

Evening the Credit Score? Impact of Psychometric Credit Scoring on Women-Owned Firms' Financial Access and Performance in Ethiopia *

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Abstract

Women's lower rates of ownership of collateralizable assets such as housing, land and vehicles is a constraint to accessing entrepreneurial finance that can fuel growth. This paper uses a randomized controlled trial in Ethiopia to test the impact of offering relatively large (up to USD 7,500) individual-liability, uncollateralized microfinance loans to women entrepreneurs, using psychometric credit scoring technology as a substitute for collateral requirements. The paper finds positive impacts on women entrepreneur's access to formal borrowing and firm survival through the COVID-19 pandemic and conflict. While the firms that the loans helped remain operational were profitable, there is limited evidence of impact on firm growth, likely due to the challenging macroeconomic environment.

Gender, Entrepreneurship, Firms
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1 Introduction

Women’s entrepreneurship can be a powerful force for economic growth and women’s empowerment (Bruton et al., 2013; Duflo, 2012). Yet a gender gap in entrepreneurial activity and performance persists across countries, both developing and developed (De Mel et al., 2009; Fafchamps et al., 2014; Berge et al., 2015; Hardy and Kagy, 2018). A key contributing factor to this gap is that, despite gender parity in access to microfinance (particularly in group lending schemes), women face more difficulty than men in getting loans of larger size and longer duration, which are typically important for business growth from micro- to small and medium enterprises (Agier and Szafarz, 2013; Field et al., 2013; Kersten et al., 2017). A major constraint to accessing larger loans is that women are less likely to own high-value assets such as land or housing that are typically required as collateral by banks, or by MFIs for larger loan sizes (Morsy and Youssef, 2017; World Bank, 2019). The “missing middle” phenomenon in credit markets, which contributes to a “missing middle” in the firm size distribution, is thus particularly pronounced for women. Such collateral constraints bind tightest in contexts where financial or digital infrastructure is lacking to identify creditworthy borrowers by other means, for example, by establishing a credit history through a well-functioning credit bureau. Absent a large shift in women’s ownership of collateralizable assets, innovative solutions are therefore needed to expand growth-oriented women-owned businesses’ access to capital.

In this paper, we test a possible such innovative solution: psychometric credit scoring. Psychometrics (literally “measurement of the mind”) assesses a borrowers’ character traits through validated psychological measures such as fluid intelligence and conscientiousness. The credit scoring technology then uses these traits to predict credit risk algorithmically, based on a model calibrated to repayment data (Alibhai, 2018). We conduct a randomized controlled trial (RCT) in Ethiopia, to evaluate the impact of offering large (up to USD 7,500), individual-liability microfinance loans to women entrepreneurs, using psychometric

credit scoring technology as a substitute for fixed-asset collateral requirements during the due diligence process. To our knowledge, our study is the first RCT to evaluate the impact of psychometric credit appraisal for microentrepreneurs on not only access to credit and repayment but also firm outcomes. Ethiopia is a particularly compelling context since enterprises in Ethiopia rank amongst the most credit-constrained in the world, and 40% of enterprises in the country rate access to finance as the biggest constraint they face (World Bank Enterprise Surveys, 2015).

Specifically, we partnered with a local microfinance institution (MFI) to introduce a product whereby women who lacked collateral but took the psychometric test and scored above a cut-off psychometric score would be in principle eligible for an uncollateralized loan ranging from 100,000 to 250,000 Ethiopian Birr (USD 7,500). The product was priced at an interest rate a few percentage points above the rate for the MFI's other loan products, and the maximum loan amount was smaller than that of the MFI's collateralized individual-liability loans, in order to dissuade women with access to collateral from applying to the uncollateralized psychometric product. After passing the test cut-off, women were also required to provide the correct documentation and to pass a business appraisal in order to qualify for an uncollateralized loan. For the purpose of the impact evaluation, women who passed both the psychometric cut-off and the business appraisal and documentation stage were then assigned into the treatment group (granted the loan they had applied for) or control group (not granted the loan despite being eligible) on the basis of computer-randomised assignment. This design enables us to estimate the impact on women business-owners of creating access to a psychometric-appraised loan, replacing traditional collateral requirements, compared to a control group of women business-owners who were assessed by the same process to be just as creditworthy but would not be able to access such a product in the absence of our partnership with the MFI to offer psychometric-appraised loans.

The psychometric-appraised, uncollateralized loan product was branded as a “WEDP-X” loan and was advertised via flyers to women entrepreneurs via the World Bank's Women

Entrepreneurship Development Project (WEDP). WEDP targets growth-oriented women-owned enterprises including via trainings and access to collateralized “WEDP” microfinance loans. Women entrepreneurs who presented themselves at the partner MFI’s branch offices and applied to take the loan were administered the baseline survey at the same time. This application and baseline process took place on a rolling basis from April 2018-March 2020. Those who qualified for uncollateralized, psychometric-appraised WEDP-X loans and were assigned to the treatment group received their loan shortly after the assessment and baseline, with a maturity of 22 months. The endline survey took place face-to-face in October 2021, after approximately half of the loans had fully matured and the other half had just a few months of repayment left.

