

# Evening the Credit Score?

## Impact of Psychometric Loan Appraisal for Women Entrepreneurs

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Africa Region

Gender Innovation Lab

November 2022

## Abstract

Women's lower rates of ownership of collateralizable assets are a constraint to accessing larger business loans. This paper tests the impact of using psychometric credit scoring as a substitute for collateral for loans up to US\$7,500, via a randomized controlled trial with a microfinance institution in Ethiopia. The paper finds positive impacts on women's access to credit, and survival of their firms during the

COVID-19 pandemic and conflict. Firms that remained operational were profitable; but there is limited evidence of impact on firm growth under these circumstances. The study showcases the potential for using innovative technologies to extend entrepreneurial finance to underserved markets.

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This paper is a product of the Gender Innovation Lab, Africa Region. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at <http://www.worldbank.org/prwp>. The authors may be contacted at [rcassidy@worldbank.org](mailto:rcassidy@worldbank.org).

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# Evening the Credit Score? Impact of Psychometric Loan Appraisal for Women Entrepreneurs \*

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Gender, Entrepreneurship, Firms, Finance, Credit  
[JEL] C93, D14, D25, J16, L25, L26, O12

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\*This paper is a product of the World Bank Africa Gender Innovation Lab, within the office of the Africa Region Chief Economist. The project was conducted in partnership with the Women Entrepreneurship Development Project (WEDP) and Wasasa Microfinance. We thank Menaal Ebrahim for excellent research assistance, and Yemsrach Kinfe Edey for expert field and relationship management. We also thank Girm Abebe, Niklas Buehren, Rachel Coleman, Toni Weis, Mengistu Bessir Achew, Marlon Rawlins, Dr Amsalu Alemayehu and Zerihun Takele for invaluable support and comments. Funding for this study was provided by Global Affairs Canada under the Innovations in Financing Women Entrepreneurs (IFWE) project, as well as the World Bank Umbrella Fund for Gender Equality (UFGE) and other World Bank sources. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent. IRB Approval was obtained from HML IRB Research and Ethics, reference 969TWBG21. The analysis plan is registered on the AEA RCT registry at <https://doi.org/10.1257/rct.8608>

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# 1 Introduction

Women’s entrepreneurship can be a powerful force for women’s empowerment and economic growth (Duflo, 2012). Yet a gender gap in entrepreneurial activity and firm performance persists across countries worldwide, with women-owned firms being less profitable and smaller than male-owned firms (Hardy and Kagy, 2018; World Bank, 2019; Delecourt and Ng, 2020; Fang et al., 2022). A key contributing factor is that women entrepreneurs are often more credit-constrained (De Mel et al., 2009). In particular, despite gender parity in access to microfinance, and many group lending schemes favoring women, women face more difficulty than men in getting loans of larger size, longer duration, individual liability and more flexible terms (Agier and Szafarz, 2013). Such features are important for growth of some micro-, small and medium enterprises (MSMEs) (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 often required as collateral, especially in contexts where well-functioning credit bureaus are lacking (Morsy and Youssef, 2017; World Bank, 2019). Absent a large shift in women’s ownership of collateralizable assets, innovative solutions are thus needed to expand access to capital for growth-oriented women-owned firms.

In this paper, we test an innovative solution to providing larger loans to women who lack collateral: psychometric credit scoring. Psychometrics (literally “measurement of the mind”) uses questions designed to measure traits such as the “big five”. Such traits, and models based on such traits, have been shown to be predictive of default risk for MSMEs (Klinger et al., 2013a,b; Arráiz et al., 2017). We partnered with a microfinance institution (MFI) in Ethiopia that, alongside group-based loans, also offers larger individual-liability loans to business owners who can provide collateral. The MFI was seeking to expand its client base to include new female entrepreneurs who lacked access to collateral. We conducted a randomized controlled trial (RCT) to test the impact of introducing psychometric credit scoring as a substitute for collateral requirements during the due diligence process. We

worked with the MFI to introduce an individual-liability, *uncollateralized* loan product of up to US\$7,500. This uncollateralized loan product was smaller than the maximum amount accessible with collateral, and was priced at an interest rate above the collateralized product, to dissuade women who had access to collateral from applying. Women entrepreneurs who applied for an uncollateralized loan, passed psychometric screening, and passed a business appraisal were randomized into the offer of an uncollateralized loan or a control group. Our design enables us to estimate the causal impact of creating access to psychometric-appraised loans in lieu of traditional collateral requirements, compared to a control group who are assessed to be creditworthy via psychometrics but cannot access uncollateralized lending.

Using a panel survey of women and their enterprises, as well as MFI administrative data, we compare outcomes across the randomly selected treated and control entrepreneurs. The results show that access to psychometric-appraised loans relaxed women entrepreneurs' credit constraints. Treatment more than doubled the likelihood that women had accessed a formal loan from any bank or MFI for their business by endline — from 42% of the control group to 89% of the treatment group. Overall, the proportion of women accessing any business loan (formal or informal) increased from 61% of the control group to 90% of the treatment group. Treatment also increased the total amount of borrowing, both on average and conditional on a woman taking any business loans.

Access to psychometric-appraised loans reduced the firm death rate to 17% over three years, compared to a firm death rate of 33% in the control group through the COVID-19 pandemic, conflict in Ethiopia (including in the Oromia region where the study took place), and related economic challenges. There is no significant impact on women exiting entrepreneurship altogether, since many control-group respondents who closed their original firm reopened a new firm, typically in a different sector. Almost all firms that remain open report positive profits in the last year, hence there is no evidence of access to psychometric-appraised loans keeping “zombie firms” alive. We therefore posit that the increase in firm survival is due to treatment firms having more liquidity, rather than them staying open in

order to repay the loan even if unprofitable.

Treated firms appear to have higher profits on average than control firms in the last year; but this is not statistically significant, and we lack power to detect moderate positive impacts on profits due to COVID-19 curtailing our sample size. In contrast, treatment-group firms report significantly *lower* sales and profits in the last 30 days prior to the endline survey, compared to control group firms. The endline survey was conducted in October 2021, which was just after national elections, and a peak in COVID-19 and subsequent restrictions. It may therefore be that surviving firms in the treatment group were particularly exposed to the challenging macroeconomic climate around the time of the survey, although we do not observe a different distribution of treatment versus control-group firms across sectors.

The psychometric-appraised, uncollateralized loans show similarly high repayment rates to regular collateralized loans offered by the MFI prior to the onset of COVID-19. However, psychometric loans disbursed in early 2020 performed worse than psychometric loans disbursed prior to 2020, since they were almost immediately hit by the COVID-19 pandemic.

To our knowledge, our study is the first RCT to evaluate the impact of psychometric credit appraisal for entrepreneurs on not only access to credit and repayment, but also firm outcomes. Convincing financial institutions to adopt an innovative technology — and to experiment with uncollateralized lending, especially in a financial sector where extensive physical collateralization of loans is the norm — is challenging. An additional challenge is convincing financial institutions to randomize the roll-out of a new product at the individual borrower level, implying that they cannot grant loans to half of the borrowers whom they deem creditworthy (and hence would expect to be profitable clients) via the screening process.

