection company (the Development Strategy Centre, Enugu, Nigeria) to collect the data through face-to-face interviews. The Development Strategy Centre has research assistants in different states. Three teams were formed to implement the field survey in each of the selected markets. Each team comprised four enumerators and one supervisor. The supervisor carefully monitored the enumerators' activities to ensure that data quality was not compromised. In addition, at the end of each day of enumeration, the supervisor reviewed the completed questionnaires to ascertain if there were any data gaps; identified gaps were addressed before the team left the market. These steps formed part of our strategy to control data quality during the field survey. Both qualitative and quantitative methods were used to analyse the collected data. The qualitative data were triangulated with the quantitative data to cross-check the reliability and consistency of the information obtained and thereby ensure higher accuracy.

4.2. Conceptual and empirical framework

Most of the merchants who have subscribed to Rensource solar energy (93%) had no access to national grid electricity. Consequently, these merchants were previously relying on diesel or petrol for power generation, and some suffered fire outbreaks resulting in loss of and damage to property. Some of the focal markets have access to the national grid, but its electricity supply is unreliable. Theoretically, this study assumes that a merchant chooses to subscribe to Rensource solar energy based on the expected benefit, given the applicable socioeconomic, institutional and technological characteristics. The benefits that Rensource seeks to deliver to Nigeria's MSMEs, including merchants, are to lower overhead costs through better business practices and to free them from the bane of generators. The decision-making process follows three steps:

1. The REA recommends a market where the programme should be rolled out.
2. Rensource makes an agreement with the market association of the market chosen by the REA.
3. Individual merchants decide whether or not to subscribe.

Thus, individual merchants make their decision only at step 3. They are not a randomly selected set of merchants but have already been subject to both choice processes at steps 1 and 2. Therefore, the study examines the decision of merchants to subscribe or not, and analyses the impact of subscribing to Rensource solar energy on merchants' income. We denote the net benefit the merchant i receives from subscribing to Rensource as R_S . R_{NS} denotes the net benefit that non-subscribers receive. Rationally, the merchant will subscribe to solar energy if net benefits are higher from subscription than from non-subscription ($R_S > R_{NS}$). This translates into a binary choice represented as:

$$R_{iS} = Z_i \alpha_S + \varepsilon_{iS} \quad (1)$$

$$R_{iNS} = Z_i \alpha_{NS} + \varepsilon_{iNS} \quad (2)$$

where Z_i is a vector of socioeconomic, institutional and technological characteristics, market-level characteristics and location-specific dummies; α_S and α_{NS} are parameters to be estimated; and ε_{iS} and ε_{iNS} are random disturbance terms for subscribers and non-subscribers, respectively. The perceived net benefits of subscribing to Rensource solar energy are not known to the researchers. Only the Z_i vector characteristics are known during the survey. We represent the net benefit associated

with Rensource solar energy subscription by a latent variable R_i^* ($R_i^* = R_{iS} - R_{iNS}$), which can be expressed as a function of observable characteristics Z_i in the form:

$$R_i^* = \alpha Z_i + \mu_i; \quad R_i = 1 [R_i^* > 0] \quad (3)$$

where R_i is a binary dependent variable that equals 1 for Rensource solar energy subscribers, and 0 for non-subscribers; α is a vector of parameters to be estimated; μ is the error term, generally known as the effect of unobservables; and Z is a vector of socioeconomic (e.g. age, gender, education, income, employees), institutional (e.g. access to credit, membership of marketing association) and technological characteristics, market-level characteristics (e.g. previous experience of a market fire outbreak, type of products) and location-specific dummies.

To determine what drives merchants to subscribe to Rensource solar energy, we used a probit regression model. Given that our research design is not experimental, the assignment to treatment is non-random: merchants that have subscribed to Rensource (the treatment group) and non-subscribers (the control group) may differ in not only their treatment status but also other characteristics that affect both subscription and the outcome of interest. To avoid the biases this may generate, we used nearest neighbour matching, radius matching and kernel-based matching to find a non-subscribed merchant that is “similar” to a subscribed merchant, allowing us to estimate the impact of subscription as the difference between a subscriber and the matched comparison case. We used the matching estimators to examine the impact of using Rensource solar energy on a shopkeeper/merchant’s income and fuel expenditure. Merchants were matched by the kind of product they sell and also by time-invariant characteristics, such as gender and state.

We calculated the average treatment effect on the treated (ATT) in propensity score matching (PSM). This approach is one of the most important innovations in developing workable matching methods and reduces the matching problem to a single dimension (Heinrich et al., 2010). Some studies have established that propensity score matching eliminates a larger proportion of the systematic differences in characteristics between treated and untreated subjects (Austin, 2011; Heckman et al., 1998, Heinrich et al., 2010) than other methods. It offers two main advantages: binary treatment is always possible if sufficient data are available (making this approach a “method of last resort”) and propensity score matching can be applied after completion of an intervention, including in the absence of baseline data. The method’s drawback is the need to match on observables.

Propensity score matching pairs treatment and control units with similar values on the propensity score and possibly other covariates, while removing all unmatched units (Rubin, 2001). Estimating treatment effects based on the propensity score requires two assumptions. The first is the conditional-independence assumption, which requires that the common variables affecting treatment assignment and treatment-specific outcomes are observable. The dependence between treatment assignment and treatment-specific outcomes is removed by conditioning on the observable variables. The second assumption is that ATT_{PSM} is only defined within the region of common support. This assumption ensures that merchants with the same Z values have a positive probability of being both subscribers and non-subscribers (Heckman et al., 1998). Once propensity is computed, the impact of treatment for an individual merchant i , denoted as Q_i , can be estimated using the average treatment effect on the treated and the average treatment effect (ATE).

The average treatment effect on the treated is of greater interest than the average treatment effect in this particular research context because it is more realistic to examine the effect of subscription on merchants who have subscribed to use Rensource solar energy. For a Rensource subscriber with characteristics Z_i , the expected outcome is stated as:

$$E(Q_{iS} | Z, R = 1) \quad (4)$$

The expected outcome for the same Rensource subscriber had he or she chosen not to subscribe to solar energy is stated as:

$$E(Q_{iNS} | Z, R = 0) \quad (5)$$

The change in outcome (i.e. monthly earnings) due to subscription is the difference between the subscription outcome (equation 4) and the non-subscription outcome (equation 5). This estimate is the average treatment effect on the treated, specified as:

$$ATT_{PSM} = E(Q_{iS} | Z, R = 1) - E(Q_{iNS} | X, R = 0) \quad (6)$$

Thus, the average treatment effect on the treated measures the average effect of subscription on merchants that have subscribed to Rensource solar energy. By contrast, the average treatment effect is the difference between the expected outcome with treatment (subscribers) and the expected outcome without treatment (non-subscribers). Generally, the mean impact of subscription is obtained by averaging the impact across all individuals in the population. This parameter is the average treatment effect, specified as:

$$ATE = E(Q_{iS} | Z, R = 1) - E(Q_{iNS} | Z, R = 0) \quad (7)$$

where Q_{iS} is the monthly earnings of subscribers and Q_{iNS} is the monthly earnings of non-subscribers. In other words, the average treatment effect is the average impact, at the population level, of moving non-subscribers from the untreated group to the treated group (Austin, 2011).