We show that access to psychometric-appraised loans relaxed female entrepreneurs’ credit constraints. In particular, treatment with access to a psychometric-appraised loan more than doubled the likelihood that women had accessed a formal business loan in the last three years (in increase from 42% in the control group to 89% in the treatment group). This increased contributed to an overall increase of 50% in the likelihood that women had taken any kind of business loan, whether formal or informal (from 61% of the control group to 90% of the treatment group) . It is noteworthy that the majority of the 42% of the control group who were able to access formal financing did so via (collateralized) loans from the WEDP program via participating MFIs; not from bank loans, which were accessed by fewer than 10% of borrowers. Thus, the observed impact on formal borrowing may reflect a lower bound on the treatment effect on formal borrowing in a population that was not already served by another credit program. Access to the psychometric-appraised loans crowded out informal loans from family and friends on average; although this is driven by smaller loans sizes, and we observe that a few larger loans are actually crowded in for women who access a psychometric loan.

Although the psychometric-appraised loan product was designed to be targeted at women who lacked access to collateral at least at the time of applying for a loan, we do observe some

collateralised lending among both the treatment and the control group (29% of the control group, including 20% using a house and 18% a car, and some using both). The treatment group reduce use of vehicles and guarantors of collateral, suggesting that even if they have access to such methods of collateral, they prefer to take the uncollateralized loan even at a higher interest rate. This may be rational if there is an implied cost of negotiating access to collateral (or guarantorship) provided by another household member such as the woman's spouse; or if the woman prices the estimated cost of losing collateral or calling on a guarantor higher than the interest rate differential. Almost 20% of those in the treatment group, i.e. who accessed uncollateralised psychometric loans, report at endline that they used business inventory as collateral — perhaps reflecting a misunderstanding that what they purchased with the loan could be repossessed.

Second, we find that access to psychometric-appraised loans increased firm survival rate throughout the COVID-19 pandemic, conflict (including in the Oromia region where the study took place) and unfavorable macroeconomic environment, from 67% in the control group to 83% in the treatment group. Put differently, access to psychometric-appraised loans lowered the likelihood of firm death after 3 years by 17 percentage points, relative to an average firm death rate of 33% among control-group firms. This implies that access to psychometric-appraised loans effectively reduced business closure from the elevated rates observed during COVID-19 and the conflict to business-as-usual rates (McKenzie and Paffhausen, 2019). There is no significant impact on exiting entrepreneurship altogether, since a substantial proportion of control-group respondents who closed their original firm reopened a new firm, typically in different sector to their original firm.

Conditional on staying in business, access to psychometric-appraised loans did not translate into improved business performance or employment. While treated firms have higher average profits than control firms in the last year, this difference is not significant and is driven by the difference in the number of firms who closed and report zero profits (which is higher in the control group). Conditional on staying open, we observe no difference in

treatment- and control-group firm profits in the last year. Almost all treatment-group (and control-group) firms report positive profits in the last year, thus there is no evidence of access to psychometric-appraised loans keeping “zombie firms” alive during the COVID-19 pandemic. That said, treatment-group firms report significantly lower sales and profits in the last 30 days prior to the endline survey than control group firms. It therefore appears that access to psychometric-appraised loans kept more firms alive, and the surviving firms performed at least as well over the last year, but surviving firms may be particularly exposed to the unfavorable macroeconomic climate at the time of the endline survey in October 2019.

In terms of loan product performance, the psychometric-appraised, uncollateralized WEDP-X loans’ showed similar, low non-performance rates to regular collateralized WEDP loans prior to COVID-19. However, WEDP-X loans disbursed in early 2020 performed worse than loans disbursed before 2020 due to being almost immediately by the COVID-19 pandemic. WEDP-X loans disbursed in early 2020 also performed worse than regular, collateralized WEDP loans disbursed early in 2020, although very few such loans were disbursed. The overall WEDP-X repayment rates are still to be determined, as some loans disbursed in early 2020 have not yet reached maturity.

Psychometric credit scoring technology has been used to address the information asymmetries faced by financial institutions in a number of developed countries and some developing countries ([Arráiz et al., 2017](#); [Alibhai, 2018](#)), but without causal evidence on downstream firm outcomes. Across a number of other recent studies — see e.g. [Fafchamps et al. \(2014\)](#); [Ahmetoglu et al. \(2015\)](#); [Koudstaal et al. \(2016\)](#) — a persistent finding emerges that entrepreneurs with high levels of intelligence and motivation, and possessing particular character traits, benefit disproportionately from SME interventions.

We are also one of the first RCT studies to estimate the impact of a large loan product on female-run enterprises. Microfinance studies typically suffer from power issues. The access to finance gender results are more positive for larger-scale entrepreneurs. For example, in Nigeria, large cash grants (USD 50,000) to winning business plans in the YouWin! competition

run by the government triggered hiring and higher sales and profits for female-owned firms (McKenzie and Woodruff, 2017). In relation to loan size, Tarozzi et al. (2015) analyze the impact of increasing access to microfinance and found that female borrowing substantially increased despite the lack of guidelines about targeting women for the loans.

2 Context and intervention

2.1 Psychometric credit appraisal intervention

This study partnered with the Ethiopian MFI Wasasa to trial a psychometric loan appraisal technology that predicts repayment likelihood. The technology was developed by a US tech company. When applying for a loan, borrowers take an interactive, tablet-based test consisting of games, puzzles and questions. This tool seeks to enhance traditional methods of credit evaluation by collecting data designed to capture fundamental qualities of entrepreneurship such as an applicant’s character, intellect, business acumen, ethics, attitudes and beliefs, and using machine learning to combine this data into a score predicting the probability of repayment. The scoring tool was first piloted in the Ethiopian context with the MFI Amhara Credit and Savings Intitute (ACSI), allowing for adaptation and calibration on a sample of Ethiopian women entrepreneurs. The tool was shown to predict repayment of loans, which during the pilot phase were granted following normal procedures rather than on the basis of the score (Alibhai, 2018). The algorithm is also trained over time on localized Wasasa-borrower data; so, the predictive power of the model on loan repayment is theorized to improve as more data is collected.