Psychometric credit scoring technology has been tested to address the information asymmetries faced by financial institutions particularly in developing countries, and shown to enhance screening of MSMEs that do or do not have other forms of credit history (Arráiz et al., 2017; Alibhai et al., 2018). These studies do not seek to provide evidence of causal impacts of psychometric-appraised lending on downstream firm outcomes. A recent related

study by Bryan et al. (2021) shows that psychometric variables can be combined with machine learning techniques to predict which firms have the highest potential returns to larger loans (although when comparing impacts it should be noted these are an order of magnitude smaller than the loans in our study), and that these are not the same as the firms with the highest returns to smaller loans. Other studies observe that entrepreneurs with high levels of intelligence and motivation, and with particular character traits, benefit disproportionately from interventions for MSMEs (Fafchamps et al., 2014; Koudstaal et al., 2016).

We also provide one of the first RCTs to estimate the impact of a large loan product of this magnitude on microenterprises, particularly women-owned microenterprises. Smaller loans have shown disappointing results. For example, Tarozzi et al. (2015) find that access to standard microfinance in Ethiopia increases female borrowing substantially (despite no specific guidelines to target women for the loans) but largely leads to null results on consumption and business outcomes. Further studies find that cash grants can have an impact for male entrepreneurs but not female entrepreneurs; at least without additional intervention such as training (Berge et al., 2015), or unless delivered in kind, due to pressure faced by women to redistribute liquid funds (Fafchamps et al., 2014).

## 2 Context and intervention

Enterprises in Ethiopia rank among the most credit-constrained in the world, with 40% rating access to finance as the biggest constraint they face (Mthimkhulu and Aziakpono, 2015). Banks and MFIs granting larger loans have stringent collateral requirements, typically in the form of housing or a salaried guarantor. The Women Entrepreneurship Development Project (WEDP) is a national program of the Government of Ethiopia, with financial and technical assistance from the World Bank. The project targets growth-oriented women-owned enterprises with interventions including information and training, and access to collateralized

“WEDP” loans from participating MFIs.<sup>1</sup> As part of WEDP, we partnered with Wasasa — one of Ethiopia’s largest private MFIs — to introduce an *uncollateralized* product supported by psychometric screening.<sup>2</sup> For the new product, women who took a psychometric test and scored above a cut-off — as well as passing a subsequent business appraisal and documentation check — were deemed eligible for an uncollateralized loan ranging from 100,000 to 250,000 Ethiopian birr (USD 3,500 to 7,500 in 2018). This maximum amount was smaller than that of the MFI’s collateralized individual-liability loans, including under WEDP.<sup>3</sup> The new product was also priced at an interest rate a few percentage points above the rate for the MFI’s collateralized loans. These features were designed to dissuade women with access to collateral from applying for the uncollateralized psychometric product.<sup>4</sup> The loan term was 22 months, which was the same as for the collateralized individual-liability loans.

The psychometric testing was provided via a US technology company. Potential borrowers took an interactive, tablet-based test consisting of games, puzzles and questions. The quiz is designed to assesses potential borrowers’ traits such as fluid intelligence, business acumen, conscientiousness, risk-aversion and honesty. These traits are then combined via machine learning into a model to predict credit risk. The model was calibrated to repayment data for a similar population in neighboring countries, and then first piloted in the Ethiopian context with the MFI Amhara Credit and Savings Institute, allowing for adaptation and calibration specifically with a sample of Ethiopian women entrepreneurs (Alibhai et al., 2018).<sup>5</sup>

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<sup>1</sup>The majority of WEDP borrowers (61%) are new borrowers, who have not previously accessed loans through a formal financial institution. The criteria for a woman entrepreneur to participate in the WEDP program are that their business has to be majority women-owned, registered for at least 6 months, and growth-oriented, and the owner must not be in full-time schooling.

<sup>2</sup>We also piloted similar psychometric products with other Ethiopian MFIs participating in WEDP. Wasasa was particularly willing to randomize loan offers conditional on approval, in order to participate in an RCT.

<sup>3</sup>The average WEDP loan size is around USD 12,500. For comparison, the maximum group-liability loan size available to such enterprises outside WEDP is approximately USD 1,000-1,500.

<sup>4</sup>The MFI did not conduct a formal verification that the women applying to psychometric-appraised loans did not hold collateral. One motivating factor was that some women may live in households that possess collateralizable assets, but face other constraints such as low household bargaining power that prevent them from leveraging these household assets to access credit.

<sup>5</sup>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 (*ibid.*).



The loans were rolled out at Wasasa’s branches in the cities of Adama and Assela, in the Oromia region of Ethiopia. The psychometric-appraised, uncollateralized loan product was branded as a “WEDP-X” loan and was advertised to women entrepreneurs participating or interested in WEDP in those cities. WEDP-X was advertised via flyers 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 prospective clients. The flyers and 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 with the features mentioned above.

### 3 Experimental design

The application and baseline survey process took place on a rolling basis from April 2018-March 2020.<sup>6</sup> Women entrepreneurs presented themselves at Wasasa branches in the cities of Adama and Assela if and when they wished to apply for a loan. The full application process was explained to women before they applied for a WEDP-X loan, including that only half of those women who qualified for the loan would actually receive the loan due to the need to test a new product, and that this would be determined by computer-randomized assignment.

As soon as a woman decided to apply, she completed the psychometric test on a tablet, in private, then and there at the Wasasa branch office. A short additional baseline survey was then administered to her by MFI loan officers working at the Wasasa branch, also on a tablet. The psychometric test data was synced to a server, which calculated the psychometric credit score in real time. The score was then sent through to the branch computer and viewed by the loan officer. Applicants scoring above the cut-off were told they were potentially eligible for the loan, and invited to submit documentation and schedule a business appraisal. For

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<sup>6</sup>The baseline survey was concluded earlier than planned due to the COVID-19 pandemic. Ethiopia saw its first confirmed COVID-19 case on March 13th. Educational institutions were closed on March 16th, and a transportation ban began on March 30th. A state of emergency was declared on April 8th.

those applicants scoring above the agreed cut-off score, the potential assignment to treatment or control (with 50-50 probability) was also calculated by the server at the same time; but the assignment was kept on the server, hidden from the loan officers and applicants.

If an applicant passed the documentation check and business appraisal — a process that typically took around three weeks — 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 immediately informed those women who were assigned to the treatment group that they would receive the loan, and those assigned to control that they had passed but unfortunately would not receive the loan due to the experimental set-up to test this new product that had been explained to them. The treatment group typically received their loan around a month after being informed of their status.

## 4 Sample and data

In total 357 women showed interest in the loan product over the baseline survey period. The volume of applicants increased steadily, after dedicated staff at the MFI were trained to promote the WEDP-X product among women business owners who were seeking a loan but lacked access to collateral. All 357 applicants completed a psychometric test on a tablet, followed by additional questions on basic business and demographic characteristics whose responses were also made available to the credit scoring technology. Of these women, 339 also completed a short additional baseline survey for the purpose of our study, with more detailed questions on the business, access to finance, and household decision-making. Of the total 357 women, 259 women scored above the cut-off and were invited to proceed. However, 128 of these women did not subsequently pass the regular screening of a documentation check and a business appraisal, and hence were excluded from the impact evaluation. Columns 8 and 10 of Table A1 in the Appendix shows that these firms who passed the psychometric cut-off but did not then pass the regular screening subsequently performed worse than the impact

evaluation control group, who passed the psychometric cut-off *and* the regular screening — in terms of endline sales and capital stock, with negative but insignificant point estimates for most other outcomes including profits (all conditional on the psychometric score). The documentation check and business appraisal thus appears to have screened positively for firm performance. The total RCT impact evaluation sample consisted of 131 women entrepreneurs who had satisfied the test cut-off score, the documentation check and the business appraisal.<sup>7</sup> Of these women, 69 were revealed to have been computer-randomized to the control group, and 62 to the treatment group to be offered the loan.<sup>8</sup>

Table 1 shows that the assignment was balanced on pre-specified observable characteristics, except for whether the respondent has children, and that the F-test for joint significant of covariates by treatment assignment is not significant. The average age of women business owners in our sample is 35, with 61% married and 59% having completed secondary school education or higher. The average business age is 6 years. The majority of firms are in the retail sector (44%), followed by cafes and restaurants (18%), and business services (12%). Over 90% of women in our RCT sample have never previously received a business loan.