4.2.1. Nearest neighbour matching

Nearest neighbour matching allowed us to match or pair merchants that have subscribed to Rensource with another “closest” merchant in the non-subscriber group. Let us assume that p_i and p_j are respective propensity scores for merchant i in the treatment group (Rensource subscribers) and merchant j in the control group (non-subscribers), with i belonging to I_1 (the set of subscribers) and j belonging to I_0 (the set of non-subscribers). We defined a neighbourhood $C(P_i)$ containing a non-subscriber j ($j \in I_0$) as a match for a Rensource subscriber i ($i \in I_1$) if the absolute difference of propensity scores was the smallest among all possible pairs of propensity scores between i and j , specified as:

$$C(P_i) = \min_j \| p_i - p_j \|, \text{ with } j \in I_0 \quad (8)$$

Once a merchant j in the non-subscriber group was found to match a merchant i in the subscriber group, that merchant j was removed from I_0 without replacement. If each merchant i in the subscriber group is found to have only a single merchant j in the non-subscriber group falling within $C(P_i)$, then

the nearest neighbour matching produces pair, or one-to-one, matching. Otherwise, if each merchant i in the subscriber group is found to have n non-subscribers falling into $C(P_i)$, then the nearest neighbour matching produces one-to-many matching. In practical terms, we used the statistical software Stata to implement the nearest neighbour algorithm of Becker and Ichino (2005). Nearest neighbours are not identified by comparing each Rensource subscriber to every single non-subscriber: rather, all observations (merchants) are first sorted by estimated propensity score, then forward and backward searches are performed to identify the closest non-subscriber(s) in the control group. Where the forward and backward matches for a merchant i in the treatment group were equally good, the algorithm randomly selected one of the two matches.

4.2.2. Radius matching

In the nearest neighbour matching described above, we did not assign or impose any restrictions on the distance between p_i and p_j . This implies that even if a non-subscriber j has a very different estimated propensity score to that of a subscriber i (i.e. $\|p_i - p_j\|$ is large), the two are still considered a good match. To overcome the bias that might arise from wrongly identifying a suitable non-subscriber j in the control group, we selected matches only if the absolute distance of propensity scores between the group of Rensource subscribers and the group of non-subscribers complied with the following condition:

$$\|p_i - p_j\| < \epsilon \quad (9)$$

where ϵ is a pre-specified tolerance for matching, also known as a caliper¹. Dehejia and Wahba (2002) developed radius matching as a variant of caliper matching. The rationale behind radius matching is to use not just the nearest neighbour within each tolerance level or caliper but all comparators within the caliper. Therefore, radius matching made it possible to use more (or fewer) merchants when good matches were (or were not) available, and avoided the risk of bad matches between merchants. We computed the average treatment effect on the treated in Stata using Becker and Ichino's (2005) algorithm, which allowed us to restrict the analysis to those Rensource subscribers matched to a "control"² non-subscriber within the defined radius³.

4.2.3. Kernel-based matching

The kernel-based matching estimator compares the outcome of each treated Rensource subscriber to the weighted average of the outcomes of all non-subscribers, with the highest weight placed on those with scores closest to that of the treated merchant. One major advantage of this approach is the lower variance achieved by using more information. However, one drawback is that some of the observations used may be poor matches. Hence, we imposed the common support condition in the estimation. We also used the kernel function and the bandwidth parameter.

¹ Rosembaum and Rubin (1985) recommended using one-quarter standard deviation of the estimated propensity score of the analysis sample as the caliper size.

² In the event of multiple best controls, the average outcome of those controls was used.

³ We followed Becker and Ichino (2005) by using 0.1 as the predefined radius.

5. Results and discussion

5.1. Descriptive results

5.1.1. Distribution of users and non-users by gender, education, shop status and ownership structure

As Table 2 shows, 64.3% of Rensource users are men, compared to 66% of non-users. These results indicate that relatively few businesses are owned by women. Chi-square test results reveal no significant difference in male and female proportions between the users and non-users of Rensource solar energy. Regarding educational status, most users and non-users have at least completed secondary school education, but the proportion reaching this level is significantly higher among non-users than among users ($\chi^2 = 7.44$, $p = 0.05$). In addition, the percentage of Rensource users that have completed tertiary or university education is higher than that of non-users, and a chi-square test indicates that the difference is statistically significant ($\chi^2 = 7.90$, $p = 0.04$). This means that Rensource users are more likely to have a higher level of education. The percentage of merchants that did not progress beyond primary school education does not differ between users and non-users. Regarding shop status, about 82% of both users and non-users work in rented shops, while similar proportions in both groups operate shops owned jointly with their family (about 3%) or individually (users 15%; non-users 16%). Chi-square results indicate that there are no statistically significant differences in the ownership status of shops between users and non-users.

In terms of business ownership structure, the vast majority of users and non-users are sole proprietors. Only 3.3% of users and 4% of non-users are in partnerships. To summarise, the results in Table 2 show that Rensource subscribers are mainly men who completed secondary education and work in rented shops as sole proprietors.

Table 2: Demographic characteristics distribution of users and non-users (%)

Variable	Users (N=300)	Non-users (N=400)	Chi-square
<i>Gender</i>			
Male	64	66	$\chi^2 = 0.21,$ $p = 0.65$
Female	36	34	
<i>Education</i>			
Adult education	1	1	$\chi^2 = 5.44,$ $p = 0.25$
No formal schooling	9	8	
Primary	20	20	
Secondary ^a	45	52	
Tertiary/University ^b	25	19	
<i>Shop status</i>			
Rented	82	82	$\chi^2 = 0.14,$ $p = 0.93$
Owned	15	16	
Family-owned	3	3	
<i>Ownership structure</i>			
Sole proprietorship	95	96	$\chi^2 = 6.89,$ $p = 0.07$
Partnership	3	4	
Association	1	-	
Other	0	-	

^{a.} $\chi^2 = 7.44, p = 0.05$

^{b.} $\chi^2 = 7.90, p = 0.04$

5.1.2. Descriptive statistics of merchant and enterprise characteristics for users and non-users

The average age of business owners is 44 for Rensource solar energy users (range: 17 to 82 years old) and 42 for non-users (range: 18 to 72 years old). The average (oldest) business age is 13 years (40 years) for users and 12 years (50 years) for non-users. The average household size is 5 (SD=3) for both Rensource users and non-users.

The proportion of Rensource users' and non-users' household income from trading ranges from 1% to 100%, with the average proportion 2% higher for non-users than for users. In terms of monthly income earned from trading, Rensource users average NGN 145 926 whereas non-users average NGN 116 436, but the maximum income earned by both groups is NGN 800 000. The average

(maximum) number of employees is two (15) for users and three (16) for non-users. Both users' and non-users' typically have one shop branch.