For this impact evaluation, it was agreed with the MFI Wasasa that women who took the psychometric test and scored above a cut-off psychometric score of 370 would be in principle eligible for an uncollateralized “WEDP-X” loan of up to \$7,500 – specifically, a loan ranging from 100,000 to 250,000 Ethiopian Birr– at an interest rate a few percentage points above the rate for the MFI’s other loan products, and term of 22 months. After passing the test cut-

off, women were also required to provide the correct documentation and to pass a business appraisal in order to qualify for an uncollateralized loan.

The psychometric-appraised uncollateralized loan product was offered to women entrepreneurs through the World Bank’s Women Entrepreneurship Development Project (WEDP), which targets growth-oriented women-owned enterprises.¹ The loans were advertised through WEDP in the cities of Adama and Assela, in the Oromia region of Ethiopia. Advertising was done via flyers, which were distributed at the “One-Stop-Shop” offices where WEDP clients register and access advice and services. One-Stop-Shop staff were trained to highlight these flyers to clients when they registered or accessed services. The advertising flyers and OSS staff script specified that if a woman wanted a loan for her business but lacked collateral, she could take a 45-minute tablet-based test to enable the MFI to know her better, and then potentially be offered an uncollateralized loan. All further information about the loan product and application process was given to women once they presented themselves at the MFI branch, before taking the test.

3 Sample and data

The study sample consists of 357 WEDP entrepreneurs who presented themselves at Wasasa branches in the cities of Adama and Assela between April 2018 to March 2020 and decided to apply for an uncollateralized loan. The baseline data collection was thus done on a rolling basis, as and when prospective borrowers came to the MFI branches. The psychometric test and a short additional baseline survey were administered on tablets by MFI loan officers working at the Wasasa branch. The tablet data was synced to a server, and the score was calculated in real time by the server. The potential assignment to treatment or control (with

¹The MFI Wasasa was one of the lenders for the Women Entrepreneurship Development Project (WEDP), a program of the Government of Ethiopia financed by the World Bank, that support for women entrepreneurs in Ethiopia by providing business services and improving access to credit. The criteria for a woman entrepreneur to participate in the WEDP program are: their business has to be majority women-owned, registered for at least 6 months, be growth-oriented, and the owner is not full-time in school. The loans received by firms in this sample through the program were much larger than the typical micro firm in developing countries, with an average loan size of around USD 12,500.

50-50 probability) was also calculated by the server for those scoring above 370. The potential treatment assignment was kept on the server, hidden from the loan officers and applicants, while the score was sent through to the branch computer and viewed by the loan officer. Applicants scoring above 370 were told they were potentially eligible, and invited to submit documentation and schedule a business appraisal. If an applicant passed the documentation check and subsequent business appraisal, only at that moment was her treatment status transferred from the server onto the branch computer system and hence revealed to the loan officer. The loan officer then informed the woman of her treatment status, and hence whether she would be offered the loan or not. The process from filling out the application to hearing about the offer took approximately three weeks on average.

Of the 357 women who showed interest over the study period, all 357 took the psychometric test on a tablet. Business and demographic characteristics were collected for all 357 women entrepreneurs, and 339 of these also completed a short additional baseline survey. Out of the 357 with a test score, 259 scored 370 or above, of whom 135 did not provide the correct documentation and/or did not pass the business appraisal. This left a total impact evaluation sample of 124 women entrepreneurs who had met all requirements: 63 who had been computer-randomized to the control group and 61 to the treatment group. Women in the treatment group were offered an uncollateralized loan.

A follow-up survey was conducted via telephone in April-May 2020, targeting just the 124 firms in the impact evaluation sample. The eventual sample for the phone midline survey included 101 of these 124 women. 20 women could not be found, due to missing or non-functioning phone numbers, and 3 did not consent to participate or could not due to illness. Of the 101 who participated, 65 women's businesses were permanently or temporarily closed due to COVID-19, and hence they did not complete parts of the survey pertaining to recent business activity. This left 36 women with measured business outcomes during the midline survey. An endline survey was conducted face-to-face in September 2021, targeting the full

