

Effects of Increasing Credit Limit in Digital Microlending: A Study of Airtime Lending in East Africa

ABSTRACT

The recent decade has witnessed a significant increase in digital micro-lending in Africa, boosted by the surge in popularity of mobile phones and, especially, mobile money. Starting with airtime and cash lending through mobile money, numerous other products are now offered, including prepaid electricity vouchers. However, these innovative loan products are often hampered by a lack of credit history from customers. Thus, lenders resort to issuing small loan amounts that are expanded as customers make timely repayments.

Research from the credit card industry shows that increasing credit limits can lead to increased indebtedness and spending. Working with an airtime lender, this experimental study finds that people with increased credit limits behave similarly to credit cardholders, by increasing their borrowing. However, this increased borrowing negatively affects their repayment rate and long-term usage of communication services. Additionally, customers' characteristics, such as their borrowing experience, influence their responses to increases in credit limits.

Based on the results of this experimental study, we present key recommendations for digital micro-lenders to minimize the potential negative impacts of increasing credit limits. We also discuss the use of randomized experiments as a research method in ICTD studies.

KEYWORDS

credit limit, digital lending, mobile phone, call detail records, CDR, RCT

1. INTRODUCTION

Access to finance, and particularly to credit, has been linked to poverty alleviation and economic development (Demirgüç-Kunt et al., 2008). Economists have shown that lack of access to credit (or financial market imperfections) impedes the ability of the poor to invest in their education despite the high marginal returns (Galor and Zeira, 1993) and significantly limits their occupational choices, pushing poorer people to choose to continue working for a wage over self-employment (Banerjee and Newman, 1993). Both of these effects can stunt countries' economic growth and increase income inequality. At the household level, access to credit can be an effective tool for poverty reduction by increasing the propensity to start income-generating activities, especially by marginalized groups (Khandker et al., 1998); improving per capita

expenditure on food and non-food items (Quach et al., 2005); and increasing the ability of the poor to educate their children (Ampah et al., 2017). Despite these stated advantages, limited work has been done to understand the amounts that could be lent without over-indebting borrowers. This question has become particularly salient as technology has lowered the cost of microlending and vastly extended its reach.

Indeed, financial technology (fintech) has revolutionized the way people access credit in the last decade, particularly in the developing world. By leveraging advances in machine learning and widespread adoption of mobile phones in developing countries, fintech companies have radically changed the microfinance infrastructure in these countries. Unlike traditional microfinance institutions, fintech firms are able to make use of the expansive infrastructure of mobile network operators (MNOs) as well as the vast amount of data routinely collected by MNOs to extend credit to significantly more people. In this manner, digital lenders are able to offer short-term loans that are instantaneous (loan approval is usually automated), convenient (borrowers request and receive loans through their mobile phones) and which do not require collateral (Chen and Mazer, 2016). As a consequence of this development, there has been a rapid growth in the number of microloans provided through digital channels in a number of developing countries. For example, the percentage of digital loans in Kenya grew from 41.5% to 91.2% of total loans issued between 2014 and 2018, with 77% of all borrowers taking loans solely through digital means (CFI, 2019). Tanzania in 2018 had as many as a fifth of its mobile owners borrowing through digital channels (Kaffenberger, 2018).

Since 2012, when the first digital microloans were disbursed on M-Pesa (Suri and Gubbins, 2018), the popular Kenyan mobile money platform, product offerings have diversified from pure cash loans. New innovative companies use mobile phones to provide a variety of products, such as Okoa Stima¹, which lets M-Pesa customers buy electricity on credit; solar kits to be paid in installments (examples include NOTS², Mobisol³ and M-Kopa⁴). In addition, Twiga⁵, a Kenyan start-up that links farmers and food vendors, partnered with IBM to provide credit scores to small vendors (Gebre, 2018). These credit scores enable the vendors to borrow from a number of digital lenders when they need to buy produce (Reagan, 2020). Other companies, such as Channel VAS⁶ and Comza⁷, work with mobile network operators to provide airtime loans to phone subscribers. For a number of digital borrowers, these loans are the first they have obtained from formal financial lenders (Goslar, 2016).

Due to a lack of credit histories and limited data from credit bureaus from many of the countries of operation (World Bank, 2016), microlenders are often required to provide small loans to many

¹ <https://www.safaricom.co.ke/personal/m-pesa/do-more-with-m-pesa/okoa-stima> (electricity on loan)

² <http://www.nots.nl> (solar kits on loan)

³ <https://www.mobisol.rw/> (solar kits and household's appliances on loan)

⁴ <http://www.m-kopa.com> (pay-as-you-go solar kits and household's appliances)

⁵ <https://twiga.com> (food distribution from farmers to retail shops)

⁶ <https://www.channelvas.com> (mobile phones and airtime on loan)

⁷ <http://www.comzafrica.com> (airtime on loan)

applicants with the understanding that a number of these consumers will default. This approach is adopted in order to collect as much data as possible to help create and refine the lenders' credit risk assessment models (Izaguirre et al., 2018). The amount that a consumer is subsequently able to borrow (their credit limit) is then changed based on their repayment patterns. This paper investigates the impact that increasing credit limits has on borrowers.

Working with an airtime lender in an East African country, we find that, like credit cardholders, airtime borrowers respond strongly to changes in credit limit. In the study, we randomly selected close to 30,000 airtime borrowers and increased their credit limits based on their previous borrowing pattern, as routinely done by microlenders. We find that increasing credit limits negatively impacts repayment rates and loan amounts. This paper also discusses other observed effects of increasing credit limits on airtime recharge and usage of telecommunication services by borrowers.

This article is organized as follows: in section 2, we review the literature on airtime and digital lending impacts on borrowers. We also present the literature on credit limits, mostly drawing from work on credit cards. Section 3 presents our methodology, including details of the study context, experiment set-up and data collection. Section 4 details the results, followed by a discussion of the findings and recommendations for digital lenders in section 5. In section 5, we also reflect on the merit of randomized experiments as a research method for ICTD. Finally, we discuss the study's limitations and possible avenues for future work before concluding the paper.