Table 3 presents a gender breakdown of the above merchant and enterprise characteristics. Among the users of Rensource solar energy, male business owners are, on average, three years older than females, whereas there was no significant difference in age between males and females among non-users (according to t-test results). For both users and non-users, the results indicate that the proportion of household income generated by trading is larger for male than for female business owners, as indicated by a significant mean difference of 32%. On average, females earned more monthly income from trading than males in both the user group (NGN 6 587) and non-user group (NGN 21 530). However, for the number of employees and shop branches, the results reveal no significant differences between males and females in either group.

Table 3: Merchant and enterprise characteristics for users and non-users of Rensource solar energy across gender groups

Variable	Users (N=300)				Non-users (N=400)			
	Gender	Mean	SD	Mean difference (t-test)	Gender	Mean	SD	Mean difference (t-test)
Age	Male (N=193)	45	12	3**	Male (N=264)	42	11	0
	Female (N=107)	42	9		Female (N=136)	42	10	
Household size	Male (N=193)	6	3	1	Male (N=264)	6	4	1
	Female (N=107)	5	2		Female (N=136)	5	3	
Household income from trading (%)	Male (N=193)	88	21	32***	Male (N=264)	87	22	24***
	Female (N=107)	56	28		Female (N=136)	63	28	
Monthly income from trading (NGN)	Male (N=193)	143 577	151 399	-6 587	Male (N=264)	109 115	106 727	-21 530*
	Female (N=107)	150 164	136 366		Female (N=136)	130 645	123 800	
Business age (years)	Male (N=193)	13	9	2**	Male (N=264)	12	8	1
	Female (N=107)	11	7		Female (N=136)	11	7	
Employees	Male (N=193)	3	2	1	Male (N=264)	3	2	1
	Female (N=107)	2	2		Female (N=136)	2	2	
Branches	Male (N=193)	1	1	0	Male (N=264)	1	1	0
	Female (N=107)	1	1		Female (N=136)	1	1	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.1.3. Energy cost of users and non-users

The results in Table 4 further show that the monthly electricity bill of Rensource users connected to the national grid (only 7%) averaged NGN 3 152 (range: NGN 200 to 36 000) before they subscribed to solar energy services. By contrast, non-users' monthly electricity bill averages NGN 3 139 (range: NGN 300 to 30 000). A t-test revealed no significant difference in the mean electricity bill between Rensource users and non-users. In terms of fuel cost, the average monthly spend on fuel for generators was NGN 10 888 for Rensource users (prior to subscription) and NGN 8 022 for non-users. A t-test revealed a significant mean difference of NGN 2 866 between users and non-users. The maximum cost for users was NGN 80 000, compared with NGN 100 000 for non-users. After subscribing to Rensource, users' average monthly bill was NGN 5 144 (range: NGN 300 to 20 000). In terms of fuel cost, Rensource subscribers who had only been using generators prior to subscription saved NGN 5 744 on average, whereas subscribers who had previously been relying solely on the national grid were paying NGN 1 992 more to receive reliable solar energy from Rensource.

The average monthly fuel cost for non-users was NGN 2 878 higher than Rensource users' average monthly bill. However, the average monthly cost for electricity from the national grid is less than the average monthly cost of Rensource solar energy. This is expected given the frequency of electricity outages that merchants experience if connected to the national grid. In terms of fuel cost, Rensource subscribers save NGN 5 744 on average. However, it is worth noting that due to the unreliability of national grid electricity, 25% of subscribers resort to using both the national grid and generators, hence incurring the costs of purchasing fuel for generators and drawing energy from the national grid. A before-after comparison suggests that the combined average cost of electricity and fuel for generators per month (NGN 14 040) is higher than the average monthly bill for Rensource solar energy (NGN 5 144). Thus, Rensource subscribers save, on average, about NGN 8 896 per month, which represents a 36.64% reduction in electricity expenditure.

The merchant and enterprise characteristics for users and non-users in different states are presented in Tables A1 and A2; the same characteristics across different product categories are reported in Table A3.

Table 4: Merchant and enterprise characteristics for users and non-users of Rensource solar energy

Variable	Description	Users (N=300)				Non-users (N=400)			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Age	Age of business owner (years)	17	82	44 ^a	11	18	72	42 ^a	11
Household size	Number of people in the household	1	15	5 ^b	3	1	17	5 ^b	3
Household income	Percentage of household income from trading	10	100	77 ^a	28	8	100	79 ^a	27
Monthly income	Average monthly income from trading (NGN) ^c	5 000	800 000	145 926 ^a	146 018	3 000	800 000	116 436 ^a	113 128
Business age	Age of business in years	1	40	13 ^b	9	1	50	12 ^b	8
Employees	Number of employees	1	15	2 ^b	2	1	16	3 ^b	2
Branches	Number of shop branches	1	7	1 ^b	1	1	6	1 ^b	1
Electricity bill ^d	Monthly electricity bill for national grid (NGN)	200	36 000	3 152 ^b	3 705	300	30 000	3 139 ^b	2 857
Rensource bill	Monthly Rensource solar energy bill (NGN)	300	20 000	5 144	3 780	-	-	-	-
Fuel cost ^d	Monthly spend on fuel (petrol/diesel) for generators (NGN)	490	80 000	10 888 ^a	8 501	500	100 000	8 022 ^a	8 315

Note: Rensource users: generator only=55 (18%); national grid only=22 (7%); both=74 (25%); neither (no electricity)=149 (50%). Non-users: generator only=167 (42%); national grid only=37 (9%); both=85 (21%); neither (no electricity)=111 (28%).

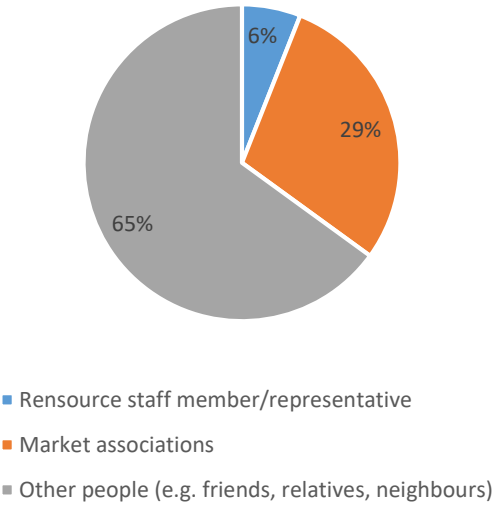
^a T-test results reveal a significant difference between users' and non-users' variable means; ^b T-test results reveal a non-significant difference between users' and non-users' variable means;

^c Exchange rate \$1: NGN 380 (Source: Central Bank of Nigeria); ^d Values for Rensource users are pre-subscription.

5.1.4. Sources of awareness

We asked Rensource users about how they had heard of Rensource solar energy prior to subscription. As Figure 2 shows, the majority of users (65%) had heard about Rensource through its staff and representatives, while 29% of users had heard about the company through market associations, and 6% had learned about Rensource through other people, including friends, relatives and neighbours. Rensource has representatives and sales agents who collect subscription fees in various markets. These paid roles contribute to job creation and enhance market awareness about Rensource services.