Table 1: Randomization Balance and Attrition Tests

	Baseline Balance					Differential Attrition				
	Control		Treatment		Difference	Non-attriters		Attriters		Difference
	Mean	N	Mean	N		Mean	N	Mean	N	
Treatment (0/1)						0.47	124	0.57	7	-0.10
Psychometric score	397.22	69	400.06	62	-2.85	398.33	124	402.71	7	-4.38
Respondent Characteristics:										
Age	35.65	68	36.40	62	-0.76	36.28	123	31.14	7	5.14
Married	0.57	69	0.65	62	-0.08	0.60	124	0.71	7	-0.12
Has children	0.72	69	0.95	62	-0.23***	0.84	124	0.71	7	0.12
Household size	4.17	66	4.24	58	-0.07	4.23	117	3.71	7	0.52
Respondent is household head	0.44	66	0.43	58	0.01	0.45	117	0.14	7	0.31
Number of people who work in the household	2.12	66	1.95	58	0.17	2.03	117	2.29	7	-0.26
Income from female workers in the household (ETB)	26828.36	66	27747.43	58	-919.07	27127.55	117	29442.86	7	-2315.31
Total household income (ETB)	41332.91	66	44223.38	58	-2890.47	40162.63	117	84842.86	7	-44680.22***
Number of household assets	4.95	66	4.98	58	-0.03	4.95	117	5.29	7	-0.34
Respondent's household has a car	0.23	66	0.22	58	0.00	0.23	117	0.14	7	0.09
Respondent's household has a house	0.24	66	0.38	58	-0.14	0.29	117	0.57	7	-0.28
Completed university education	0.17	69	0.15	62	0.03	0.16	124	0.14	7	0.02
Completed secondary education	0.38	69	0.48	62	-0.11	0.41	124	0.71	7	-0.30
Number of businesses owned in life	2.25	68	2.08	61	0.17	2.19	122	1.86	7	0.33
Years of business related experience	3.19	67	3.43	60	-0.24	3.36	120	2.43	7	0.93
Is the sole owner of her main business	0.98	66	0.98	58	0.00	0.98	117	1.00	7	-0.02
Business Characteristics:										
Number of years business has been operating	6.13	69	5.92	62	0.21	5.99	124	6.71	7	-0.72
Main business is in manufacturing	0.05	66	0.09	58	-0.04	0.06	117	0.14	7	-0.08
Main business is in services	0.33	66	0.31	58	0.02	0.33	117	0.14	7	0.19
Main business is in Agriculture	0.03	66	0.03	58	-0.00	0.03	117	0.00	7	0.03
Main business is in Trade	0.58	66	0.55	58	0.02	0.56	117	0.71	7	-0.16
Starting capital (ETB)	43393.94	66	42543.10	58	850.84	42536.75	117	50671.43	7	-8134.68
Outcomes:										
Number of loans received	0.09	69	0.10	62	-0.01	0.10	124	0.00	7	0.10
Largest loan received (ETB)	38231.88	69	66943.55	62	-28711.66	54745.97	124	0.00	7	54745.97
Largest loan received (IHS)	2.38	69	3.00	62	-0.62	2.83	124	0.00	7	2.83
Amount still owed (ETB)	14.85	69	0.66	62	14.19	8.59	124	0.00	7	8.59
Amount still owed (IHS)	0.23	69	0.23	62	0.01	0.24	124	0.00	7	0.24
Average monthly profit from main business (ETB)	25442.75	69	24318.06	62	1124.69	24848.95	124	26000.00	7	-1151.05
Average monthly profit from main business (IHS)	10.50	69	10.46	62	0.04	10.47	124	10.62	7	-0.15
Average monthly profit from all businesses (ETB)	34645.65	69	26495.16	62	8150.49	31058.47	124	26000.00	7	5058.47
Average monthly profit from all businesses (IHS)	10.62	69	10.56	62	0.06	10.59	124	10.62	7	-0.02
Average monthly sales from main business (ETB)	68566.45	69	84223.64	62	-15657.19	74523.80	124	101714.29	7	-27190.49
Average monthly sales from main business (IHS)	11.34	69	11.62	62	-0.28	11.45	124	11.83	7	-0.38
Average monthly sales from all businesses (ETB)	75080.94	69	85078.48	62	-9997.54	78576.22	124	101714.29	7	-23138.07
Average monthly sales from all businesses (IHS)	11.39	69	11.64	62	-0.26	11.49	124	11.83	7	-0.34
Number of employees in main business	1.79	69	1.73	62	0.06	1.79	124	1.29	7	0.50
Number of employees in all businesses	1.91	69	1.80	62	0.11	1.89	124	1.29	7	0.60
Number of hours worked in a week	59.28	69	62.52	62	-3.24	61.10	124	55.71	7	5.39

Table presents 99th percentile winsorized and Inverse Hyperbolic Transformation (IHS) of continuous variables.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

baseline sample of 357 entrepreneurs. Of these, 314 completed the endline survey (participation rate 88%); and of these, 117/124 (94%) of the women in the IE sample completed the endline survey. Table 1 shows that attrition was not significantly differential by treatment status.

3.1 Data sources

We use the following data sources:

- **Baseline Survey:** April 2018-March 2020, N=357. The psychometric scoring included basic demographic and firm characteristics, and measures of personality traits. The short additional baseline instrument included modules on: additional demographic information, additional business characteristics, additional information on business performance, business practices, access to business finance, and household decision-making.
- **Midline Survey:** April-May 2020, N=101. Modules included: business performance (closures, profits, revenues, employment, capital), challenges faced, and preferences for support measures during the COVID-19 pandemic.
- **Endline Survey:** September 2021, N=314. Modules included: demographic information, current business characteristics (e.g. sector of operation), business performance (e.g. closures, profits, revenues, employment, capital) in the main business and any other businesses, COVID-19 related business challenges, business practices, access to business finance, household decision-making, and entrepreneur characteristics (self-efficacy, grit, personal initiative, short survey measures of risk and time preferences).
- **Wasasa administrative data:** June 2018-November 2022 (ongoing), N=61 treatment-group individuals receiving uncollateralized loans. Loan principal, disbursement date, monthly repayment, maturity date.