2. RELATED WORK

2.1. Airtime as a Financial Tool

Airtime can be seen to share some of the same characteristics as money, such as the ability to act as storage of value and an exchange mechanism of value (Madise, 2015). Prior to the introduction and thereafter widespread adoption of mobile money services, a number of mobile network operators were already offering airtime transfer services, often called "Me2U" (me to you), which let subscribers share airtime. Users readily adopted these services as a form of money transfer and, to a lesser extent, a payment system for services and goods. For example, close to 10% of Tanzanian respondents to a survey by Comninou et al. (2009) mentioned that they used airtime to pay for goods or services. Furthermore, a number of companies, such as SendAirTime.com⁸, allow people abroad to purchase airtime for friends and families back in their home countries. The recipients can then exchange this airtime for cash by selling the airtime, thereby turning airtime into a form of remittance transfer service. Removing the need for middlemen (the airtime buyer), Aamo et al. (2017) propose a mechanism of directly crediting

⁸ <https://www.sendairtime.com> (airtime purchase for people abroad)

bank accounts from customers' airtime. The combination of these two systems could result in a fully-fledged remittance method. However, their further adoption by users may have been stunted with the introduction and rise of mobile money services.

At the country level, some mobile phone subscribers have used airtime transfer to help those in their communities facing a sudden, external shock, particularly in the context of underdeveloped financial structures. A study by Blumenstock et al. (2016) showed that in the wake of a devastating earthquake affecting the southwestern region of Rwanda, people from other parts of the country responded by increasing airtime transfers to those affected. Thus, airtime transfer enabled people to quickly send financial assistance over large geographic distances.

2.2. Digital Lending

In the first major study to evaluate the effects of digital lending on borrowers, Bharadwaj et al. (2019) found that access to M-Shwari, a Kenyan digital lending platform, increased households' resilience to financial shocks. Users able to quickly borrow small amounts of money could maintain long-term expenses, such as paying for education. These expenses would have otherwise suffered cuts in favor of more basic necessities such as food and medication (Bharadwaj et al., 2019; Ahmed and Cowan, 2019). Similarly, Barriga-Cabanillas and Lybbert (2020) observed that users of an airtime lending platform in Haiti were driven to borrow for mainly two reasons: (1) poorer users tended to borrow to maintain communication when facing liquidity constraints; (2) the less poor users tended to borrow for convenience. Thus, it would seem that the convenience and speed afforded by digital lending increase resilience by allowing people to smooth their consumption in times of financial and other disruptions.

However, most digital lending products remain less suited for entrepreneurs due to their short duration (typically between a few days to a month) and the high interest rates charged (Francis et al., 2017). It is hoped that loan products that are more effectively tailored to entrepreneurs, such as microfinance crowdfunding (Sun, 2017), might address this shortcoming. Digital loans have also been associated with unsustainable borrowing, with some consumers taking loans to settle those taken from a different lender (Wathome, 2020). Defaulting on microloans has led to millions of people being blacklisted in credit reference bureaus, most with outstanding loans of less than \$10 (CFI, 2019). More research is needed to understand the effects of digital lending on various groups of borrowers, such as entrepreneurs and women. The results could help in designing more suitable products. This article makes such a contribution by specifically investigating how borrowers respond to increases of credit limits in digital lending.

2.3. Impact of Credit Limit Changes in the Credit Card Industry

Within the credit card industry, multiple existing studies have shown that raising credit limits tends to lead to increased borrowing and indebtedness (Soman and Cheema, 2002; Lin et al.,

2019). Lin et al. (2019) determined that a 1% increase in credit limit led to increases of 0.44% in monthly spending and of 0.20% in debt among Chinese credit cardholders. Two possible reasons have been offered to explain this: (1) borrowers use their credit limit as a signal of their future income (Soman and Cheema, 2002; Lin et al., 2019); or (2) borrowers tend to maintain the same ratio of debt to credit limit (utilization rate) regardless of their credit limits (Bertaut and Haliassos, 2006; Gross and Souleles, 2000, 2002). In addition to these causes, Bearden and Haws (2012) found that borrowers may respond differently to changes in credit limit based on their attitude to spending.

The generalized borrowing patterns described above seem to be exploited by certain lenders. For example, Gan et al. (2016) found that a number of credit card companies in China were issuing higher credit limits. This is done to entice applicants and increase credit card uptake, particularly amongst high spending demographics, such as married people with children or those living with extended families. These groups have been shown to have high expenditures on their credit cards (Chien and Devaney, 2001; Kinsey, 1981; Steidle, 1994). As a result, some consumer advocacy groups now recommend to regulators that credit card issuers be restricted in increasing their customers' credit limits to mitigate over-indebtedness (Citizens Advice, 2017).

2.4. Borrowing and Repayment in the Microfinance Industry

Currently, there is limited work which considers the impact of credit limit changes on loan repayment in microfinance. Relevant studies considering the impact of loan size on repayment patterns have proven inconclusive, with larger loan sizes found to be both a positive (Roslan and Karim, 2009) and a negative (Sharma and Zeller, 1997) predictor of loan repayment. Roslan and Karim (2009) found that larger loans had a better repayment rate since the lender (in this case, a microfinance institution working with farmers in Malaysia) was more careful in evaluating the creditworthiness of borrowers of larger amounts. In addition, borrowers mentioned that smaller loan amounts were insufficient and negatively affected the cash flow of their projects. On the other hand, analyzing the loan performance of group-based lending in Bangladesh, Sharma and Zeller (1997) noted that larger loan sizes increased the risk of default due to "limited investment capacities and the limited risk-bearing abilities of the rural poor" (Sharma and Zeller, 1997, p. 1741). Thus, it would seem that the impact of loan size on repayment within microfinance may be dependent on context-specific factors.

Most existing studies have tended to focus on alternative factors which may impact loan repayment patterns. Key elements identified by this body of work include:

- group vs individual loans: group lending has a better repayment rate than lending to individual customers (Brehanu and Fufa, 2008);
- gender: female borrowers tend to be better at repaying loans than their male counterparts (D'espallier et al., 2011; Abdullah and Quayes, 2016);
- age: loans to older borrowers tend to outperform those to younger borrowers (Mokhtar, 2011);

- business productivity: people engaged in more productive activities are able to make timely repayments (Brehanu and Fufa, 2008; Haile, 2015); and
- repayment installment: shorter repayment period (for example, weekly vs monthly) and higher installments amount were linked to poor repayment (Mokhtar, 2011; Haile, 2015).

Schicks (2010) provides an extensive literature review on the causes of over-indebtedness of microfinance customers, such as external shocks, lender behavior like offering unsuitable products and borrowers' unstable income.

The reason for the current lack of research on the effect of increasing credit may be attributed to the perceived economic behaviours and attributes of microfinance customers. Specifically, this group of consumers has been considered to be credit constrained (Diagne et al., 1998, 2000; Diagne, 2002; Hazarika and Alwang, 2003; Kedir, 2003) and this may have limited the number of studies able to analyze credit limit changes. This paper contributes to the literature by analyzing the effects that increasing credit limits have on borrowing patterns and loan repayments of airtime borrowers.