Figure 2: Rensource users’ sources of awareness



5.2. Determinants of merchants’ choice of electricity supplier

5.2.1. Drivers of choice of electricity supplier for users and non-users

Table 5 presents the merchants’ ranking of different characteristics that influence their choice of electricity supplier. It should be noted that the question concerned electricity suppliers in general, and did not specifically mention Rensource. The results indicate that both users and non-users of Rensource rank reliability of electricity supply as the most important characteristic influencing their supplier choice. This finding can be attributed to user fatigue over frequent power outages that plague the energy sector. The second most important attribute in both groups is affordability. This is followed by ease of access and flexibility of use for Rensource users, whereas non-users consider flexibility of use and installation cost as the third and fourth most important attributes that determine their choice of electricity supplier. Both users and non-users rank “prone to theft” and “no alternative source” as the least important factors determining their electricity supplier choice.

A statistical test (Kendall’s ranking of the attributes) was used to investigate the null hypothesis that there is no agreement among merchants regarding the ranking of the attributes. The significant chi-square returned by this test allows us to reject that hypothesis.

Table 5: Drivers of the choice of electricity supplier

Characteristic	Users (N=300)		Non-users (N=400)	
	Mean	Rank	Mean	Rank
Reliability	10.82	1 st	8.98	1 st
Affordability (user fees)	9.51	2 nd	8.61	2 nd
Ease of access	9.04	3 rd	7.54	8 th
Flexibility of use	9.03	4 th	8.48	3 rd
Risk of fire outbreak	8.83	5 th	7.75	6 th
Installation cost	8.65	6 th	8.14	4 th
Frequency of maintenance	8.38	7 th	7.58	7 th
User-friendliness	7.90	8 th	7.30	9 th
Noise generation	7.85	9 th	6.92	11 th
Flexible payment plan	7.81	10 th	7.97	5 th
Air pollution	7.18	11 th	6.90	12 th
Health problems	6.88	12 th	7.18	10 th
Environmental problems	6.61	13 th	-	-
Prone to theft	5.87	14 th	6.05	13 th
No alternative supplier	5.65	15 th	5.59	14 th
Kendall's W	0.125		0.079	
Chi-square	523.75***		406.40***	
Degree of freedom	14		13	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.3. Intermediate impacts

The merchants were asked to indicate if their current source of electricity had affected their sales volume and profit. The observed difference in sales and profits between users and non-users can be helpful in highlighting the importance of Rensource solar for businesses. As Table 6 shows, about 34% of Rensource users (101 of 300) had observed an increase in their sales volume, which ranged in size from 3% to 100% and averaged 39%. Furthermore, about 37% of Rensource users (111 of 300) had observed an increase in profit ranging in size from 3% to 100% and averaging 34%. It is noteworthy that no Rensource users observed a decrease in sales volume or profit. We used qualitative data to pinpoint uses of solar energy that increase sales volume and profit:

- Improved shop lighting enhances product visibility and customer attraction. In the merchants' own words: "The light brightens the shop and make the goods more attractive"; "More patronage as a result of constant light. Customers see my goods displayed for sale"; "Attracting more customers through brightening the shop and making goods look attractive"; "My shop has never been in darkness since I joined and customers see my goods for patronage"; "my shop is now bright, customers can now see my goods clearly"; "The light generated by solar has made my shop brighter and enables my customers to differentiate between cloth colours, leading to me having more customers"; "Before Rensource solar, my shop used to be dark, and as a result customers didn't patronise [buy] my goods that much, but with solar and steady light my shop is bright and customers can see my goods very well"; "It plays a major role in showcasing our products and making customers buy them through illumination and beauty enhancement."
- Creating a more comfortable and friendly environment for customers. In the merchants' own words: "I use it to power the fans, which provides comfort for my customers when they come into my shop"; "The fan makes our customers comfortable to carry out business with us"; "Comfort of customers in a well-lit office"; "It has provided comfort and a friendly environment for customers and regular accessibility."
- Testing electrical appliances to build trust and customer confidence in products. In the merchants' own words: "We use the solar energy for testing any electrical appliances for a customer without having to look for another shop to do this"; "Using the solar to recharge and test my goods for my customers"; "To test the electric stoves before selling to customers, and they will tell others to come because they trust me."
- More working hours and days. In the merchants' own words: "It has increased the time I spend in my shop"; "I stay longer in the shop than I used to because of Rensource solar energy and it has increased my sales and profitability"; "I now stay longer in the shop unlike before and by staying longer I make more profit"; "Use of solar has helped me utilise the lighting hours"; "It increases the number of days spent in the shop." These comments reinforce Matungwa's (2014) observation that photovoltaic solar offers merchants an opportunity to do business at night.
- Additional machines to increase productivity. In the merchants' own words: "Additional electric machines and manpower have been added due to Rensource solar energy"; "We can now use electric sewing machines for efficiency."
- Refrigeration to avoid spoilage and loss of perishable goods. In the merchants' own words: "Use to power the fridges for perishable goods and products"; "The use of fridges has reduce[d] losses due to spoilage and this increases profit."

For non-users who were mostly using generators, the results indicate that 32% (128 of 400) and 38% (152 of 400) observed changes in their sales volume and profit, respectively, compared with the period when they had no generators. Of the 128 that observed a change in sales volume, 70% (89) experienced an increase, averaging 54%, while 30% (39) experienced a decrease, averaging 23%. Of the 152 that observed a change in profit, 71% (108) recorded an increase, averaging 50%, while 29% (44) recorded a decrease, averaging 19%.

In comparison to the users, 22% of non-users experienced an increase in sales, averaging 54%, while 27% of non-users experienced an increase in profits, averaging 50%. This shows that although more users reported increases in both sales and profits, their average increases were lower than those attained by the non-users. One probable explanation with regard to profits could be that the profits of users are generally lower given the initial investment to adopt Rensource solar as well as the

observation that they all pay a slightly higher fee for the solar installed compared to those still using the national grid and generators. The higher average sales reported by non-users compared to users is a puzzling result but could be in part explained by a higher variance across non-users who resort to different kinds of energy sources. It should be noted that the sales volume and profit values are self-reported figures and so may be subject to biases such as incorrect recall by respondents.

Table 6: Effects of current electricity source on sales and profit

Outcome variable	Frequency	Change direction	Percentage change		
			Mean (%)	Min. (%)	Max. (%)
<i>Panel A: Rensource users (N=300)</i>					
Change in sales volume	Yes (N=101)	Increase (N=101)	39	3	100
		Decrease (N=0)	-	-	-
	No (N=199)				
Change in profit	Yes (N=111)	Increase (N=111)	34	3	100
		Decrease (N=0)	-	-	-
	No (N=189)				
<i>Panel B: Non-users (N=400)</i>					
Change in sales volume	Yes (N=128)	Increase (N=89)	54	3	100
		Decrease (N=39)	23	5	100
	No (N=272)				
Change in profit	Yes (N=152)	Increase (N=108)	50	3	100
		Decrease (N=44)	19	5	100
	No (N=248)				

Table 7 presents results on electricity-related fire outbreaks and estimated losses. The results show that 29% of Rensource users had experienced electricity-related fire outbreaks prior to subscription, ranging in number from one to four (averaging one) and with estimated losses from fire outbreaks averaging NGN 1 886 442 (maximum of NGN 10 000 000). All Rensource users indicated that they had not experienced any fire outbreaks after subscribing to Rensource; thus, by avoiding electricity-related fires, Rensource users, on average, had saved an estimated NGN 1 886 442. For non-users, the results show that 15% had experienced electricity-related fire outbreaks, with an average of less than two occurrences and a maximum of four. The estimated loss associated with such fires averaged NGN 1 039 675, with a maximum of NGN 8 000 000.