4 Empirical Strategy

Our main impact estimations use the following ANCOVA specification:

$$Y_{ib,t=1} = \beta_0 + \beta_1 T_{ib} + \beta_2 Y_{ib,t=0} + \beta_3 M_{ib,t=0} + \beta_4 test_{ib,t=0} + \beta_5 X'_{ib,t=0} + \epsilon_{ibt} \quad (1)$$

Where: $Y_{ib,t=1}$ is the outcome variable measured at endline. T_{ib} is a dummy variables taking the value of one if the individual was in the treatment or control group respectively. β_1 gives the intent-to-treat effect of being assigned to the treatment group (offered an uncollateralized loan), compared to the control group. $Y_{ib,t=0}$ is the baseline value of the outcome variable, set to zero for missing values. If a very similar but non-identical question was asked at baseline (e.g. the same outcome but for a different recall period), we control for the similar variable as measured at baseline instead. $M_{i,t=0}$ is a dummy variable indicating whether the baseline value is missing. $test_{ib,t=0}$ is the individual’s EFL score, measured at baseline. $X'_{ib,t=0}$ is a vector of any baseline control variables identified as unbalanced above in Table 1.² The error term is robust to individual heteroskedasticity (i.e. clustered at the individual level, since treatment was randomized at that level). We report standard regression estimations, as well as p-values from randomisation inference tests to account for the relatively small IE sample size (Young, 2019). We account for multiple inference by calculating q-values for coefficients of interest within the families of outcome variables specified above, limiting the false discovery rate (FDR) using the method proposed by Benjamini and Hochberg (1995). We report both uncorrected p-values and FDR-adjusted q-values for each regression.

All of the results presented below are robust to inverse probability weighting to account for differential attrition by baseline characteristics as shown in Table 1; Tables available on request. The results are also robust to using a post-double LASSO procedure allowing selection from all of the baseline covariates presented in Table 1; Tables available on request.

²We specified inclusion of a branch branch fixed effect. However, given the final sample size, only eight observations are from one branch so we omit these fixed effects due to power concerns. They are not needed for inference, as randomisation was not stratified by branch.

5 Results

In the following section we present intention-to-treat (ITT) results using the estimation framework outlined in equation 1. We begin by estimating the treatment impact on women’s access to credit. We then turn to firm-level outcomes and examine impacts on firm survival, profits, and capital investments. In addition, we conduct heterogeneity analysis based on the timing of the psychometric test assessment to examine impacts for loans assessed before and after the onset of the COVID-19 pandemic.

5.1 Impacts on Credit Constraints

In Tables 2 and 3 we present the treatment effects on women’s access to financial credit. In Table 2 column 1 we confirm that the implementing MFI partner complied with the randomized assignment where treatment firms were 93 percentage points more likely to have received the uncollateralized loan product than control group firms, as reported by MFI administrative data.³

Table 2 columns 2 to 6 presents borrowing outcomes as reported by the firm owner. Column 2 shows that treatment increased the likelihood of borrowing from any source in the last three years from 61% to 90%. This suggests psychometric credit appraisal technology successfully increased access to credit for women-owned firms. The higher pricing of the uncollateralized loan product to the collateralized alternative suggests that those firms who were attracted to take the psychometric test were indeed those who were collateral constrained.

Further breakdown into formal and informal sources of borrowing in columns 3 and 4 suggests that the treatment more than doubled the likelihood of formal borrowing in the last three years, from 42% to 89%; and treatment decreased informal borrowing (mainly smaller

³Only 3% of control group firms received an uncollateralized loan i.e. 2 respondents in the control group received a WEDP-X loan and 2 in the treatment group did not, as reported by the MFI Wasasa.

loans mainly from family and friends).⁴ It is important to note that some women attracted larger informal loans to complement their uncollateralized loan (see figure 1). The crowding-in of larger informal loans may represent complementary investment from individuals seeking growth opportunities; although we cannot rule out that individuals take informal loans to pay off formal loans. We find no evidence that the treatment had an impact on borrowing from commercial banks or other microfinance institutions (shown in columns 5 and 6).

⁴The 42% of control group firms who borrowed from a formal source in the past 3 years most commonly report the use of a guarantor or business assets as collateral for attaining their loan. Approximately one third of these borrowers received collateralized loans through the WEDP program.

Table 2: Impacts on Credit Constraints, Extensive Margin (any borrowing)

	(1) Received an Uncollateralized Loan (Yes 1; No 0)	(2) Borrowed any money in the past 3 years (Yes 1; No 0)	(3) Borrowed from a formal source in the past 3 years (Yes 1; No 0)	(4) Borrowed from an informal source in the past 3 years (Yes 1; No 0)	(5) Borrowed from a Bank in the past 3 years (Yes 1; No 0)	(6) Borrowed from an MFI in the past 3 years (Yes 1; No 0)	(7) Total amount borrowed in the past 3 years (IHS)
Treatment (0/1)	0.931*** (0.035)	0.292*** (0.076)	0.476*** (0.077)	-0.176** (0.084)	0.001 (0.059)	-0.101 (0.077)	0.631** (0.302)
Psychometric score is above the IE sample median	0.034 (0.030)	0.104 (0.076)	0.170** (0.076)	-0.026 (0.079)	0.075 (0.057)	0.131* (0.074)	-0.078 (0.237)
ANCOVA	x	✓	✓	✓	✓	✓	✓
Imbalanced baseline controls	✓	✓	✓	✓	✓	✓	✓
Observations	131	124	124	124	124	124	95
Control group mean	0.029	0.606	0.424	0.318	0.106	0.258	12.514
R^2	0.883	0.138	0.282	0.050	0.020	0.039	0.086
Randomization inference p value	0	0.003	0	0.031	0.985	0.198	0.066
Sharpened Q value	0.001	0.006	0.001	0.032	0.301	0.102	0.056

Uncollateralized loan indicates if the loan was received or not according to the bank. Other dependent variables reflect self-reported borrowing in the past three years.