3.METHOD

3.1. Study Background

For this study, we partnered with an airtime lender that works with a mobile phone operator (MNO) to provide micro airtime loans. Both the lender and the MNO are based in a small East African country that is classified in the “low income” category (i.e., countries whose gross national income per capita is less than \$1,036 per year) by the World Bank. This MNO is the second largest mobile service provider in the country, commanding about 46% of the total national subscriber base in July 2019, at the start of this study. Due to the sensitivity of the commercial data disclosed in this article, we were not authorized to reveal the identities of the lender, the MNO and the country.

Similar to many developing countries, the vast majority of mobile phone subscribers in that country are prepaid customers; i.e., they have to load (or recharge) airtime on their phone account before they can make phone calls, send text messages or access the Internet. Customers running out of airtime when they are unable to recharge their accounts means that the MNO is losing potential revenue, while the customers are inconvenienced in their phone usage. In this situation, the lender provides a means of borrowing airtime that the customer can repay later, with the addition of a service fee. This independent lender underwrites the entire loan amount, guaranteeing the MNO payment in case of customer default, in exchange for a share of the service fee. Therefore, the lender has two ways of maximizing profits: (1) increasing the lent amount, while (2) reducing the loan default rate.

About 73% of the MNO's active subscribers were qualified to borrow in July, with 45% of qualified customers taking loans. Airtime loans represent $\approx 27\%$ of the airtime spent on the network, with a number of customers borrowing up to 40% of their monthly airtime usage. The median borrower is in the bottom third of spenders on the network, suggesting that most of the lender's customers were predominantly low-income people with limited spending capability.

Unlike her neighbors in the wider East Africa region, such as Kenya and Tanzania, digital lending in our country of study is not yet widespread. The consumer digital credit landscape remains dominated by banks that extend this facility solely to their existing customers. With only a quarter of the population having bank accounts, airtime lending is currently the most used form of digital borrowing in this country, especially among the poor and unbanked people who have access to mobile phones.

The MNO's subscribers are offered 7 possible discrete loan amounts (denominations), which range from $\approx \$0.021$ to $\approx \$0.316$. Though seemingly low in absolute value, the \$0.316 airtime loan gives a phone user up to 200 minutes of voice calls as well as 20 text messages.

The service fee charged is a fixed, non-compounding fee, whose amount depends on the loan amount. It ranges from 15% for the highest denomination to 75% for the lowest denomination. The lender uses the past recharge amounts of the MNO's subscribers, among other factors, to assign customers various available credit limits from the seven different denominations. Therefore, a subscriber with a relatively large past recharge amount who fulfills the lender's other criteria (such as the time since their phone number was activated) will be offered the highest credit limit (i.e., the highest denomination of \$0.316). This subscriber is then able to borrow different amounts multiple times until they have exhausted their credit, at which time they have to make some payment before they can borrow again. Thus, this system can be considered akin to credit card lending, if customers had to borrow in specific discrete amounts.

When a subscriber borrows airtime successfully, they are informed of the commission fee, the total amount they will have to pay, as well as the loan due date which is seven days from the time of borrowing. In reality, unpaid loans remain due until the subscriber churns from the network. To repay the loan, the borrower simply needs to recharge their phone and the loan amount and commission fee are automatically deducted from their account.

3.2. Study Set-up

In this experimental work, we first started by randomly selecting 50,000 potential participants from the over 2.6 million mobile phone subscribers active on the network. We computed their new credit limits based upon their existing borrowing and repayment pattern, reflecting the practices of microlenders in the real-world, as noted in the previous section (Bharadwaj et al., 2019). To create the new credit limit for each borrower, we first computed the probability that the borrower would repay all their loans. This approach was based on the method described in (Shema, 2019), which provides an effective way of computing the probability that an airtime

borrower would repay within seven days each loan borrowed in a month. This method, based on the random forest algorithm, uses data on recharges and past loans to compute this probability. However, in this study we increased the expected repayment period from seven to thirty days. The new credit limit for each borrower was then obtained by multiplying this probability by the total loan amount used by the borrower in the month prior to the start of the experiment; i.e., July 2019. We reasoned that if a customer is able to repay all their loans within thirty days, then they would be eligible to borrow up to the total amount they used in the previous month before they were required to make repayments in order to borrow further. Since the probability of repayment ranged from 0 to 1, the highest credit limit would be the total amount borrowed by a customer in July.

Using the above method to compute the new credit limit, 29,985 (or 64.44%) of our participants saw their credit limit increased compared to the July level. 2,521 (or 5.42%) had theirs decreased, mostly due to low borrowing in July. The remaining participants, 14,025 (or 30.14%), maintained the same credit limits. Since the focus of this study is on the effect that increasing credit limits has on borrowers of microloans, our treatment group comprised the 29,985 participants with increased credit limit.

We did not actively recruit the participants and did not inform them of the ongoing study. This was in order to minimize any potential influence on their borrowing behavior. Our participants instead learned about their new credit after the first borrowing, when they received a message regarding the remaining amount from their credit limit that they could still borrow. Thus, the change of credit limit was initiated by the researchers through the lender, with no input from the borrowers, besides their borrowing habit. We conducted this experiment for 8 months, from August 2, 2019 to March 31, 2020.

Figure 1 shows the distribution of the ratio in credit limit increase. The study participants with the median credit limit increase saw their credit limit doubled, some from $\approx \$0.16$ to $\approx \$0.32$, while the highest from $\approx \$0.47$ to $\approx \$0.94$. The highest credit increase was 209.15% for a participant with a large borrowing in July, but whose credit limit had been $\approx \$0.02\$$.

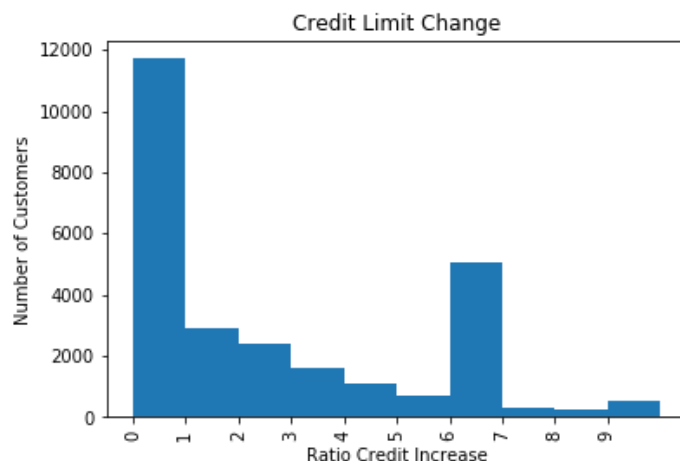


Figure 1: Ratio of Credit Limit Changes for Experiment.