The endline survey was conducted face-to-face in September-October 2021, targeting the entire baseline sample of 357 entrepreneurs.<sup>9</sup> Of these 357, a total of 314 (88%) completed the endline survey, including 124/131 (95%) of the women in the impact evaluation sample. Table 1 shows that attrition was not significantly different by treatment status, nor by pre-specified covariates except for total household income, and that the F-test of joint significance

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<sup>7</sup>Our target sample size according to initial power calculations was 600. The reduced sample size reflects the early curtailing of the project by the MFI due to the onset of the COVID-19 pandemic in March 2020. Ex post power calculations suggest reasonable power for outcomes such as firm closure; but weaker power for noisier, continuous outcomes such as profits.

<sup>8</sup>The pre-analysis plan mentioned a sample of 124 women, of whom 63 were in the control group and 61 were in the treatment group. This was due to an administrative error in the first version of administrative data shared by the MFI, where seven women (6 control, 1 treatment) were marked as having their applications still in process when in fact the applications had been fully processed.

<sup>9</sup>We also conducted a short follow-up phone survey to understand the impacts of COVID-19 in April-May 2020, targeting just the firms in the RCT impact evaluation sample. The eventual sample for the phone survey included 101 of these firms. 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 only 36 women with measured business outcomes during the phone survey. We hence do not rely on this phone survey as a major data source for the impact evaluation.

of covariates by attrition status is not significant.

At the time of the endline survey, approximately half of the WEDP-X loans had fully matured and the other half had just a few months of repayment left. Wasasa also shared administrative data on loan characteristics and monthly loan repayment for the entire period of the study from June 2018-March 2022 (i.e. covering the months after the endline when some loans were still active) for all 62 women in the treatment group.

## 5 Empirical Strategy

Our main impact estimations use the following ANCOVA specification:

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

where  $Y_{i,t=1}$  is the outcome variable measured at endline.  $T_i$  is a dummy variable taking the value of one if the individual was in the treatment group.  $\beta_1$  gives the intent-to-treat effect of being assigned to the treatment group (i.e. randomly assigned to be offered an uncollateralized loan), compared to the control group who passed the cut-off score, documentation check and business appraisal but were not assigned to be offered a loan.  $Y_{i,t=0}$  is the baseline value of the outcome variable, set to zero for missing values. If a 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.  $test_{i,t=0}$  is an indicator for whether the individual's psychometric score at baseline was above the median within the RCT sample.  $X'_{i,t=0}$  is a vector of any unbalanced baseline control variables from Table 1.<sup>10</sup>

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<sup>10</sup>We pre-specified a version of Equation 1 indexed by branch  $b$  and including a branch fixed effect. However, in the final sample only eight observations are from one of the two branches; so we omit these fixed effects due to power concerns. Branch fixed effects are not needed for inference, as randomization was not stratified by branch. We also pre-specified inclusion of the continuous test score. However, given the distribution observed at baseline, our preferred specification uses a median split of the score to improve power to identify  $\beta_4$ . All reported treatment effects  $\beta_1$  are virtually identical if we include the continuous test score instead.

Table 1: Randomization Balance and Attrition Tests

	Baseline Balance					Differential Attrition				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Control Mean	Control N	Treatment Mean	Treatment N	Difference	Non-attriters Mean	Non-attriters N	Attriters Mean	Attriters N	Difference
Treatment (0/1)						0.47	124	0.57	7	-0.10
Psychometric score	397.2	69	400.1	62	-2.85	398.3	124	402.7	7	-4.38
<b>Respondent Characteristics:</b>										
Age	35.6	68	36.4	62	-0.76	36.3	123	31.1	7	5.14
Married	0.57	69	0.65	62	-0.080	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	-0.075	4.23	117	3.71	7	0.52
Respondent is household head	0.44	66	0.43	58	0.0084	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 (100 ETB)	268.3	66	277.5	58	-9.19	271.3	117	294.4	7	-23.2
Total household income (100 ETB)	413.3	66	442.2	58	-28.9	401.6	117	848.4	7	-446.8***
Number of household assets	4.95	66	4.98	58	-0.028	4.95	117	5.29	7	-0.34
Respondent's household has a car	0.23	66	0.22	58	0.0031	0.23	117	0.14	7	0.088
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	0.029	0.16	124	0.14	7	0.018
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	0.0021	0.98	117	1	7	-0.017
<b>Business Characteristics:</b>										
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	0.045	66	0.086	58	-0.041	0.060	117	0.14	7	-0.083
Main business is in services	0.33	66	0.31	58	0.023	0.33	117	0.14	7	0.19
Main business is in agriculture	0.030	66	0.034	58	-0.0042	0.034	117	0	7	0.034
Main business is in trade	0.58	66	0.55	58	0.024	0.56	117	0.71	7	-0.16
Starting capital (100 ETB)	433.9	66	425.4	58	8.51	425.4	117	506.7	7	-81.3
<b>Outcomes:</b>										
Number of loans received	0.091	69	0.10	62	-0.013	0.10	124	0	7	0.10
Largest loan received (100 ETB)	382.3	69	669.4	62	-287.1	547.5	124	0	7	547.5
Largest loan received (IHS)	2.38	69	3.00	62	-0.62	2.83	124	0	7	2.83
Amount still owed (100 ETB)	0.15	69	0.0066	62	0.14	0.086	124	0	7	0.086
Amount still owed (IHS)	0.23	69	0.23	62	0.0064	0.24	124	0	7	0.24
Average monthly profit from main business (100 ETB)	254.4	69	243.2	62	11.2	248.5	124	260	7	-11.5
Average monthly profit from main business (IHS)	10.5	69	10.5	62	0.044	10.5	124	10.6	7	-0.15
Average monthly profit from all businesses (100 ETB)	346.5	69	265.0	62	81.5	310.6	124	260	7	50.6
Average monthly profit from all businesses (IHS)	10.6	69	10.6	62	0.063	10.6	124	10.6	7	-0.023
Average monthly sales from main business (100 ETB)	685.7	69	842.2	62	-156.6	745.2	124	1017.1	7	-271.9
Average monthly sales from main business (IHS)	11.3	69	11.6	62	-0.28	11.5	124	11.8	7	-0.38
Average monthly sales from all businesses (100 ETB)	750.8	69	850.8	62	-100.0	785.8	124	1017.1	7	-231.4
Average monthly sales from all businesses (IHS)	11.4	69	11.6	62	-0.26	11.5	124	11.8	7	-0.34
Number of employees in main business	1.79	69	1.73	62	0.060	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	59.3	69	62.5	62	-3.24	61.1	124	55.7	7	5.39
F-stat of joint significance	0.36					0.43				

Notes: 62 individuals were randomized to treatment, while 69 were randomized to control. Discrepancies in numbers are due to some missing observations in baseline data. 124 individuals from the sample were interviewed at endline, while 7 individuals did not participate (5 percent attrition). Income, loan amounts, profit and sales are in 100 Ethiopian birr (100 ETB = 3.4 USD at baseline). Table presents 99th percentile winsorized continuous variables and Inverse Hyperbolic Transformed (IHS) continuous variables measured in ETB. The bottom row presents the F statistic of joint significance of the t-tests of all variables tested for baseline balance and attrition, respectively. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

We report error terms robust to individual heteroskedasticity, i.e. clustered at the individual level, since treatment was randomized at the individual level. We present standard p-values from regression estimations, but also rely on p-values from randomization inference tests to account for the relatively small sample size (Young, 2019). We account for multiple inference by calculating q-values for coefficients of interest within pre-specified families of outcome variables, 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.