Total amount borrowed estimates are conditional on borrowing

Robust standard errors are in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Impacts on Credit Constraints, Intensive Margin (amounts borrowed)

	Unconditional			Conditional		
	(1)	(2)	(3)	(4)	(5)	(6)
	All β / (s.e.)	Formal β / (s.e.)	Informal β / (s.e.)	All β / (s.e.)	Formal β / (s.e.)	Informal β / (s.e.)
Treatment (0/1)	4.564*** (1.030)	6.547*** (1.001)	-2.121** (0.963)	0.631** (0.302)	0.204 (0.319)	0.587 (0.555)
Psychometric score is above the IE sample median	1.043 (1.005)	2.462** (0.980)	-0.407 (0.883)	-0.078 (0.237)	-0.106 (0.217)	-0.088 (0.548)
ANCOVA	✓	✓	✓	✓	✓	✓
Imbalanced baseline controls	✓	✓	✓	✓	✓	✓
Observations	124	124	124	95	83	31
Control group mean	7.043	5.022	3.399	12.514	12.863	11.757
R^2	0.174	0.328	0.053	0.086	0.056	0.127
Randomization inference p value	0.001	0	0.018	0.066	0.587	0.201
Sharpened Q value	0.003	0.001	0.022	0.053	0.272	0.110

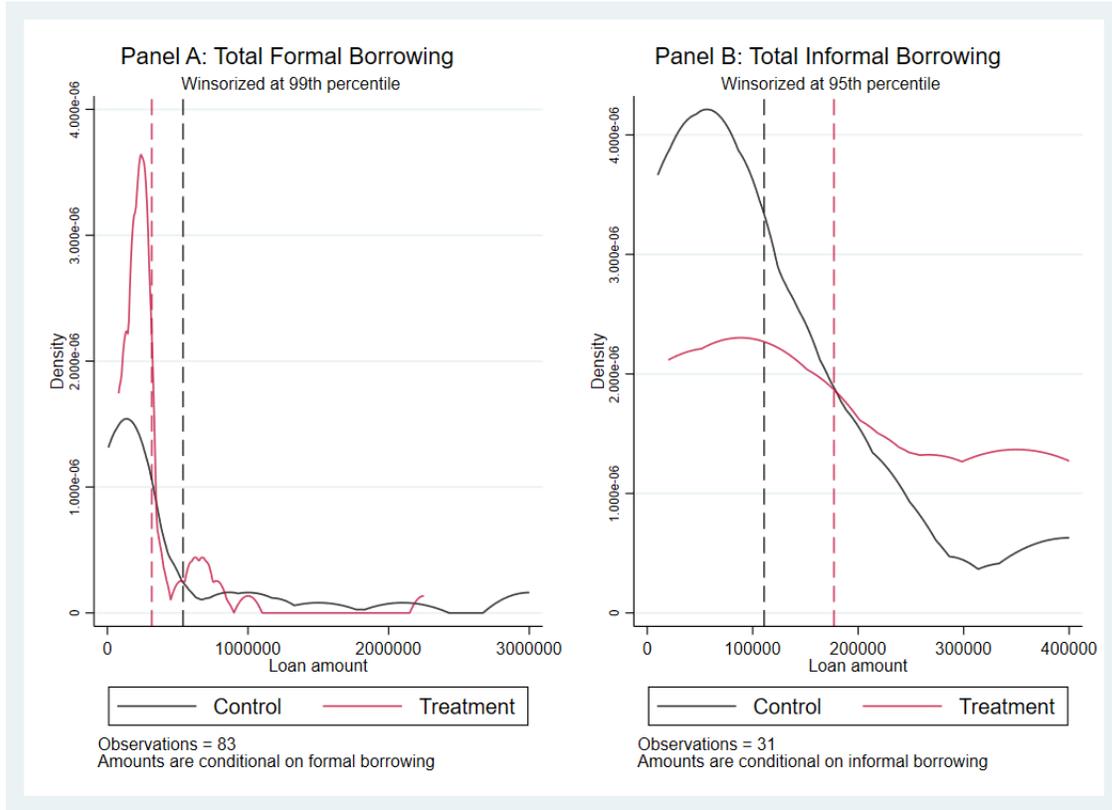
Conditional amounts represent only those who borrowed, whereas unconditional amounts include non-borrowers with a value of 0.

Due to presence of extreme values, amounts borrowed are Inverse Hyperbolic Sine (IHS) transformed.

Robust standard errors are in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1: Formal and Informal Borrowing at Endline



5.2 Impacts on Firm Survival

Table 4 shows that treatment increased the firm survival rate through the COVID-19 pandemic and other shocks, from 67% to 83%. McKenzie and Paffhausen (2019) estimates business-as-usual closure for small firms at 50% over 6 years, so interpolating linearly we infer that an average closure rate of 20-25% over three years is to be expected.⁵ Using this as a benchmark, we find that treatment took firms from pandemic levels of closure of 33% to 17% which is better than business-as-usual levels.