To isolate the effect of increasing credit limit on borrowing and repayment, we had to control for two major factors. First, the study participants had their credit limit increased based on their previous borrowing and repayment behavior. Thus, our participants had borrowed larger amounts in July and/or had been making timely repayments compared to the average airtime borrowers. To control for these two factors, we randomly selected another 29,985 group of borrowers who could have had their credit limits increased, but had not been selected as treatment participants. These borrowers had continued to be evaluated by the lender's current system.

Second, the lender re-evaluates credit limits on a daily basis. Thus, borrowers can have their credit limits changed any day based on their repayment behavior as well as other criteria used by the lender for credit risk assessment. However, during the experiment, in addition to increasing the credit limits of our participants, we also froze these throughout the study period to allow for a longer evaluation period. To control for this factor, our second control group is made of the 14,025 participants who had their credit limit kept the same during the study period.

3.3. Data

Working with the lender, we obtained data from three sources: the MNO's subscribers' recharges, airtime usage, and their airtime borrowings. These three datasets cover a nine months period from July 1, 2019 to March 31, 2020.

The recharge dataset contains daily summaries of airtime recharges. Thus, each record has 1) an anonymized identifier of the phone number whose account is credited, 2) the date of the recharges, 3) the number of recharges, and 4) the total amount recharged on that day. We do not have specifics of each individual recharge, such as the time of a recharge or the amount recharged at once, and these records are only summations conducted on a daily basis by the MNO. Also excluded from these daily summaries are phone numbers that did not make any recharge at all. In total, our recharge dataset has more than 75 million records generated by more than 3 million unique subscribers.

The second dataset contains daily summaries of airtime usage. The MNO considers "usage" any activity that generates revenue for its business, such as voice calls, texting, Internet surfing, bundle purchases, or airtime loan repayment. Recharging of phone accounts does not necessarily result in revenue for the MNO, as people could keep the airtime without spending it. Airtime transfers between two mobile subscribers are also not considered as usage until the airtime is spent by the recipient. Each record in the usage dataset represents the total amount spent by a subscriber on a particular day. Thus, each record has the following fields: 1) an anonymized identifier of the phone number incurring the expense, 2) the date of the usage, and 3) the total airtime amount spent by the subscriber on that day. It is worth mentioning that we do not have details of how the airtime was spent or which activity the subscriber conducted to spend the airtime. The dataset only shows the total airtime amount spent by a subscriber on any

particular day. This dataset has more than 165 million records of daily airtime usage from more than 3 million MNO's subscribers.

Our last dataset contains details of airtime loans disbursed by the lender. For each loan issued, the lender records details of the loan such as, 1) an anonymized identifier of the borrower, 2) the exact date and time when the loan was disbursed, 3) the amount borrowed, 4) the service fee (interest) associated with the loan, and 5) a flag indicating whether the loan has been fully or partially paid. In addition, details for each payment are also captured by the lender, including, 1) the date and time the payment was made, and 2) the amount paid. Though the lender saves the details for each partial payment, we only have the details of the last payment as well as the total amount paid for each loan. Therefore, we are unable to identify the amounts paid in multiple payments, although we have the total number of payments for each loan. Between July 1st, 2019 and March 31st, 2020, the lender had disbursed close to 40 million microloans. The median loan amount was \$0.105, which attracts a 30% service fee. On average, the loans were paid in approximately 1.43 installments.

4.RESULTS

In this section we first report the effects that increasing credit limits has on borrowers' behavior, such as the borrowing patterns, airtime recharges and mobile service usage, and loan repayment rates. Second, we report the results of a regression analysis that shows factors that influence debt repayment when credit limits are manipulated.

4.1. Effects of Increasing Credit Limits

To better understand the effects that increasing credit limit has on these indicators, we divided the experimental group into two subgroups, (i) those with increased credit limit (credit increase), and (ii) those whose credit limit was not changed from its level prior to the experiment. This second group helps in controlling for the effect that freezing the credit limit of (i) might have had on the outcomes of interest. In addition to these two groups, we also have two control groups of similar sizes to the corresponding experimental groups, (i) those who could have had their credit limit increased, and (ii) those whose credit limit would not have changed. These control groups help isolate possible effects that pre-existing conditions (previous repayment patterns and loan volumes) of the experimental groups might have had on borrowing and repayment outcomes. The credit limit of these control groups continued to be assessed by the lender's current system.

Therefore, in this section, we compare the outcomes of the two treatment groups with their corresponding control groups. Unless otherwise stated, the lines in the following graphs represent the difference between the experiment groups and their control groups. We will use

these differences to also compare the participants who saw their credit limits increased to those whose credits were maintained the same throughout the study period.

4.1.1 Impact on borrowing

Figure 2 shows the total loan amount borrowed by each treatment group as a percentage of the total loan amount borrowed by their corresponding control groups. The participants with increased credit limits responded to the change by immediately increasing their borrowing by about 10.73% compared to their control group. However, this increase in borrowing almost completely disappears the following month and becomes smaller than that of the control group, reaching a low of 91.05% of the total amount borrowed by the control group in February. The group with the frozen credit limit experienced a more gradual reduction of the total amount borrowed, before stabilizing at about 95% of the amount borrowed by its control group. Therefore, the drastic reduction in loan amount experienced by the group with increased credit limits does not appear to be due to the frozen credit limit, since it happened faster than that of people whose credit limits were not changed. This suggests that increasing credit limits can lead to a dramatic increase in borrowing followed by a similarly quick reduction to levels comparable to those with frozen credit limits.