There is no significant difference between users and non-users in the number of fire outbreaks. The mean difference between users' and non-users' average estimated losses from fire outbreaks is NGN 846 766. However, it is important to note that the fire outbreaks reported by Rensource users all occurred prior to subscription. Hence, comparing the average estimated fire-related loss pre-subscription to the zero fire-related loss post-subscription shows that subscribing to Rensource saves merchants from losing an average of NGN 1 886 441.56

Table 7: Electricity-related fire outbreaks and estimated losses

Variable	Mean	Min.	Max.	SD
<i>Panel A: Rensource users (N=300)</i>				
Number of outbreaks (N=87)	1.37	1	4	0.70
Estimated loss from fire outbreaks (NGN)	1 886 441.56	5 000	10 000 000	238 264.05
<i>Panel B: Non-users (N=400)</i>				
Number of outbreaks (N=61)	1.61	1	4	0.71
Estimated loss from fire outbreaks (NGN)	1 039 675.00	1 500	8 000 000	182 765.31
	Mean difference (t-test)			
Number of outbreaks	-0.24			
Estimated loss from fire outbreaks (NGN)	846 766.56***			

5.4. Empirical results

5.4.1. Factors influencing merchants' subscription to Rensource solar energy

Table 8 presents probit estimates of factors influencing subscription to Rensource solar energy. The explanatory variables kept in the probit model are those that satisfied the balancing property of the propensity score (Maffioli et al., 2009). We performed t-tests of equality of means before and after matching to validate if the propensity score matching succeeds in balancing the characteristics between treated and untreated groups. The t-test results revealed that after matching (see Table A4) there were no significant differences in the means of variables kept in the probit model, suggesting that matching helped to reduce the bias associated with observable characteristics (see Table A4).

The proportion of household income from trading has a significantly positive influence on subscription to Rensource solar energy. This is likely because those households' livelihood is highly affected by the state of the business, which they expect to boost by investing in solar energy, leading to higher household income. The sampled merchants are mainly microenterprises operating at the subsistence level, providing employment and income to their owners only (Etuk et al., 2014).

Membership of a merchant group is also positively related to subscription at the 1% significance level. This implies that business owners who join merchant groups or associations are more likely to

subscribe to Rensource solar energy compared to those who do not. Given that Rensource works with market associations, it is likely that these associations also advertise Rensource or otherwise help the company to reach more merchants. This finding accords with the view of Carattini et al. (2018) and Grossman (2020) that an individual's decision to subscribe to solar energy is likely influenced by wider social units or communities of practice through interactions within social networks. Additionally, Schelly and Letzelter (2020) argue that peer recommendations of solar power and the solar installer's reputation are the fastest growing decision factors influencing adoption.

In terms of business characteristics, the number of shop branches positively influences subscription to Rensource solar energy at the 5% level, suggesting that merchants with more branches are more likely to subscribe. This may be because merchants who own more than one shop also have higher incomes and so can overcome the cost hurdle of solar subscription. Owning one's shop (either individually or through family) is positively related to subscription at the 10% significance level, which suggests that merchants who operate in such shops are more likely to subscribe to Rensource solar energy compared to those in rented shops. Ownership implies more secure property rights, so investment in solar makes more business sense in the long run, whereas merchants only temporarily renting their premises may not benefit from the upfront outlay. Best et al. (2019) argue that being a renter fundamentally constrains solar uptake, while Hai (2019) suggests that high mobility among residents leads to the discontinuation of solar energy services even after adoption.

The fire outbreak variable is positively related to subscription at the 1% level, suggesting that merchants who have experienced an electricity-related fire outbreak in the past five years are more likely to subscribe to Rensource solar energy compared to those who have not. This finding is consistent with Ogeah and Omofonmwan's (2014) assertion that frequent power outages have led to reliance on generators and the subsequent problem of frequent fire outbreaks in markets, increasing the likelihood that merchants will seek to adopt a safer and more reliable energy source. Merchants with access to credit for the business are also more likely to subscribe to Rensource solar energy compared to those without such access (significant at the 5% level). Credit eases the cost constraint on merchants, which Qureshi et al. (2017) note as the greatest barrier to the diffusion of solar photovoltaic systems in Pakistan.

Regarding the kind of product traded, the results indicate that merchants who sell food (fresh and processed) products and those who operate salons or sell cosmetics are more likely to subscribe to Rensource solar energy compared to those selling products in the reference category (i.e. manufacturing, stationery, sewing and agrochemicals). The machines used in manufacturing, stationery and sewing operations often require high power that solar energy may not be able to consistently provide, especially during periods when the sun is less intense. Foods usually require preservation, while beauty salons need electricity for most of their services. Hafner et al. (2018) argues that energy is a key input at all stages of the food value chain. Cold storage, particularly from ice makers, can allow communities to store fish and other foods for longer periods (Kyriakarakos et al., 2020). In addition, Anane (2016) notes that beauty salons are among the businesses that heavily depend on electricity in business operations.

Finally, we found that merchants who rank the reliability of a given energy supply as very important are much more likely to subscribe to Rensource solar energy than those who do not prioritise reliability (significant at the 1% level). This reinforces Eronini's (2014) finding that a regular power

supply is enough motivation for adopting solar energy, and supports Lee and Callaway's (2018) assertion that decentralised solar power is competing with grid systems in terms of reliability.