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

## 6 Results

### 6.1 Impacts on Credit Constraints

Table 2 presents the treatment effect of access to psychometric-appraised loans on women entrepreneurs' access to credit. Panel A, Column 1 uses the MFI Wasasa's administrative data to confirm that the MFI managed near-perfect compliance with the randomized assignment. Just 3% (two respondents) of the control group received a WEDP-X loan due to an administrative error, while two treatment-group respondents did not receive the WEDP-X loan (the administrative data does not distinguish whether this was an administrative error or the borrower declining the final offer). Altogether, treated women were 93 percentage points more likely to have received the uncollateralized loan product than the control group. Three control-group respondents eventually accessed regular, collateralized WEDP loans at Wasasa, compared to zero in the control group; thus treatment leads at most to very minor substitution into uncollateralized borrowing at Wasasa from clients who might have gone

on to and access collateralized borrowing at Wasasa. Columns 2 to 6 present impacts on business borrowing outcomes as reported by respondents. Column 2 shows that treatment increased the likelihood of borrowing for business purposes from any source in the last three years, from 61% to 90% of respondents. In particular, Column 3 shows that treatment more than doubled the likelihood that women had accessed a *formal* business loan in the last three years — from 42% to 89%.

Panel A, Column 4 shows that treatment with psychometric-appraised loans crowds out informal loans (which are typically from family and friends) on average. Figure A1 in the Appendix shows that the crowding out is driven by smaller loans, and we in fact observe a few larger loans being crowded in by psychometric loans. The crowding out of smaller informal loans may represent entrepreneurs preferring to switch away from such loan sources (which may carry relatively high transaction costs) once they have access to formal finance; or it may represent family and friends being reluctant to give loans if they observe the entrepreneur’s access to formal finance. 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. Columns 5 and 6 show no evidence that the treatment had an impact on borrowing from commercial banks or other microfinance institutions. Borrowing from banks is very infrequent in our sample (11% of the control group).

Panel B confirms that treatment also substantially increased the total amount borrowed (Column 1) and the total formal amount borrowed (Column 3) as well as decreasing the total informal amount borrowed (Column 5). The total amount borrowed conditional on taking one or more loans also increased in the treatment group (Column 2); although the increase in formal borrowing conditional on taking one or more formal loans is not significant (Column 4). The amount borrowed conditional on taking one or more informal loans is also larger in the treatment group, but not significantly so (Column 6), and we only observe 31 informal loans. Panel C shows the same estimations using the raw loan amounts winsorized at the 99th

percentile; although our preferred estimations are panel B, since panel C decreases precision and allows greater influence of a couple of large formal loans observed in the control group.

Most of the 42% of the control group who were still able to access formal financing did so via collateralized loans from other MFIs participating in the WEDP program. Thus, the impact we observe may reflect a lower bound on the impact of providing psychometric-appraised lending (conditional on passing the psychometric screening) on formal borrowing for a population that was not already served by such a credit program.<sup>11</sup> Although the psychometric-appraised loan product was designed to be targeted at women who lacked access to collateral at least at baseline, we observe some collateralized lending among both the treatment and control groups at endline: 44% of the control group used a guarantor, asset collateral or both in the past three years before endline; of whom 29% used a guarantor, 20% used a house and 8% used a car (Appendix Table A2). Use of guarantors and of vehicles as collateral is substantially lower among the treatment group — although only the reduction in use of vehicles is statistically significant — suggesting that treated women prefer the uncollateralized loan with a higher interest rate over a collateralized loan with the implied cost of a guarantor or collateral. This implied cost may include negotiation with a guarantor, or with the owner of the collateral since assets such as housing and vehicles are typically not owned by women within the household in Ethiopia. Alternatively or additionally, the implied cost may reflect the expected cost of potentially losing the collateral. That said, there is suggestive evidence that some respondents mistakenly believed that business assets purchased with WEDP-X loans could be repossessed. Despite the fact that WEDP-X loans were fully uncollateralized, almost 20% of entrepreneurs in the treatment group report at endline that they used business inventory as collateral (Appendix Table A2, Column 6). Overall, the reported use of collateral is not significantly lower among the treatment group (Column 1); but this largely captures the seemingly mistaken reporting that business assets

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<sup>11</sup>If the product were scaled up extensively, we might expect a lower proportion of the general population to *pass* the psychometric screening and business appraisal, given that WEDP targets female entrepreneurs who are already in business and actively seeking opportunities to grow.



were used as collateral.

Related, when asked about the primary use of their WEDP-X loans, almost half of the treatment group say they used the loan for marketing materials or services; while 25% say they purchased inputs, and 21% equipment. While marketing may have been an important use of funds, for loans of this size we suspect inputs and equipment may have been a larger use, and that there may have been some reticence to report this use linked to the mistaken belief that business assets might count as collateral for the loan.

## 6.2 Impacts on Firm Survival

Table 3 shows that treatment increased the firm survival rate from baseline to endline from 67% in the control group to 83% in the treatment group. Put differently, access to psychometric-appraised loans reduced firm death over three years to 17%, from the control-group rate of 33% through the COVID-19 pandemic, conflict in Ethiopia (including in the Oromia region where the study took place), and the related challenges in the economic environment. For illustrative comparison, McKenzie and Paffhausen (2019) use data from small firms in 12 developing countries to estimate firm death rates of 50% over six years. As a rough benchmark, we might interpolate this linearly to a business-as-usual closure rate of 25% over three years — our treatment group faring better than this, our control group faring worse. It appears the loan helped slightly smaller firms to survive: firms that stayed open (closed) had 2.33 (1.41) employees in the control group versus 1.75 (1.73) employees in the treatment group. The additional firms kept alive in the treatment group are roughly evenly distributed across sectors.

There is no significant impact on women exiting entrepreneurship altogether (Column 2), since many of those control-group respondents who closed their original firm reopened a new firm, typically in a different sector (Column 4). These sector switches did not follow a clear pattern — for example, as many women move into retail as out of it — and thus it is not clear whether these adjustments were in response to COVID-19 or idiosyncratic factors.

### 6.3 Impacts on Firm Performance

Table 4 shows that we generally do not observe significant treatment impacts on business performance outcomes; although due to power limitations, we cannot rule out some sizeable impacts.<sup>12</sup> Treated firms report insignificantly higher unconditional profits than control firms in the last year (Column 1). A large part of this difference is driven by the larger number of control-group entrepreneurs who closed their original firm, did not open a new firm, and hence report zero profits, and so differences in conditional profits are smaller and also insignificant (Column 2).<sup>13</sup> Almost all firms who stay open report positive profits in the last year; thus there is no evidence of access to psychometric-appraised loans keeping “zombie firms” alive during the challenging macroeconomic circumstances. That said, treatment-group firms report significantly *lower* profits in the last 30 days prior to the endline survey in October 2021 compared to control group firms (Column 4 randomization inference p-value  $< 0.1$ ; and Columns 3 and 4 of Appendix Table A3 show significant reductions in levels).