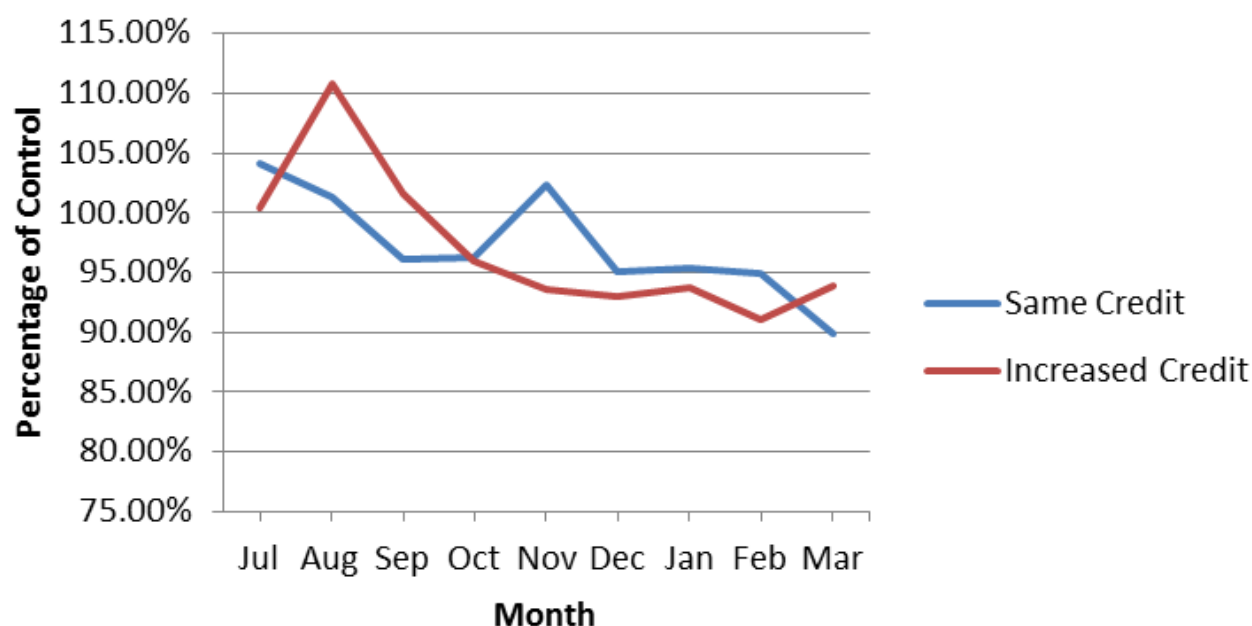


Figure 2: Total loan amount.

4.1.2 Impact on airtime usage and recharge

The sudden increase in borrowing described above could have been an indication of unmet communication needs. That is, perhaps people want to use the MNO's services more, but are constrained by a lack of means to afford them. If this is the case, we would expect to see a corresponding spike in the amount spent on various MNO's services.

However, figure 3 shows that, whereas the increase in loan amount observed in August correlates with an increase in the amount spent on communication, the magnitude of these increases greatly differ (about 1.06% increase in the amount spent on communication services compared to the 10.73% increase in borrowing). This suggests that people viewed the ability to borrow more airtime as an alternative, instead of a complement, to buying it.

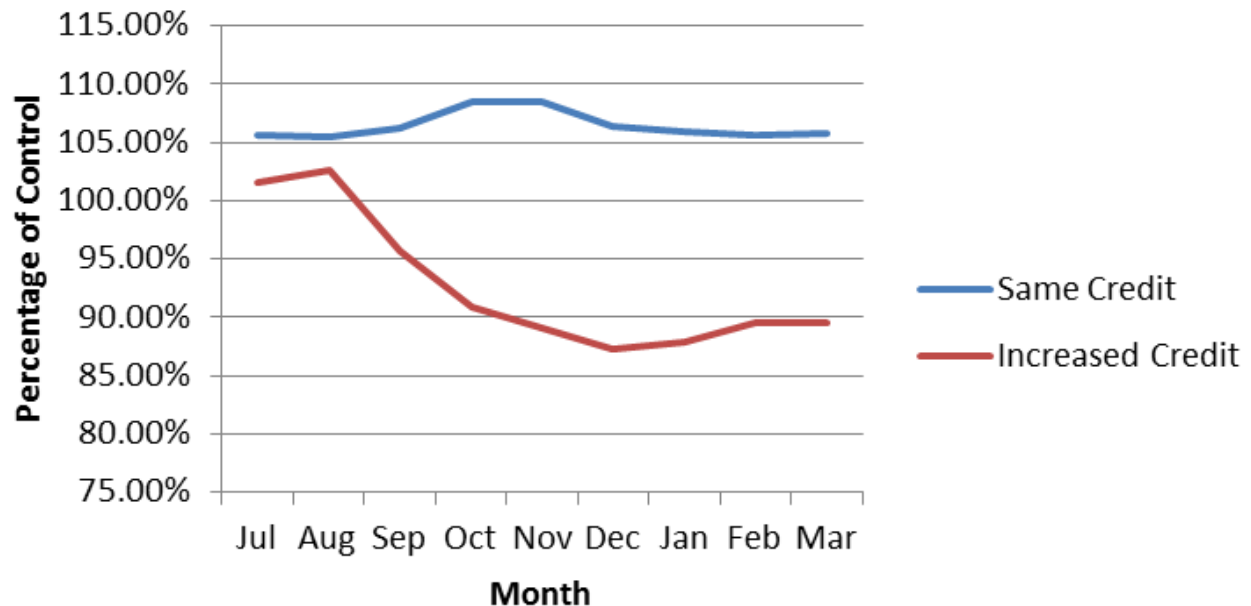


Figure 3: Total usage amount compared to control groups.

Indeed, figure 4 shows a drastic reduction in airtime purchases (recharges) that correspond to the observed increase in airtime borrowing. Perhaps more worrying is the fact that neither airtime usage, nor recharge ever recovered from this effect during the study period. Increasing credit limit for airtime borrowers seems to reduce the amount of airtime usage and recharge by about 15% and 25%, respectively, once we control for borrowers' preexisting characteristics as well as the fact that their credit limit was not changed throughout the experiment period.