⁵McKenzie and Paffhausen (2019) estimate firm death rates using data from small firms in 12 developing countries.

Table 4: Impacts on Firm Survival

	(1) Business was operating at endline (Yes 1; No 0)	(2) No longer operates a business (Yes 1; No 0)	(3) Started a new business (Yes 1; No 0)	(4) Opened business in a new sector (Yes 1; No 0)	(5) Opened business in the same sector (Yes 1; No 0)
Treatment (0/1)	0.165** (0.081)	-0.089 (0.065)	-0.121 (0.073)	-0.129** (0.061)	0.014 (0.031)
Psychometric score is above the IE sample median	0.165** (0.080)	-0.185*** (0.065)	0.045 (0.067)	0.037 (0.056)	-0.020 (0.029)
ANCOVA	✗	✗	✗	✗	✗
Imbalanced baseline controls	✓	✓	✓	✓	✓
Observations	124	124	124	124	124
Control group mean	0.667	0.197	0.197	0.152	0.015
R^2	0.066	0.082	0.045	0.049	0.011
Randomization inference p value	0.072	0.209	0.096	0.022	0.715
Sharpened Q value	0.147	0.191	0.147	0.124	0.354

Robust standard errors are in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

It is important to note that while control group entrepreneurs close their original WEDP registered firm at a greater rate than treatment, some control firms reopen a new firm in a new sector. The sector changes did not follow a clear pattern and therefore we are unable to conclude whether these adjustments were in response to COVID-19 adaptation or other factors.

5.3 Impacts on Firm Performance

In terms of firm performance, in Table 5 we include outcomes for profits in the last year and investments in business inputs that includes the value of capital, inventory stock and raw materials held by the firm at the time of the survey.⁶

⁶Note we show the pre-specified IHS transformation of the value outcomes in Table 4 but also present the values in Ethiopian Birr in the Appendix.

Table 5: Impacts on Firm Performance

	Profits				Business inputs		
	(1) Last year's profit (Unconditional) (Level)	(2) Last year's profit (Unconditional) (IHS)	(3) Last year's profit (Conditional) (Level)	(4) Last year's profit (Conditional) (IHS)	(5) Value of owned equipment (Unconditional) (IHS)	(6) Value of inventory stock (Unconditional) (IHS)	(7) Value of raw materials (Unconditional) (IHS)
Treatment (0/1)	46694.685 (38001.663)	1.644 (1.109)	40065.261 (44155.450)	0.596 (1.003)	1.540 (0.932)	0.826 (1.057)	-0.834 (0.954)
Psychometric score is above the IE sample median	16185.450 (36366.284)	1.977* (1.017)	-29768.944 (45076.381)	-0.182 (0.864)	2.278** (0.922)	1.127 (1.039)	0.880 (0.879)
ANCOVA	✓	✓	✓	✓	✗	✗	✗
Imbalanced baseline controls	✓	✓	✓	✓	✓	✓	✓
Observations	124	124	105	105	124	124	124
Control group mean	139368.939	9.102	172044.340	11.334	8.760	7.409	3.404
R^2	0.031	0.050	0.027	0.019	0.071	0.023	0.016
Randomization inference p value	0.135	0.125	0.300	0.406	0.105	0.430	0.324
Sharpened Q value	0.370	0.370	0.370	0.370	0.460	0.460	0.460

Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0.

IHS refers to Inverse Hyperbolic Sine (IHS) transformation of outcomes.

Robust standard errors are in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Impacts on firm performance are overall muted. In Table 5 column 1 and 2 the treatment group report higher average business profits in the last year, however, this result is not statistically significant. Since firms are, on average, profitable and profits are higher for the treatment group in both the unconditional and conditional estimates this suggests that the treatment loan is helping keep viable firms alive and not necessarily supporting zombie firms. In the Appendix we also show business profits with a shorter recall period "in the past 30days" where we find a slight negative treatment effect on sales and profits in the last 30 days. We speculate that the lower recent profits may reflect surviving firms being more exposed to a business demand shock related to COVID-19 and the conflict that was ongoing at the time of the survey. The muted impacts on profits suggests that the loan did not necessarily spur higher firm growth but instead helped firms to remain operational at a time when firms in Ethiopia were exposed to a multitude of demand shocks.

In Table 5 columns 5 to 7 we find no evidence of a treatment impact on the value of capital stock, inventory stock, or raw materials held by the firm. While treatment firms hold slightly higher capital stock i.e. owned business equipment (randomized inference p-value is 0.105), this likely reflects the higher likelihood of treated firms to remain in operation as shown in Table 3.⁷ We find no evidence of a treatment impact on employment, own labor inputs, or business practices (not shown).

5.4 Heterogeneity Analysis by Timing of Loan Appraisal

In Table 6 we re-estimate equation 1 with a pre-specified interaction term between treatment and an indicator variable for before/after median date of assessment (0/1) in the regression.⁸

⁷Note the results on capital stock conditional on being in operation is not shown in the Table 5 but also shows a higher average amount of capital for treatment firms (not statistically significant)

⁸The median date for appraisal was December 2019 so this cut-off provides a useful turning point for examining before COVID-19 pandemic and after COVID-19 onset