It therefore appears that access to psychometric-appraised loans kept more, and slightly smaller, firms alive; that this at least did not lead to weaker average performance among the treatment group in the last year; but that treatment-group firms were performing worse specifically around the time of the endline survey. It may be that firms in the treatment group are in specific product or service lines that were particularly exposed to the challenging macroeconomic climate around the time of the endline survey — which took place just after national elections, and prior to those a late peak of COVID-19 and restrictions. We do not see evidence, however, that the new firms that opened up in the control group are those with the highest profits in the last 30 days. Nor, as mentioned above, do we see that the new firms are distributed differently across sectors. Thus if the control group had greater flexibility to

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<sup>12</sup>The firm performance outcomes in Tables 4 and 5 and Appendix Tables A3, A5 and A7 are measured for the respondent’s main business (whether the original business, or a new one she opened); but results are almost identical across all businesses (Appendix Table A4), and 85% of women who are still operating a business at endline have only one.

<sup>13</sup>Table 4 shows the pre-specified Inverse Hyperbolic Sine transformation of the value outcomes, but we also present the values in Ethiopian birr in Appendix Table A3.

adapt to circumstances at the time of the endline, it may have been on intensive margins, rather than via closing and opening a new firm better adapted to current conditions.

There is tentative evidence that treatment firms hold a greater value of owned equipment (Column 5, randomized inference p-value 0.105), which is also only marginally insignificant conditional on firms remaining in operation (not shown). We find no evidence of a treatment impact on the value of inventory stock, or raw materials held by the firm (Columns 6 and 7); nor on employment, own labor inputs (Appendix Table A5).

## 6.4 Heterogeneity by Timing of Loan Appraisal

Given that the median loan appraisal date for our study was December 2019, the onset of the COVID-19 pandemic in March 2020 may have disproportionately affected entrepreneurs who were appraised and received loans in the later part of our study. Table 5 presents a re-estimation of Equation 1 adding a pre-specified interaction between treatment and an indicator for the entrepreneur being assessed after the median appraisal date. The observed treatment effects on borrowing are larger for firms that were assessed *after* the median date (Columns 1 and 2). Firms appraised in 2020 also show a positive treatment effect on annual profits unconditional on being in operation (Column 6), and value of inventory stock (Column 9).

We cannot say, however, if the increased treatment effects on borrowing and profits for entrepreneurs applying later reflects greater impact of psychometric loans in the face of COVID-19. It may also be that firms who applied earlier simply had more time by endline to access credit via other means — even if they found themselves in the control group — and to start other businesses. Columns 1 and 2 show that control-group firms appraised after the median date were less likely to have borrowed — and specifically to have borrowed from a formal source — compared to control-group firms assessed earlier, although these correlations are insignificant. Control-group firms appraised after the median date were also significantly less likely to have started a new business than control-group firms appraised before the

median date; tables available on request. Part of the weaker impacts for women applying earlier may also be explained by women who applied earlier appearing more vulnerable at baseline: specifically they were more likely to be divorced/separate/widowed, and to be the household head, i.e. live in a female-headed household; less likely to be university-educated; and operated firms with slightly lower revenues at baseline (Appendix Table A6). Earlier borrowers also appear more credit-constrained: only 61% of entrepreneurs who borrowed early said they could get 5,000 Ethiopian birr (approx. USD 100) in two weeks in an emergency, compared to 95% of borrowers appraised in 2020.

We also observe that some treatment effects appear larger for firms with below-median profits at baseline (Appendix Table A7). Otherwise we find little systematic evidence of heterogeneity in impact by pre-specified median splits of baseline psychometric test score, capital stock, household collateralizable assets, and household income (tables available on request); with the caveat that power to detect heterogeneity is limited given our sample size.

Table 2: Impacts on Credit Constraints

Panel A: Extensive margin (any borrowing for business purposes)						
	(1) Received an uncollateralized loan (Yes 1; No 0)	(2) Borrowed in the past 3 years (Yes 1; No 0)	(3) Borrowed from formal source in the past 3 years (Yes 1; No 0)	(4) Borrowed from informal source in the past 3 years (Yes 1; No 0)	(5) Borrowed from bank in the past 3 years (Yes 1; No 0)	(6) Borrowed from MFI in the past 3 years (Yes 1; No 0)
Treatment (0/1)	0.931*** (0.035)	0.292*** (0.076)	0.476*** (0.077)	-0.176** (0.084)	0.000921 (0.059)	-0.101 (0.077)
Psychometric score above median (0/1)	0.0344 (0.030)	0.104 (0.076)	0.170** (0.076)	-0.0260 (0.079)	0.0755 (0.057)	0.131* (0.074)
<b>ANCOVA</b>	<b>x</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>
Observations	131	124	124	124	124	124
Control mean	0.0290	0.606	0.424	0.318	0.106	0.258
$R^2$	0.88	0.14	0.28	0.050	0.020	0.039
Randomization inference p-value	0	0.0030	0	0.031	0.98	0.20
Sharpened q-value	0.01	0.0100	0.01	0.071	0.46	0.20
Panel B: Intensive margin (amount borrowed for business purposes) - IHS						
	(1) Total amount borrowed (Unconditional)	(2) Total amount borrowed (Conditional)	(3) Formal amount borrowed (Unconditional)	(4) Formal amount borrowed (Conditional)	(5) Informal amount borrowed (Unconditional)	(6) Informal amount borrowed (Conditional)
Treatment (0/1)	4.564*** (1.03)	0.631** (0.30)	6.547*** (1.00)	0.204 (0.32)	-2.121** (0.96)	0.587 (0.55)
Psychometric score above median (0/1)	1.043 (1.00)	-0.0777 (0.24)	2.462** (0.98)	-0.106 (0.22)	-0.407 (0.88)	-0.0877 (0.55)
<b>ANCOVA</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>
Observations	124	95	124	83	124	31
Control mean	7.043	12.51	5.022	12.86	3.399	11.76
$R^2$	0.17	0.086	0.33	0.056	0.053	0.13
Randomization inference p-value	0.01	0.066	0	0.59	0.018	0.20
Sharpened q-value	0.0050	0.11	0.01	0.43	0.049	0.20
Panel C: Intensive margin (amount borrowed for business purposes) - Levels						
	(1) Total amount borrowed (Unconditional)	(2) Total amount borrowed (Conditional)	(3) Formal amount borrowed (Unconditional)	(4) Formal amount borrowed (Conditional)	(5) Informal amount borrowed (Unconditional)	(6) Informal amount borrowed (Conditional)
Treatment (0/1)	272.3 (1089.6)	-1127.3 (1527.9)	850.5 (866.1)	-2534.6 (1984.8)	-12523.8* (7269.5)	434.1 (580.0)
Psychometric score above median (0/1)	1045.0 (932.2)	973.1 (1172.9)	1471.9** (713.3)	318.2 (1268.5)	-2483.4 (6591.6)	206.4 (480.6)
<b>ANCOVA</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>
Observations	124	95	124	83	124	31
Control mean	2529.4	4283.5	1789.7	5380	21045.5	1108.1
$R^2$	0.062	0.055	0.085	0.056	0.13	0.24
Randomization inference p-value	0.76	0.44	0.28	0.14	0.063	0.22
Sharpened q-value	0.43	0.39	0.26	0.18	-0.11	0.21