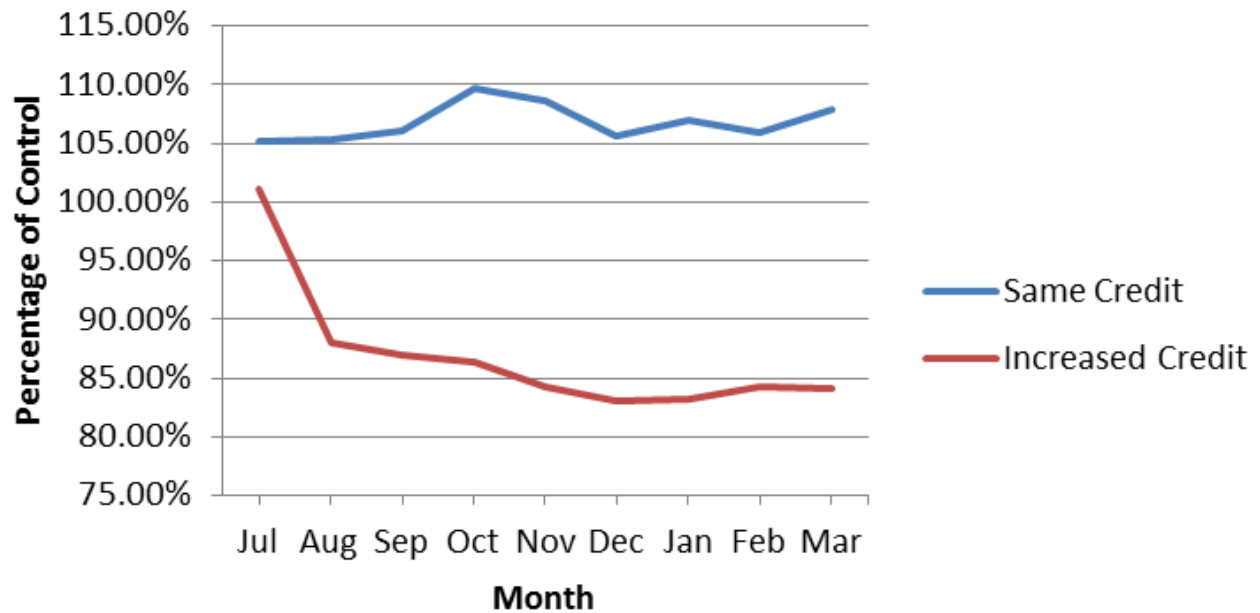


Figure 4: Total recharge amount compared to control groups.

4.1.3 Impact on loan repayments

Unsurprisingly, this reduction in recharges coupled with an increase in borrowing led to a drastic reduction in repayment rates by the group that had a credit limit increase. Figure 5 shows the difference in repayment rates between the two experimental groups (those with increased credit limits and those with frozen credit limits) and their corresponding control groups. Loan repayment rate is here defined as the percentage of loans paid within thirty days of borrowing. In July, prior to the start of the experiment, the thirty-days repayment rates for both groups were similar to their control groups.

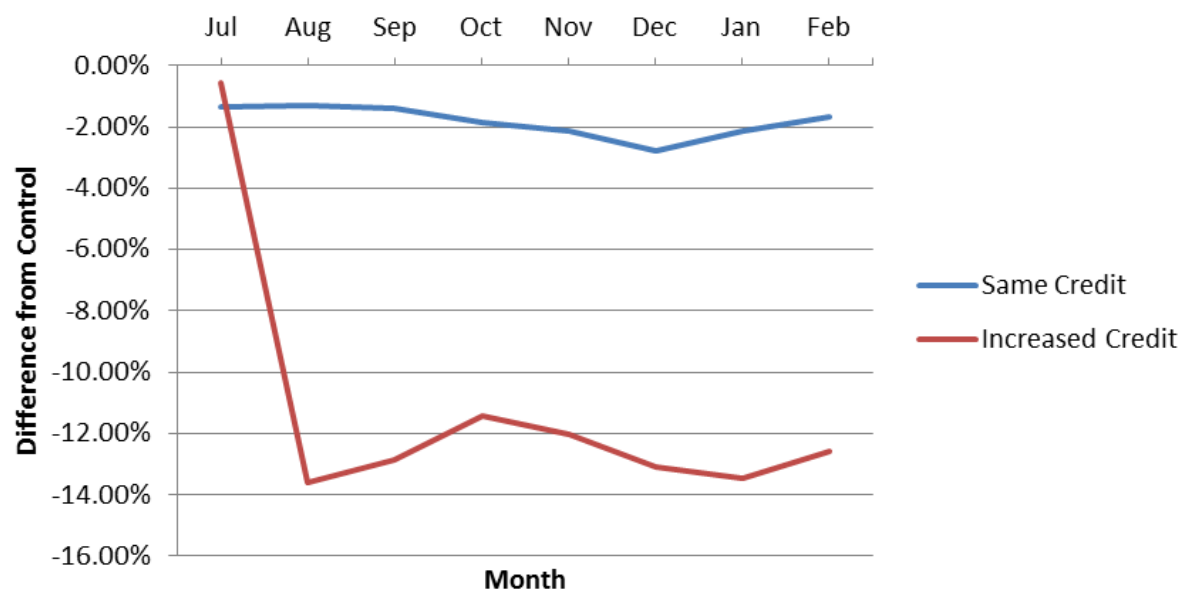


Figure 5: Difference in repayment rates between the experimental and the control groups.

Freezing credit limit appears to have minimal impact on repayment rate, as the “same credit” group reduced theirs only slightly and gradually when compared to the average repayment rate of their corresponding control group. The largest reduction in repayment rate attributable to the freezing credit limit was observed in December, five months after the start of the experiment, when it was 2.78 percentage points lower than that of the control group.

On the other hand, the people with increased credit limit had the sharpest decrease in repayment rate at the very start of the experiment, by 13.62 percentage points compared to people who could have had their credit increased but had not been selected. This loan repayment rate stayed low throughout the study period and never recovered. Figure 5 shows that increasing credit limits was responsible for roughly a 10 percentage point decrease in repayment rate.

In summary, airtime borrowers seem to respond by taking on more loans when their credit limits are increased. However, this increase in borrowing is only temporary and quickly dissipates, with the borrowing amount returning to previous levels. On the other hand, their usage of communication services suffers a fast and long lasting reduction after a small initial increase. Similarly, our participants decreased their purchases of airtime even long after the initial credit limit increase, impacting their repayment rates. However, increasing credit limits seemed to impact people differently. Some people completely stopped using the services of MNO and may have left the network; while others continued to make timely repayments. Therefore, in the next section we explore possible factors that might affect how people respond to credit limit increases.

4.2. Factors Influencing Debt Repayment

In order to understand how various factors affect the airtime loan repayment rates when credit limits are increased, we ran two separate linear regression models for the group with increased credit limits and those whose credit limits were not changed, who act as a control group. The regression independent variables were partially inspired by the body of literature on the effect of increasing credit limit on borrowing and repayment. Here, the dependent variable is the percentage of loans paid within 30 days (repayment rate) in the month after the independent variables were observed. For example, to predict the 30 days repayment rate of March, we computed the independent variables as they occurred in and up to February. This was in order to observe how a customer would respond to changes in their credit limit before these changes are effected.