Table 8: Probit estimates of factors influencing subscription to Rensource solar energy

Variable		Coefficient	R. std error	t-value
<i>Merchant characteristics</i>				
Age	Age of business owner (years)	0.0072	0.0052	1.31
Gender	1 if business owner is male, 0 otherwise	-0.0147	0.1279	-0.11
Education	Years of formal education	0.0076	0.0117	0.65
Household size	Number of people in household	-0.0105	0.0186	-0.57
Household income	Percentage of household income from trading	0.0059**	0.0022	2.64
Membership	1 if business owner is member of a merchant group, 0 otherwise	0.4007***	0.1470	2.72
<i>Business characteristics</i>				
Employees	Number of employees	-0.0233	0.0292	-0.80
Branches	Number of shop branches	0.2183**	0.0918	2.38
Owned shop	1 if shop is individually or family-owned, 0 otherwise	0.2407*	0.1406	1.71
Fire outbreak	1 if fire outbreak occurred in the past five years, 0 otherwise	0.5561***	0.1311	4.24
Credit access	1 if merchant has access to credit for the business, 0 otherwise	0.2713**	0.1368	1.98
<i>Product traded</i>				
Food products	1 if the merchant sells food products, 0 otherwise	0.5093***	0.1219	4.18
Clothing, shoes, bags and textiles	1 if the merchant sells clothing, shoes, bags or textiles, 0 otherwise	0.3063	0.2485	1.23
Electronics	1 if the merchant sells electronics, 0 otherwise	0.1807	0.1984	0.91
Cosmetics	1 if the merchant sells cosmetics or operates a beauty salon, 0 otherwise	0.3063**	0.1485	2.06
Homeware and kitchenware	1 if the merchant sells home or kitchen products, 0 otherwise	-0.0739	0.2073	-0.36
<i>Energy characteristics</i>				
Reliability	1 if the merchant ranks reliability of energy source as very important, 0 otherwise	1.1833***	0.1494	7.92
Pseudo R ²				0.15
Wald chi ² (19)				139.69
Number of observations				700

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.4.2. Factors influencing merchants' subscription to Rensource solar energy

Table 9 presents the results of the average treatment effect on the treated of Rensource subscription on merchants' monthly earnings following the propensity score matching approach. The average treatment effect on the treated results show the effect of the subscription on those merchants who have subscribed to use Rensource solar energy. Across all propensity score matching specifications, Rensource subscribers had significantly higher monthly earnings than non-subscribers. Specifically, using nearest neighbour matching, the effect of subscription on Rensource subscribers is an increase in monthly earnings of 13.28% (NGN 19 382). The nearest neighbour matching was based on 300 treated and 167 control merchants, and used a bootstrapping approach. The region of common support is [0.03, 0.85]. Using kernel-based matching and radius matching, the effect of subscription on Rensource subscribers is an increase in monthly earnings of 13.82% (NGN 20 174) and 15.70% (NGN 22 912), respectively. These findings are consistent with those of Babajide and Brito (2020), who found that the possibilities for additional income generation and fuel cost savings through adopting solar energy were comparable to reliance on the existing electricity grid in its current state.

Table 9: Average treatment effect on the treated of Rensource subscription on merchants' monthly earnings

Outcome variables	Nearest neighbour matching ^a	% change	Kernel-based matching ^b	% change	Radius matching ^c	% change
Monthly earnings ^d	19 382* (23 105)	13.28%	20 174*** (4 828)	13.82%	22 912** (9 821)	15.70%

*Notes: These results are based on propensity score matching. Standard errors are in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. ^a Nearest neighbour matching: treated (N=300), control (N=167); ^b Kernel-based matching: treated (N=300), control (N=394); ^c Radius matching: treated (N=300), control (N=394); ^d Exchange rate \$1: NGN 380 (Source: Central Bank of Nigeria).*

Table 10 reports the average treatment effect results, which show that Rensource subscribers had significantly higher monthly earnings than non-subscribers. Using nearest neighbour matching, Rensource subscribers earn 27.60% more each month than non-subscribers, while kernel-based matching indicates that subscribers generate 19.24% higher monthly earnings than non-subscribers. It is unsurprising that the average treatment effect values are higher than the average treatment effect on the treated values given that the two approaches do not use the same population. The average treatment effect takes into account differences between control and treatment group characteristics. While the average treatment effect estimates show what non-subscribers would have obtained had they moved from the untreated to the treated group at the population level, the average treatment effect on the treated estimates show what subscribers would have obtained had they decided not to subscribe. The average treatment effect on the treated estimates are more relevant in this study.

The results also show that Rensource subscribers had lower monthly fuel expenditure for generators prior to Rensource subscription compared with non-subscribers' current monthly spending on fuel. However, these differences are not significant at any of the conventional statistical levels.

We further matched the monthly earnings on gender, state and product kind after the average treatment effect estimation using exact match (ematch; Cattaneo, 2010). This allowed us to restrict matches to only those subjects in the same gender, state and product categories. The results for exact matching on gender reveal that, within the same gender category, Rensource subscribers had higher monthly earnings (NGN 28 541) than non-subscribers, with the difference being statistically significant

at the 1% level. With exact matching on state, Rensource subscribers had significantly higher monthly earnings (NGN 28 372) than non-subscribers, with the difference being statistically significant at the 1% level. In addition, within the same product category, the results show that Rensource subscribers had higher monthly earnings (NGN 27 087) than non-subscribers, with the difference being statistically significant at the 1% level. Ritchie and Roser (2019) note that the availability (and affordability) of electricity and clean fuels is strongly related to income, while Roche and Blanchard (2018) contend that solar energy can be designed for income-generating activities.

Table 10: Average treatment effect of Rensource subscription on merchants' monthly earnings

Outcome variables	Nearest neighbour matching	% change	Kernel-based matching ^a	% change
Monthly earnings	4 0271***(11 343)	27.60%	28 077***(9 863)	19.24%
Exact matching on:				
Monthly earnings	Gender		28 541*** (9 830)	
Monthly earnings	State		28 372*** (9 592)	
Monthly earnings	Product kind		27 087*** (9 772)	

Notes: These results are based on propensity score matching. Standard errors are in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. ^a Kernel-based matching: treated (N=297), control (N=394).

6. Summary, conclusions and implications

This research examined the impact of Rensource solar energy on subscribers in selected markets of Lagos, Kano and Ondo, Nigeria. Specifically, the study characterised the profile of Rensource's customer base and assessed the drivers of merchants' decision to subscribe to Rensource solar energy. Finally, we examined how Rensource merchants benefit from the company's services. We used descriptive statistics to profile Rensource's subscribers and non-subscribers, and employed Kendall's ranking and a probit model to examine the drivers of merchants' subscription decisions. Through propensity score matching employing nearest neighbour matching, kernel-based matching and radius matching, we empirically assessed the impact of subscribing to Rensource solar energy on the monthly earnings and fuel expenditure of merchants. A total of 700 merchants were sampled, comprising 300 subscribers (treatment group) and 400 non-subscribers (control group).

In summary, the findings show that both subscribers and non-subscribers of Rensource solar energy are generally MSMEs with a similar number of employees, business age, number of branches and household size. Sole proprietorship and male ownership are predominant among subscribers and non-subscribers, and it is most common for merchants in both groups to rent (rather than own) the shops where they operate. Most subscriber and non-subscriber merchants are secondary school leavers, but a higher proportion of subscribers completed tertiary or university education. Both merchant groups work in clothing, shoes, bags and textiles; electronics (including phones, computers and accessories); food products (including fresh produce and processed foodstuffs), homeware and kitchenware; manufacturing; tailoring; agrochemicals; stationery (including books, gift cards, graphics and paper); services (including mobile money and credit transfer); and cosmetics and beauty salons.