Notes: Panel A outcomes are as follows: (1) Uncollateralized loan indicates if the loan was received or not according to the financial institution. (2) "Borrowing any money" takes the value of 1 if respondent borrowed formally or informally, and 0 otherwise. (3) Formal borrowing indicates if respondent borrowed any money for their business from Banks, Micro-finance Institutions (MFI), or Credit Unions. (4) Informal borrowing indicates if respondent borrowed any money for their business from their spouse, friends and relatives, and informal savings groups. (5) Borrowing from bank indicates if respondent borrowed any money for their business from a bank. (6) Borrowing from MFI indicates if respondent borrowed any money for their business from an MFI (other than Wasasa). Panel B and C outcomes are as follows: Outcomes 1 and 2 are total borrowing, 3 and 4 are total formal borrowing amount which includes self-reported amounts borrowed for the business from formal sources such as Banks, Micro-Finance Institutions (MFI), and Credit Unions, and 5 and 6 are total informal borrowing amount which includes self-reported amounts borrowed for the business from the spouse, friends and relatives, and informal savings. Panel B presents inverse hyperbolic transformed outcomes and panel C presents 99th-percentile winsorized raw outcomes. Conditional amounts represent self-reported estimates for those who borrowed, whereas unconditional amounts include those who did not borrow with a value of 0. All outcomes have a three year recall period, so Panel A represents any borrowing in the past 3 years and Panel B and C represent total borrowing from all loans in the past 3 years. Psychometric scores in the impact evaluation sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table 3: 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)	-0.0893 (0.065)	-0.121 (0.073)	-0.129** (0.061)	0.0139 (0.031)
Psychometric score above median (0/1)	0.165** (0.080)	-0.185*** (0.065)	0.0449 (0.067)	0.0373 (0.056)	-0.0201 (0.029)
<b>ANCOVA</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Observations	124	124	124	124	124
Control mean	0.667	0.197	0.197	0.152	0.0152
$R^2$	0.066	0.082	0.045	0.049	0.011
Randomization inference p-value	0.072	0.21	0.096	0.022	0.71
Sharpened q-value	0.15	0.19	0.15	0.12	0.35

Notes: Outcome 1 takes the value of 1 if the WEDP business was operating at the time of the endline survey (September 2021). Outcome 2 takes the value of 1 if respondent stated that they closed their original business, and their main economic activity is not another business they own. Outcome 3 takes the value of 1 if respondent reported starting a new business regardless of their WEDP business's operational status. Outcome 4 takes the value of 1 if respondent stated their new business is in a different sector from their original WEDP business. Outcome 5 takes the value of 1 if respondent stated their new business is in the same sector as their original WEDP business. Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table 4: Impacts on Firm Performance

	Profits				Business inputs		
	(1) Last year's profit (Unconditional) (IHS)	(2) Last year's profit (Conditional) (IHS)	(3) Last 30 days profit (Unconditional) (IHS)	(4) Last 30 days 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)	1.644 (1.11)	0.596 (1.00)	-1.754 (1.58)	-2.747 (1.75)	1.540 (0.93)	0.826 (1.06)	-0.834 (0.95)
Psychometric score above median (0/1)	1.977* (1.02)	-0.182 (0.86)	0.792 (1.48)	-0.541 (1.69)	2.278** (0.92)	1.127 (1.04)	0.880 (0.88)
<b>ANCOVA</b>	✓	✓	✓	✓	✗	✗	✗
Observations	124	105	124	105	124	124	124
Control mean	9.102	11.33	5.967	7.431	8.760	7.409	3.404
$R^2$	0.050	0.019	0.046	0.084	0.071	0.023	0.016
Randomization inference p-value	0.13	0.41	0.20	0.075	0.10	0.43	0.32
Sharpened q-value	0.20	0.26	0.23	0.20	0.83	0.83	0.83

Notes: Outcomes 1-2 are self-reported profits from the main business from the year 2013 in the Ethiopian calendar (which is 2020 in the Gregorian calendar). Outcomes 3-4 are self-reported profits from the main business for the past 30 working days. Outcome 5 is the self-reported value of owned equipment, where the respondent was asked to estimate the replacement value of all owned equipment and machinery for the main business. Outcome 6 is the self-reported value of inventory stock, where the respondent was asked to estimate the value of final goods for sale that they currently have in stock for their main business. Outcome 7 is the self-reported value of raw materials, where the respondent was asked to estimate the value of product components and raw materials for their main business. Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0. Only Inverse Hyperbolic Sine (IHS) transformed versions of variables are presented. Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table 5: Impacts by Timing of Loan Appraisal

	Borrowing				Survival	Performance (Main business)		Inputs (Main business)		
	(1) Borrowed in the past 3 years (Yes 1; No 0)	(2) Borrowed from formal source in the past 3 years (Yes 1; No 0)	(3) Borrowed from informal source in the past 3 years (Yes 1; No 0)	(4) Total amount borrowed (Conditional) (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 (0.11)	0.335*** (0.11)	-0.185 (0.12)	0.543* (0.31)	0.0734 (0.13)	-0.0883 (1.58)	-0.0496 (1.42)	0.589 (1.25)	-1.295 (1.52)	-1.310 (1.34)
Assessment was done after median date (0/1)	-0.183 (0.12)	-0.122 (0.12)	-0.0690 (0.12)	0.0611 (0.56)	0.117 (0.12)	-0.952 (1.59)	0.0745 (1.38)	-1.292 (1.36)	-0.922 (1.45)	-1.583 (1.28)
Interaction term between assessment date (0/1) and treatment	0.327** (0.14)	0.277* (0.15)	0.0271 (0.16)	0.147 (0.59)	0.158 (0.15)	3.367* (2.02)	1.188 (1.60)	1.942 (1.77)	4.094** (2.03)	1.085 (1.77)
ANCOVA	✓	✓	✓	✓	✗	✓	✓	✗	✗	✗
Observations	124	124	124	95	124	124	105	124	124	124
Control mean	0.697	0.485	0.364	12.46	0.606	9.534	11.24	9.401	7.950	4.229
R <sup>2</sup>	0.17	0.30	0.054	0.090	0.12	0.073	0.029	0.082	0.063	0.031
Randomization inference p-value	0.043	0.082	0.87	0.81	0.32	0.12	0.46	0.28	0.049	0.54
Sharpened q-value	0.20	0.20	0.77	0.77	0.47	0.31	0.31	0.39	0.17	0.56
Treatment + Interaction p-value	0.01	0.01	0.15	0.21	0.01	0.02	0.35	0.06	0.05	0.86

Notes: Assessments were done from April 2nd 2018 until March 3rd 2020, and the median assessment date used as a cut-off is December 15th 2018. Outcome 1 takes the value of 1 if respondent borrowed formally or informally and 0 otherwise. Outcome 2 takes the value of 1 if the respondent borrowed any money for their business from Banks, Micro-Finance Institutions (MFI), or Credit Unions. Outcome 3 takes the value of 1 if the respondent borrowed any money for their business from their spouse, friends and relatives, and informal savings groups. Outcome 4 includes both formal and informal borrowing amounts reported by the respondent, conditional on borrowing. Outcome 5 takes the value of 1 if business was operating at the time of the endline survey (September 2021). Outcomes 6-7 are self-reported total profits from the main business for the year 2013 in the Ethiopian calendar (which is 2020 in the Gregorian calendar). Outcome 8 is the self-reported value of business capital, where the respondent was asked to estimate the replacement value of all owned equipment and machinery for the main business. Outcome 9 is the self-reported value of inventory stock, where the respondent was asked to estimate the value of final goods for sale that they currently have in stock for their main business. Outcome 10 is the self-reported value of raw materials, where the respondent was asked to estimate the value of product components and raw materials for their main business. Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0. Only Inverse Hyperbolic Sine (IHS) transformed versions of borrowing amounts, profits and business inputs are presented. Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline, as well as if the respondent was above or below the median psychometric score cut-off. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$