Table 1 reports the coefficients of the two linear regression models. For these models, we used the data from the participants, collected during the experiment period from August 2019 to March 2020. However, since the experiment ended in March 2020, we used only the dependent variable, the 30 days repayment rate, from this month’s data. The independent variables

computed for February are used to predict the 30 days repayment rate of March. We cannot use the independent variables from March since our data does not have the 30 days repayment rate for April.

Table 1: Regression Coefficients

Features	Description of Features	Increased Credit Limit	Same Credit Limit
New credit limit	assigned credit limit at the start of the experiment (in USD)	(0.030) [†]	(0.040) [†]
Percentage of credit limit change	ratio of new credit limit to July credit limit	(0.009) [†]	0.000
Probability of payment	computed probability that borrower will repay all loans within 30 days (ranges from 0 to 1), see Shema (2019)	0.242 [†]	0.336 [†]
Average loan duration	average number of days before loan repayment	(0.001) [†]	(0.001) [†]
30 days payment rate	percentage of loans paid within 30 days in a month	0.217 [†]	0.144 [†]
30 days payment rate in the past 3	average 30 days payment rate of the previous three months	0.125 [†]	0.121 [†]
Number of loans	total number of loans taken in a month	0.002 [†]	0.007 [†]
Number of loans in the past 3	total number of loans taken in the previous three months	0.000 [†]	0.003 [†]
Age of Borrowing	number of days since the first loan was granted	0.000 [†]	0.000 [†]
Age on network	number of days since the phone number was activated on the network	0.000 [†]	0.000
Total recharge	total amount recharged in a month (in USD)	0.016 [†]	0.002 ^{**}
Is recharge greater than last 3	dummy variable indicating whether the total recharge for this month is greater than the average recharge of the previous three months	0.006 ^{***}	0.008 ^{**}
Is recharge greater than market average	dummy variable indicating whether this borrower's total recharge amount is greater than the average subscriber's recharge amount for this month	0.010 ^{***}	0.003
Total usage	total amount used in a month on all MNO's services (in USD)	0.010 [†]	0.001 [†]
Is usage greater than last 3	dummy variable indicating whether the total usage for this month is greater than the average usage of the previous three months	0.004 ^{**}	0.005
Is usage greater than market	dummy variable indicating whether this borrower's total usage amount is greater	0.016 [†]	0.014 ^{***}

average	than the average subscriber's usage amount for this month		
Total loan	total loan amount taken in a month (in USD)	0.003 ^{***}	0.030 [†]
Service fee rate	average percentage of service fee (or interest) paid per loan	0.270 [†]	0.326 [†]
Ratio of loan to recharge	total loan amount divided by total recharge amount	(0.003) ^{**}	0.017 ^{***}
Airtime balance	the sum of loans and recharges in the month minus total usage amount (in USD)	0.009 [†]	0.010 [†]

[†] p-value = 0

^{***} p-value ≤ 0.001

^{**} p-value ≤ 0.01

^{*} p-value ≤ 0.05

4.2.1. Repayment patterns

Unsurprisingly, the variables related to repayment patterns (the computed probability of payment, the average loan duration, and the 30 days repayment rates of the loans taken in the past month and previous three months respectively) are significant predictors of the 30 days repayment rate. These variables are even stronger predictors for consumers with an increased credit limit, suggesting that the repayment behavior of borrowers should be considered before increasing their credit limit, as people with good repayment history are more likely to maintain this payment behavior after a credit limit increase.

4.2.2. Rate of credit increase

For participants with increased credit limits, the new credit limits as well as their ratio of increase negatively correlates with repayment rates. The higher the new credit limit and the bigger the increase, the less likely participants are able to fully service their loans within 30 days. This result seems to indicate that higher credit limits negatively affect repayment rates regardless of the participants past repayment behavior and total amounts borrowed. Since the new credit limits were computed based on patterns of previous borrowing and repayment, the participants who received higher credit limits were those with good repayment rates in the past and/or high levels of borrowings.

4.2.3. Length of borrowing and phone number ownership

As mentioned by Soman and Cheema (2002), we also find that how long a person has been borrowing (i.e., “age of borrowing”) is also a significant, positive factor in their repayment behavior, regardless of whether their credit limit was increased. The more experienced a borrower is, the more likely they are to pay their loans within 30 days. However, the number of

days since a person acquired their phone number (i.e., “age on network”) is a significant predictor of 30 days repayment rate only for people with increased credit limit. This result may also be linked to the fact that people are reluctant to change their phone numbers often, especially for those who have held the same phone number for a longer period of time. Thus, people would rather pay their airtime loan than change phone numbers by defaulting on their loan.

4.2.4. Airtime recharge and use

The total amounts of airtime that people recharge and use in a month were also significant predictors of their repayment rates for the following month, particularly for borrowers whose credit limits were increased. It appears that increasing credit limits encourages repayment for those borrowers whose airtime usage and recharge were already higher than the average subscriber of the MNO.

Paradoxically, higher service fees charged on loans seemed to result in better loan repayments across both treatment groups. This can be explained by the fact that smaller loan denominations incur higher service fee rates. Thus, this predictor might indicate that people who borrow in smaller denominations (amounts) tend to be better payers than those who borrow in bigger amounts, notwithstanding the higher fees (in comparison to loan amount) that small loans attract.

In the next section, we discuss what these results reveal about the effects of changing credit limits on borrowers' behavior and present some recommendations for digital lenders in general. We also reflect on the use of randomized experiments as a research method for ICTD studies.

5. DISCUSSION

5.1. Results Implications

As noted by previous studies, access to credit is crucial in helping people cope with unexpected financial shocks. However, the results of this study show that it is also important to investigate the optimal loan amount that can be extended to people. Past work demonstrated that mobile phone users with limited economic means borrow airtime to smooth out their consumption of communication services (Barriga-Cabanillas and Lybbert, 2020). Our results show that when credit limits are increased, people borrow more airtime as an alternative to purchasing it, leading to higher default rates.

In our study design, people had their credit limit increased based on the total loan amount taken in the previous month, as well as their repayment pattern. Those with the highest increase in

credit limits had borrowed bigger amounts as well as made timely repayments. With increased credit limits (i.e., the ability to borrow larger amounts at once), our study participants struggled to repay their loans. Therefore, it appears that the ability of borrowing a large amount at once, instead of multiple smaller amounts, can have a negative effect on repayment. Previous studies had proven inconclusive on the link between loan amount and repayment (Roslan and Karim, 2009; Sharma and Zeller, 1997). Perhaps more pertinent than the total amount borrowed, is the size of single loan instalments. Indeed, we observe that people borrowing in smaller denominations were more likely to make timely repayments than those borrowing larger denominations.