The drivers identified as most influential in merchants' decision to subscribe to Rensource solar energy include reliability, affordability (weekly/monthly user fees), flexible payment plan, ease of access, flexibility of use, low risk of fire outbreak, and low health risk. Besides these attributes, we

conclude that the proportion of household income from trading and membership of a merchant association each increase the likelihood of subscription to Rensource. In addition, we conclude that individual or family-owned businesses with more branches and which own their shops (and are thus entitled to change appliances) are more likely to subscribe to Rensource solar energy. Merchants that have experienced electricity-related fire outbreaks are also more likely to subscribe. Finally, we conclude that merchants selling fresh and processed food products and those operating beauty salons or selling cosmetic products are more likely to become Rensource subscribers.

In terms of impact, we conclude that Rensource has provided reliable solar energy to merchants who were previously using the national grid and standby generators, as well as those that had no access to either. The provision of reliable solar energy has reduced the burden for some merchants who used to pay bills for their national grid connection while also incurring the costs of acquiring and fuelling a generator. Thus, subscription to Rensource solar energy reduces expenditure on electricity. Our empirical results for the average treatment effect on the treated suggest that subscribing to Rensource increases monthly earnings by 13.28% (nearest neighbour matching), 13.82% (kernel-based matching) and 15.70% (radius matching). The average treatment effect results also confirmed that the causal effect of subscribing to Rensource solar energy is an increase in monthly earnings. We further conclude that within the same gender, state and product categories, Rensource subscribers earn more than non-subscribers.

In conclusion, this study's findings suggest that subscription to Rensource solar energy has a positive impact on merchants' monthly earnings, sales volume and profits. The decision on whether to subscribe to Rensource hinges on a complex set of personal, business and product characteristics, as well as the supplier's characteristics and features of the electricity supply.

Our findings on the subscription decision drivers have important implications from different perspectives. First, the insights on merchants' ranking of supplier and electricity characteristics can be used to design better measures for promoting solar energy subscription, including a communication strategy that alludes to the whole range of characteristics that merchants prioritise. In particular, when advertising and promoting Rensource solar energy, its reliability and how much merchants can save on fuel expenditure by subscribing should be highlighted. Second, the commonly held view that a firm's choice of electricity supplier depends solely on pricing should be revisited: we found that reliability is the most important factor across different gender groups and states.

The future design of strategies, models and communications that aim to attract individual and business subscriptions should also incorporate the merchant, business and product characteristics identified to influence subscription decisions. For instance, Rensource can target more clients through market associations and focus particularly on individual or family-owned shops with the right to install solar energy equipment. In addition, Rensource should strive to maintain the constant supply of solar energy and minimise the risk of power outages. This can be done by conducting routine maintenance and by identifying ways to improve the functionality and longevity of solar panels.

It is important to raise broader awareness of the evident benefits of Rensource solar energy in the private sector, particularly in markets and other states where Rensource does not currently operate. Finally, future research should conduct long-term and indirect analysis to gain a broader perspective and support the innovative aspect of the Rensource service.

Several caveats should be considered when interpreting this study's findings. First, we relied on cross-sectional data for our empirical analysis. Panel data would have allowed us to measure the impact from the time merchants subscribed to Rensource solar energy until the time differences in earnings and income became evident. Second, a randomised experiment would have been a better way to measure the impact of subscription to Rensource solar energy on earnings and income; however, such data were not available. Notwithstanding these caveats, we believe that the control group and use of different matching methods served to minimise the impact of any systematic biases. As this study only considered financial outcomes, future research should examine the impact of subscription to Rensource solar energy on health and environmental outcomes.

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Annex A: Tables

Table A1: Descriptive statistics of non-users by state

Variable	Description	Kano (N=250)				Lagos (N=100)				Ondo (N=50)			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Age	Age of business owner (years)	18	72	43	11	21	63	41	10	22	69	45	11
Household size	Number of people in household	1	17	6	4	1	16	5	3	1	8	4	2
Household income	Percentage of household income from trading	8	100	88	23	20	100	64	27	15	100	65	26
Monthly income	Average monthly income from trading (NGN) ^a	3 000	700 000	84 457	78 714	15 000	800 000	211 150	144 108	10 000	350 000	86 899	79 706
Business age	Age of business (years)	1	40	13	9	1	40	10	6	1	50	11	9
Employees	Number of employees	1	15	2	2	1	16	3	3	1	5	1	1
Branches	Number of shop branches	1	6	1	1	1	4	1	0	1	2	1	0
Electricity bill ^b	Monthly electricity bill for national grid (NGN)	500	30 000	4 129	3 315	500	70 000	2 436	1 355	300	20 000	2 063	3 697
Fuel cost ^b	Monthly spend on fuel (petrol/diesel) for generators (NGN)	500	50 000	6 400	6 050	2 000	100 000	11 266	10 566	1 000	15 000	3 977	3 350

Notes: ^a Exchange rate \$1: NGN 380 (Source: Central Bank of Nigeria); ^b Values for Rensource users are pre-subscription.

Table A2: Descriptive statistics of users by state

Variable	Description	Kano (N=180)				Lagos (N=75)				Ondo (N=45)			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Age	Age of business owner (years)	17	82	45 ^a	12	26	55	40 ^a	7	27	77	45 ^a	10
Household size	Number of people in household	1	15	6 ^b	3	1	13	5 ^b	2	1	8	4 ^b	1
Household income	Percentage of household income from trading	10	100	89 ^a	21	20	100	57 ^a	28	10	100	60 ^a	31
Monthly income	Average monthly income from trading (NGN) ^a	10 000	750 000	130 149 ^a	133 191	30 000	750 000	180 667 ^a	136 672	5 000	800 000	151 135 ^a	195 447
Business age	Age of business (years)	1	40	14 ^b	9	2	22	9 ^b	5	1	37	12 ^b	9
Employees	Number of employees	1	15	3 ^b	2	1	12	3 ^b	2	1	4	2 ^b	1
Branches	Number of shop branches	1	7	1 ^b	1	1	4	1 ^b	1	1	3	1 ^b	1
Fuel cost	Monthly spend on fuel (petrol/diesel) for generators (NGN)	6 000	80 000	10 547 ^a	12 733	490	300 00	11 870 ^a	4 560	6 000	6 000	6 000 ^a	0
Electricity bill	Monthly electricity bill for national grid (NGN)	500	36 000	4 017 ^b	3 841	500	28 000	2247 ^b	3 723	200	10 000	1 619 ^b	1 912

Table A2: Descriptive statistics of users by state (Continued)

Variable	Description	Kano (N=180)				Lagos (N=75)				Ondo (N=45)			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Rensource bill	Monthly Rensource bill (NGN)	1 000	12 000	5 745	2 813	1 000	20 000	5 780	5 013	300	11 200	1 948	2 273
Increase in sales	Percentage increase in sales volume	3	100	45	26	5	40	24	9	10	100	33	24
Increase in profit	Percentage increase in profit	5	100	39	27	5	30	18	7	10	100	28	24
Fire outbreaks	Number of fire outbreaks in the past five years	1	4	1	1	1	3	2	1	-	-	-	-
Cost of fire outbreaks	Estimated business cost of fire outbreaks (NGN)	5 000	10 000 000	2 038 042	2 421 539	10 000	200 000	92 500	86 357	-	-	-	-

Notes: ^a T-test results reveal a significant difference between variable means across states; ^b T-test results reveal a non-significant difference between variable means across states.