## 6.5 Loan Repayment Rates

A typical metric of loan non-performance used by MFIs is the “Portfolio at Risk 90 Days (PAR-90)” rate, i.e. the percentage of the portfolio that is at least 90 days overdue on scheduled repayment. Prior to the onset of COVID-19, the psychometric-appraised, uncollateralized WEDP-X loans showed a PAR-90 of around 2%. This figure is healthily low, and was similar to that achieved by regular, collateralized WEDP loans offered by the MFI. However, the psychometric loans disbursed in early 2020 performed worse than the psychometric loans disbursed prior to 2020, since loans disbursed in early 2020 were almost immediately hit by the consequences of the COVID-19 pandemic. The psychometric loans disbursed in early 2020 also performed worse than regular, collateralized loans disbursed early in 2020, although very few regular collateralized loans were being disbursed at that time. Most of the psychometric loans that fell into arrears during the COVID-19 pandemic had already been partially repaid. By September 2022, all WEDP-X loans had matured and Wasasa was no longer collecting on the initial WEDP-X portfolio. Total defaults amounted to just under 9% of total funds disbursed under WEDP-X. Out of the 62 borrowers, 54 fully repaid the WEDP-X loan, and 8 partially defaulted.

Appendix Table A8 shows that the psychometric score positively predicts repayment of WEDP-X loans within the treatment group as observed from Wasasa administrative data. Thus psychometric scoring has predictive power for its intended outcome — repayment — even among a sample that already passed a cut-off score as well as due diligence checks. We note that by design we cannot observe whether a score below versus above the cut-off predicts repayment of uncollateralized lending, since those scoring below the cut-off were not eligible for an uncollateralized loan. However, in Columns 6 and 8 of Appendix Table A1 we show that women who scored below 370 went on to have lower annual profits and monthly sales by endline compared to the impact evaluation control group who scored above 370 (and passed due diligence) but were randomly assigned to control.

## 7 Conclusion

Our study provides evidence that using psychometric credit scoring as a substitute for traditional collateral requirements significantly alleviates credit constraints for women entrepreneurs. Access to a psychometric-appraised loan also halved firm closure during the COVID-19 pandemic and other aggregate shocks. Treated firms were almost all profitable in the last year despite the challenging macroeconomic environment, so there is no evidence of supporting “zombie firms”. Repayment rates of the uncollateralized loan product were arguably respectable, given that the loans performed well prior to 2020, and most of the default was partial and came from loans disbursed just before the onset of the COVID-19 pandemic. However, the overall default rate on the portfolio was worse than non-performance thresholds typically required by regulators, or by MFIs’ key performance indicators.

We argue that these findings are a “proof of concept” that psychometric-appraised lending can be a viable and impactful solution for women who lack collateral, in contexts where lending is highly collateral-constrained. The benefits of psychometric-appraised lending may also naturally extend to other populations who lack access to collateral — including other marginalized groups, and also poorer borrowers in general — and thus to broader reduction of inequality in credit markets. If the product were scaled up to populations not already served by a lending program such as WEDP, we might expect even greater impacts on relaxing credit constraints for those who pass psychometric screening; although a smaller proportion of potential borrowers might actually pass the screening. However, while our results are evidence that psychometrics can substitute for collateralization, we do not test if they could be used as a low-cost substitute for other aspects of the due diligence process such as business appraisal. Further work is also needed to understand financial institutions’ incentives to invest in costly screening such as psychometric testing, in contexts where other financial institutions may make offers to borrowers once they are screened (Arráiz *et al.*, 2021).

Combining psychometric variables with machine learning has also been shown to be predictive of returns to larger loans (Bryan et al., 2021). This finding potentially indicates a use case for psychometrics in targeting larger loans in donor-subsidized lending, or incorporating psychometrics into equity products where the MFI objective function includes returns rather than just repayment. More research is needed on further financial innovations to serve women and other disadvantaged groups who lack assets to secure growth-size loans.