Table 6: Impacts by Timing of Loan Appraisal

	Borrowing				Survival	Performance		Inputs		
	(1) Borrowed any money in the past 3 years (Yes 1; No 0)	(2) Borrowed from a formal source in the past 3 years (Yes 1; No 0)	(3) Borrowed from an informal source in the past 3 years (Yes 1; No 0)	(4) Total amount borrowed in the past 3 years (IHS)	(5) Business was operating at endline (Yes 1; No 0)	(6) Last year's profit (Unconditional) (IHS)	(7) Last year's profit (Conditional) (IHS)	(8) Value of owned equipment (Unconditional) (IHS)	(9) Value of inventory stock (Unconditional) (IHS)	(10) Value of raw materials (Unconditional) (IHS)
Treatment (0/1)	0.129 (0.114)	0.335*** (0.114)	-0.185 (0.119)	0.543* (0.307)	0.073 (0.127)	-0.088 (1.581)	-0.050 (1.420)	0.589 (1.251)	-1.295 (1.516)	-1.310 (1.344)
Assessment was done after median date	-0.183 (0.120)	-0.122 (0.124)	-0.069 (0.116)	0.061 (0.564)	0.117 (0.117)	-0.952 (1.587)	0.074 (1.377)	-1.292 (1.365)	-0.922 (1.447)	-1.583 (1.278)
TreatxDate	0.327** (0.145)	0.277* (0.145)	0.027 (0.155)	0.147 (0.595)	0.158 (0.154)	3.367* (2.019)	1.188 (1.597)	1.942 (1.772)	4.094** (2.033)	1.085 (1.769)
ANCOVA	✓	✓	✓	✓	✗	✓	✓	✗	✗	✗
Imbalanced baseline controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	124	124	124	95	124	124	105	124	124	124
Control group mean	0.606	0.424	0.318	12.514	0.667	9.102	11.334	8.760	7.409	3.404
R^2	0.174	0.303	0.054	0.090	0.120	0.073	0.029	0.082	0.063	0.031
Randomization inference p value	0.043	0.082	0.869	0.809	0.317	0.118	0.462	0.278	0.049	0.538
Sharpened Q value	0.197	0.197	0.769	0.769	0.465	0.309	0.309	0.386	0.173	0.560

Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0.

Level of profits winsorized at 99th percentile whereas IHS are Inverse Hyperbolic Sine (IHS) transformed.

Robust standard errors are in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Interestingly, we find that some treatment effects are larger for firms that were assessed *after* the median date of assessment. This was somewhat surprising since our expectation that firms receiving loans in 2020 would be more exposed to COVID-19 shocks, would have trouble repaying their loans, and also suffer worse business outcomes. We find evidence that firms appraised in 2020 were in fact marginally more likely to report higher borrowing rates in the past 3 years; have higher annual profits and hold larger inventory stocks than treated firms who were appraised at an earlier date.

To explore these findings further, in the Appendix we present a t-test for the differences between early and late borrowers. This analysis shows that firms that borrowed prior to 2020 were somewhat different to firms that borrowed in 2020 and we find women who borrowed early were more likely to be divorced, separate or widowed; the head of her household; was less likely to be university educated; and operated firms with slightly lower revenues at baseline. Of note we find a difference for the variable that asks whether the firm owner could get 5,000 Ethiopian Birr (approx. USD 100) in 2 weeks for a business emergency. Only 61% of entrepreneurs who borrowed early said they could get money in an emergency relative to 95% of borrowers appraised in 2020. This suggests firms that were attracted to the uncollateralized loan product in the early phase of the pilot were relatively more credit constrained. Firms who borrowed an uncollateralized loan in 2020 managed to use their loan to remain in operation and invest in inventory stock to earn higher profits. We can only speculate that firms who borrowed early perhaps had already invested their loan and couldn't respond to the business demand shock caused by COVID-19, or those early borrowers may have faced more pressure to close with the onset of the pandemic and conflict.

We also conduct heterogeneity analysis for the following variables (using an indicator variable for below/above median, 0/1): psychometric score; baseline profits; baseline capital stock; baseline household collateralizable assets; and baseline household income. We find little systematic evidence of heterogeneity in impact, with the caveat that our power to detect such heterogeneity is limited. The exception is that it appears that some treatment

effects are larger for firms with below-median profits at baseline. In the Appendix we present the heterogeneity results by baseline profits.

5.5 Loan Repayment Rates

Repayment rates of the uncollateralized loan product were low and comparable to regular collateralized loans prior to COVID-19 (default rates for the portfolio was approximately 2%). However, loans disbursed in 2020 performed worse due to the COVID-19 pandemic. Given the term of the loan spans 24 months, at the time of writing, overall repayment rates are still to be determined, as some loans disbursed in early 2020 have not yet reached maturity. In addition, some loans experienced rescheduling under COVID-19 and of those that are PAR90 (“Portfolio at Risk 90 days” i.e. payment had not been made on the loan for over 90 days) some repaid a considerable amount before going into arrears. The MFI expects that some of the more recent PAR90 loans with lower arrears days may still be (at least partially) recovered.

6 Conclusion

In this paper, we provide evidence that using psychometric credit scoring to substitute traditional collateral requirements significantly alleviates credit constraints for growth-oriented women entrepreneurs. The loan brings firm closure under a pandemic down to business-as-usual levels. Importantly, treatment firms were profitable in the last year despite COVID and the ongoing conflict, so there is no evidence of supporting “zombie firms”. Repayment rates of the uncollateralized loan product is respectable, given COVID-19 and conflict; but worse than the traditionally-collateralized alternative. We urge further research on getting more appropriate financing to women, especially in light of the persistence of a gender gap in entrepreneurship.

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A Online Appendix