Table A3: Descriptive statistics of users and non-users by product kind

Variable	Description	Clothing, shoes, bags and textiles				Food products (fresh and processed)			
		Users (N=148)		Non-users (N=140)		Users (N=27)		Non-users (N=50)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Household income	Percentage of household income from trading	81 ^b	27	82 ^b	26	70 ^b	29	69 ^b	28
Monthly income	Average monthly income from trading (NGN)	162 011 ^a	154 622	119 129 ^a	104 241	180 818 ^a	218 555	123 355 ^a	109 786
Employees	Number of employees	3 ^b	2	2 ^b	2	2 ^b	1	3 ^b	3
Branches	Number of shop branches	1 ^b	1	1 ^b	1	1 ^b	1	1 ^b	1
Electricity bill	Monthly electricity bill for national grid (NGN)	3 742 ^b	4 794	3 068 ^b	2 089	2 852 ^b	1 589	2 717 ^b	1 679
Fuel cost	Monthly spend on fuel (petrol/diesel) for generators (NGN)	11 473 ^a	10 299	8 243 ^a	5 682	13 925 ^a	7 488	10 164 ^a	9 414
Fire outbreaks	Number of fire outbreaks in the past five years	1 ^b	1	2 ^b	1	1 ^b	1	2 ^b	1
Cost of fire outbreaks	Estimated business cost of fire outbreaks (NGN)	1 864 408 ^a	222 292	808 182 ^a	1 673 051	1 643 571 ^a	2 774 192	779 333 ^a	1 973 143

Table A3: Descriptive statistics of users and non-users by product kind (Continued)

Variable	Description	Electronics (phones, computers and accessories)				Cosmetics and beauty salons			
		Users (N=35)		Non-users (N=52)		Users (N=20)		Non-users (N=44)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Household income	Percentage of household income from trading	70 ^a	30	79 ^a	30	75 ^a	29	83 ^a	23
Monthly income	Average monthly income from trading (NGN)	9 9478 ^a	66 671	116 403 ^a	97 442	86 850 ^a	66 218	116 841 ^a	57 988
Employees	Number of employees	2 ^b	1	2 ^b	1	3 ^b	3	4 ^b	3
Branches	Number of shop branches	1 ^b	1	1 ^b	0	1 ^b	0	1 ^b	1
Electricity bill	Monthly electricity bill for national grid (NGN)	3 164 ^a	1 623	4 305 ^a	3 794	3 785 ^b	2 039	29 223 ^b	6 529
Fuel cost	Monthly spending on fuel (petrol/diesel) for generators (NGN)	9 625 ^a	3 138	6 756 ^a	4 096	6 275 ^a	2 038	8 125 ^a	6 702
Fire outbreaks	Number of fire outbreaks in the past five years	1 ^b	1	1 ^b	1	2 ^b	1	1 ^b	1
Cost of fire outbreaks	Estimated business cost of fire outbreaks (NGN)	2 938 333 ^a	3 078 834	2 624 111 ^a	3 451 154	195 000 ^a	249 015	2 020 000 ^a	537 424

Table A3: Descriptive statistics of users and non-users by product kind (Continued)

Variable	Description	Homeware and kitchenware				Manufacturing			
		Users (N=24)		Non-users (N=40)		Users (N=14)		Non-users (N=21)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Household income	Percentage of household income from trading	66 ^a	30	79 ^a	26	96 ^a	9	91 ^a	23
Monthly income	Average monthly income from trading (NGN)	170 171 ^a	124 555	106 393 ^a	70 165	200 228 ^a	198 654	89 668 ^a	61 364
Employees	Number of employees	2 ^b	2	3	3	3	2	2	1
Branches	Number of shop branches	1 ^b	1	1	0	1	0	1	1
Electricity bill	Monthly electricity bill for national grid (NGN)	1 936 ^b	2 073	1 967 ^b	1 096	3 785	2 039	5 412 ^a	6 529
Fuel cost	Monthly spend on fuel (petrol/diesel) for generators (NGN)	10 444 ^a	2 744	5 573 ^a	3 076	8 000 ^a	0	5 533 ^a	2 850
Fire outbreaks	Number of fire outbreaks in the past five years	1 ^b	0	1 ^b	0	2 ^b	1	2 ^b	1
Cost of fire outbreaks	Estimated business cost of fire outbreaks (NGN)	1 100 000	1 272 792	6 250 000	2 500 000	268 333	249 015	453 333	537 424

Table A3: Descriptive statistics of users and non-users by product kind (Continued)

		Stationery (books, graphics and gift cards)			
		Users (N=18)		Non-users (N=36)	
		Mean	SD	Mean	SD
Household income	Percentage of household income from trading	69 ^a	31	69	28
Monthly income	Average monthly income from trading (NGN)	109 611 ^a	72 048	151 825 ^a	171 537
Employees	Number of employees	2 ^b	2	3 ^b	1
Branches	Number of shop branches	1 ^b	0	1 ^b	1
Electricity bill	Monthly electricity bill for national grid (NGN)	3 133 ^b	2 984	2 712 ^b	1 695
Fuel cost	Monthly spending on fuel (petrol/diesel) for generators (NGN)	12 031 ^a	11 205	9 946 ^a	17 877
Fire outbreaks	Number of fire outbreaks in the past five years	2 ^b	1	2 ^b	1
Cost of fire outbreaks	Estimated business cost of fire outbreaks (NGN)	2 483 333 ^a	3 837 795	177 333 ^a	279 788

Notes: ^a T-test results reveal a significant difference between users' and non-users' variable means; ^b T-test results reveal a non-significant difference between users' and non-users' variable means.

Table A4: Differences in means after matching

Variable	Treated	Controlled	% bias	t	p> t
Age	44.00	45.64	-14.4	-1.59	0.160
Gender	0.64	0.60	9.1	1.09	0.275
Education	10.85	10.67	3.9	0.46	0.645
Household size	5.47	5.46	0.5	0.07	0.948
Household income	76.57	77.59	-3.7	-0.44	0.658
Membership	0.19	0.19	-0.8	-0.10	0.918
Employees	2.41	2.59	-9.1	-1.08	0.280
Branches	1.28	1.32	-6.8	-0.74	0.459
Owned shop	0.82	0.83	1.7	0.21	0.832
Fire outbreak	0.30	0.26	9.6	1.09	0.278
Credit access	0.26	0.28	-4.7	-0.55	0.583
Food products	0.37	0.27	-2.1	-0.25	0.806
Clothing, shoes, bags and textiles	0.49	0.46	6.8	0.82	0.415
Electronics	0.06	0.08	-6.4	-0.81	0.419
Cosmetics	0.08	0.05	9.3	1.31	0.191
Homeware and kitchenware	0.05	0.05	0	-0.00	1.000
Reliability	0.93	0.95	-5.3	-1.06	0.290
R-square			0.02		
Chi-square			14.08		
P-value			0.78		
Mean bias			5.8		
Median bias			6.4		

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