In addition, increasing credit limits seems to have the unintended consequence of locking people out of future borrowing. A number of our participants with increased credit limits stopped using their phones altogether and left the mobile network with outstanding loans. Luckily, they still have the opportunity of joining other mobile network operators in the country as the information about their default status is not shared across MNOs. However, millions of defaulters of digital microloans are not so fortunate as lenders report them to credit bureaus (CFI, 2019), barring them from future borrowing and sometimes leaving these borrowers at the mercy of abusive debt collectors.

Finally, this study found that borrowers' response to increases in credit limits is mitigated by factors such as their past repayment patterns and length of time since they started borrowing, akin to credit card users (Soman and Cheema, 2002). These findings have powerful implications for digital microlending. For example, the current high default rates observed among borrowers might be due to a lack of experience in using these products. We may expect that as these services mature and users gain more experience, borrowing might become less influenced by credit limit changes. Meanwhile, people should be given a chance to gain experience in borrowing digital loans with smaller credit limits.

Based on the results of this study, we would recommend that, in general, digital microcredit lenders may wish to limit changing customers' credit limits where possible. Maintaining the same credit limit is beneficial as people seem to be better able to realistically plan their borrowing and keep up with repayments. Changing credit limits, on the other hand, may send a signal to users that makes them change their borrowing and repayment patterns. However, if a customer's credit limit needs to be increased, the lender could consider the following factors that impact future payment:

- **Borrowing experience:** customers who have been borrowing for a longer period of time seem to be better payers when credit limits are increased. Borrowing experience should not simply be looked at as the number of loans taken, but also the duration since the client started borrowing as this also appears to increase future repayments.
- **Product use experience:** in addition to borrowing experience, how long a client has been using a particular product may strongly contribute to their repayment rate when their

credit limit has been increased. For example, for cash lenders operating through a mobile money service, accounting for the duration since a client started using mobile money, and not just borrowing, might lead to better repayment rates. Some lenders appear to have learned this and are now actively discouraging “spinning”, a practice where people borrow small amounts and repay them quickly in order to have their credit limit increased (Oppong and Mattern, 2020).

- Repayment history: prior to increasing a customer’s credit limit, lenders would benefit from looking at the longest possible repayment history. Although analyzing the payment patterns of the period prior to increasing the credit limit is beneficial, the lender would also benefit by looking at the customer’s repayment history from further in the past.
- Borrowing amounts: in addition to repayment history, people who borrow small amounts tend to remain good payers after the credit increase. This borrowing pattern might indicate that either the client has a high “consumer spending self-control”, preferring to borrow only the amount they need or that the client is not cash strapped and, thus, able to service their loan.

5.2. Using Randomized Experiment Method in ICTD

In this study, we employed a randomized experiment, or randomized control trial (RCT), method to evaluate the effects of increasing credit limits in digital microlending. Randomized experiments, which are increasingly used in development economics (Banerjee and Duflo, 2009), find limited adoption in ICTD studies which mostly employ observational research methods such as case studies (Walsham and Sahay, 2006). However, randomized experiments can be particularly well-suited for exploring causal relationships between treatments and outcomes (Babbie, 2020). Such knowledge can lead to robust results (Nan et al., 2020) able to facilitate effective policy-making (Ilavarasan, 2017) and provide relevant avenues for further research.

Digital lending platforms present a number of advantages that can help overcome key challenges identified with randomized experiments (Banerjee and Duflo, 2009). For example, digital lending platforms operate countrywide and some even across countries. Thus, a randomized experiment conducted on participants spread across single or multiple countries is less “environment dependent” and more generalizable. This type of study might answer questions such as the influence of loan size on repayment in microfinance (Roslan and Karim, 2009; Sharma and Zeller, 1997). However, implementer effects could still be an issue depending on the platform of study. For example, the lender in this study works with one of the two mobile operators in the country. It is possible that there might be specific traits of this MNO’s subscribers and / or of the subscribers that are airtime borrowers, which differentiate them from other subscribers. To be truly reflective of a certain environment (e.g., mobile phone subscribers

in a country), experiments such as the one conducted in this study would have to be reproduced with the other MNO.

The digital nature of these lending platforms permit researchers to truly randomize participation in treatment and control groups since the cost of reaching any participants is the same regardless of their locations and other physical constraints. In addition, RCTs conducted on these platforms suffer less from the John Henry effect (Saretsky, 1972) and the Hawthorne effect (McCarney et al., 2007) since study participants are not aware of being part of a study nor that their behavior is being evaluated. However, this might raise ethical issues that have to be carefully considered when designing these types of research.

In the next sections, we discuss a number of limitations of this study and avenues for future research, before concluding.

6. LIMITATIONS AND CONCLUSION

This study was conducted with a specific lending product: airtime loans for facilitating communication. Therefore, it might be limited by specific aspects present in airtime usage that might differ from the usage of other products. For example, the usage of telecommunication services might be more difficult to change in a short time. Additionally, our partner lender charges a service fee that does not compound over time. Unlike interest charges from other digital lending products, the airtime loans in this study attract a fixed service fee that is charged regardless of the duration of the loan. Thus, borrowers might not have the same incentive to pay sooner to avoid compounding interest on their loan as they might for other digital loans. Finally, other factors resulting from the implementation of this specific airtime loan might affect the generalization of this study. For example, repayments are deducted automatically from the customer's account when they recharge. The results from this study might have been different if customers had to actively repay their loans, as is the case for a number of digital lending products. All these factors, therefore, call for similar studies to be conducted with other lending products in order to obtain a more complete picture of the effects that increasing credit limits has on borrowers' behavior under other lending conditions.

The results of this quantitative work could be enriched by a qualitative study that would interview participants to better explore their views of credit limit and how its changes impact their mental models. For example, while this study has shown that people change their borrowing and telecommunication usage behavior in response to changes in their credit limit, a qualitative study might be better suited to uncover the reasons, from the borrowers' perspective, behind these changes.

Overall, our results indicate that increasing credit limits negatively affect repayment rates, future borrowing and can lead borrowers to stop using the service. However, the effects of credit limit

increases on borrowers are mitigated by factors such as how long they have been using a particular service, and their borrowing experience. Based on these findings, we have proposed a number of recommendations to digital microlenders about increasing their customers' credit limits.

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