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# A Online Appendix

Figure A1: Formal and Informal Borrowing at Endline

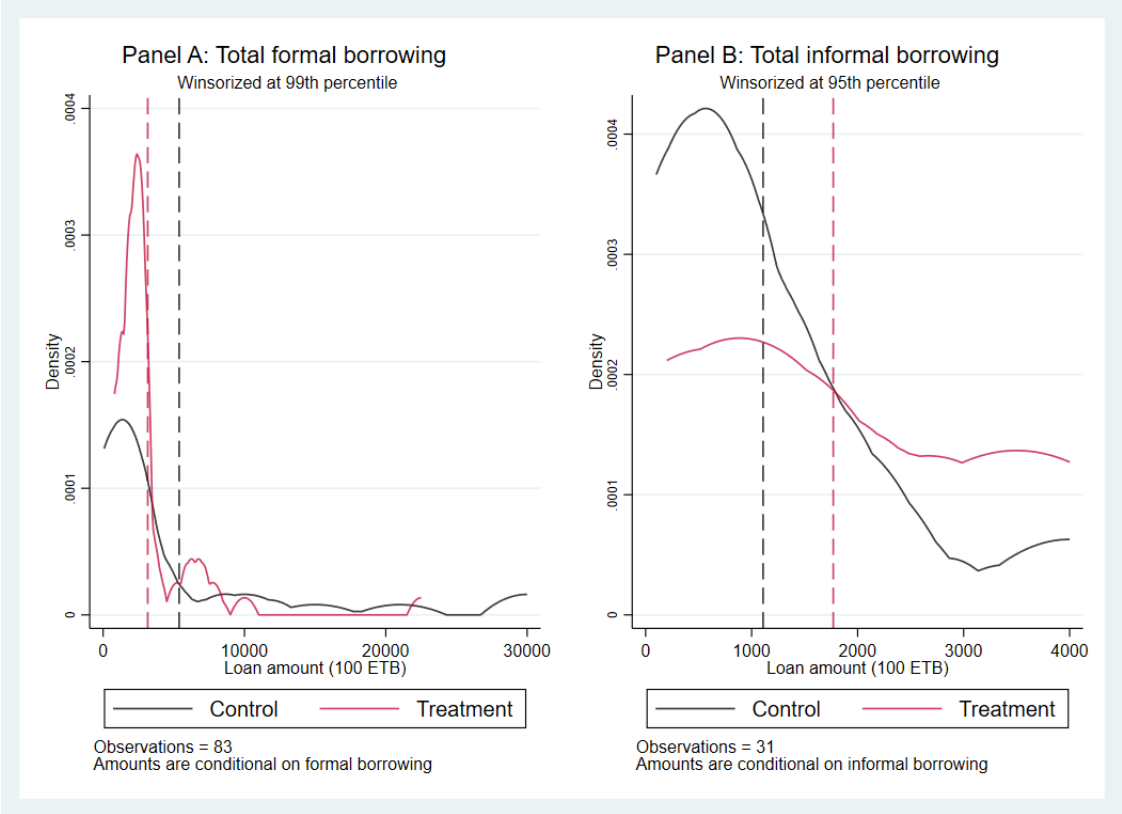


Table A1: Endline outcomes by sample groups

	Borrowing				Survival	Performance (Main business)				Inputs (Main business)
	(1) Borrowed in the past 3 years (Yes 1; No 0)	(2) Borrowed from formal source in the past 3 years (Yes 1; No 0)	(3) Borrowed from informal source in the past 3 years (Yes 1; No 0)	(4) Total amount borrowed (Conditional) (IHS)	(5) Business was operating at endline (Yes 1; No 0)	(6) Last year's profit (Unconditional) (Level)	(7) Last year's profit (Unconditional) (IHS)	(8) Last 30 days sales (Unconditional) (Level)	(9) Last 30 days sales (Unconditional) (IHS)	(10) Inputs index (Unconditional) (IHS)
IE Treatment Group	0.302*** (0.074)	0.468*** (0.074)	-0.117 (0.081)	0.607** (0.284)	0.144* (0.079)	342.133 (371.587)	1.366 (1.043)	-194.344 (251.091)	0.494 (0.751)	-0.038 (0.145)
Non-IE Above 370	-0.052 (0.077)	-0.073 (0.075)	-0.030 (0.072)	-0.445 (0.312)	-0.020 (0.073)	-417.840 (266.668)	0.317 (0.930)	-418.011** (196.415)	-0.404 (0.722)	-0.344*** (0.111)
Non-IE Below 370	-0.046 (0.090)	0.009 (0.087)	-0.048 (0.084)	-0.192 (0.334)	0.094 (0.086)	-634.874** (283.595)	0.886 (1.065)	-491.378*** (178.347)	0.438 (0.858)	-0.129 (0.120)
Psychometric score above median (0/1)	0.038 (0.061)	0.099* (0.059)	-0.004 (0.058)	0.118 (0.220)	0.126** (0.060)	-7.959 (244.444)	1.355* (0.758)	34.497 (146.487)	1.442** (0.595)	0.141 (0.092)
<b>ANCOVA</b>	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗
Observations	320	320	320	203	321	307	311	307	307	321
Control mean	0.61	0.42	0.32	12.5	0.67	1393.7	9.10	909.2	9.28	0.18
$R^2$	0.076	0.17	0.014	0.13	0.031	0.048	0.046	0.10	0.078	0.063

Notes: The impact evaluation (IE) control group is the omitted reference group. The IE control group refers to the individuals who passed the assessment (scored above 370) and business appraisal and were randomized to the control group (not offered an uncollateralized loan). IE treatment group refers to the individuals who passed the assessment and business appraisal and were randomized to receive an uncollateralized loan. Non-IE above 370 refers to those who passed the assessment (scored above 370) but failed the business appraisal. Non-IE Below 370 refers to those who did not pass the test. Outcome 1 takes the value of 1 if respondent borrowed formally or informally and 0 otherwise. Outcome 2 takes the value of 1 if the respondent borrowed any money for their business from Banks, Micro-Finance Institutions (MFI), or Credit Unions. Outcome 3 takes the value of 1 if the respondent borrowed any money for their business from their spouse, friends and relatives, and informal savings groups. Outcome 4 includes both formal and informal borrowing amounts reported by the respondent, conditional on borrowing. Outcome 5 takes the value of 1 if business was operating at the time of the endline survey (September 2021). Outcomes 6-7 are raw and IHS transformed self-reported total profits from the year 2013 in the Ethiopian calendar (which is 2020 in the Gregorian calendar), respectively. Outcomes 8-9 are sales from the past 30 working days. Outcome 10 is an index of average z scores of capital, inventory and raw materials for main business. Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline, as well as if the respondent was above or below the median psychometric score cut-off. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table A2: Impacts on Using Collateral

	(1) Any collateral used in the past 3 years (Yes 1; No 0)	(2) Guarantor used as collateral in the past 3 years (Yes 1; No 0)	(3) Asset used as collateral in the past 3 years (Yes 1; No 0)	(4) House used as collateral in the past 3 years (Yes 1; No 0)	(5) Car used as collateral in the past 3 years (Yes 1; No 0)	(6) Business assets used as collateral in the past 3 years (Yes 1; No 0)
Treatment (0/1)	0.0475 (0.092)	-0.108 (0.079)	0.100 (0.088)	-0.0222 (0.075)	-0.0807* (0.045)	0.181*** (0.056)
Psychometric score above median (0/1)	0.213** (0.089)	0.00719 (0.077)	0.159* (0.083)	0.114 (0.072)	-0.00741 (0.039)	0.0324 (0.053)
<b>ANCOVA</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Observations	124	124	124	124	124	124
Control mean	0.439	0.288	0.258	0.197	0.0758	0.0152
$R^2$	0.073	0.019	0.065	0.024	0.042	0.10
Randomization inference p-value	0.62	0.20	0.20	0.73	0.042	0
Sharpened q-value	0.43	0.20	0.20	0.43	0.087	0.01

Notes: Outcome 1 takes the value of 1 if the respondent reported using any collateral for any loans borrowed in the last 3 years and 0 otherwise. Outcomes 2-6 are binaries from a multi-select question stating "Which of the following items have you personally used as collateral for any loans borrowed in the past 3 years?". Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table A3: Impacts on Monthly Sales and Profits of the Main Business

	Last 30 days sales		Last 30 days profits		Last year's profit	
	(1)	(2)	(3)	(4)	(5)	(6)
	(Unconditional) (Level)	(Conditional) (Level)	(Unconditional) (Level)	(Conditional) (Level)	(Unconditional) (Level)	(Conditional) (Level)
Treatment (0/1)	-313.8 (275.4)	-481.3 (336.4)	-155.6* (89.8)	-195.9* (107.3)	466.9 (380.0)	400.7 (441.6)
Psychometric score above median (0/1)	148.2 (242.2)	15.16 (308.1)	-40.72 (76.1)	-72.40 (94.3)	161.9 (363.7)	-297.7 (450.8)
<b>ANCOVA</b>	✓	✓	✓	✓	✓	✓
Observations	124	105	124	105	124	105
Control mean	909.2	1170	117.1	149.0	1393.7	1720.4
$R^2$	0.094	0.14	0.054	0.069	0.031	0.027
Randomization inference p-value	0.11	0.061	0.017	0.021	0.14	0.30
Sharpened q-value	0.20	0.20	0.20	0.20	0.20	0.26

Notes: Outcomes 1-2 are sales from the past 30 working days. Outcomes 3-4 are profits from the past 30 working days. Outcomes 5-6 are profits from the past year (Ethiopian 2013/Gregorian 2020). Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0. Level refers to amounts in ETB, winsorized at 99th percentile. Outcomes indicated with "Level" are in 100 Ethiopian birr (100 ETB = 3.4 USD at baseline and 2.2 USD at endline). Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$



Table A4: Impacts on Monthly Sales and Profits of All Businesses

	Last 30 days sales		Last 30 days profits		Last year's profit	
	(1)	(2)	(3)	(4)	(5)	(6)
	(Unconditional Level)	(Conditional Level)	(Unconditional Level)	(Conditional Level)	(Unconditional Level)	(Conditional Level)
Treatment (0/1)	-261.3 (282.1)	-391.8 (353.9)	-139.2 (97.1)	-181.0 (114.9)	536.7 (427.3)	461.5 (495.5)
Psychometric score above median (0/1)	247.2 (247.2)	154.3 (320.1)	-33.84 (84.1)	-56.19 (106.1)	370.1 (408.6)	-76.95 (502.8)
<b>ANCOVA</b>	✓	✓	✓	✓	✓	✓
Observations	124	105	124	105	124	105
Control mean	962.4	1236.2	133.7	171.8	1558.1	1941.2
$R^2$	0.098	0.13	0.028	0.036	0.036	0.021
Randomization inference p-value	0.20	0.14	0.042	0.038	0.14	0.30
Sharpened q-value	0.23	0.20	0.20	0.20	0.20	0.26

Notes: Outcomes 1-2 are sales from the past 30 working days. Outcomes 3-4 are profits from the past 30 working days. Outcomes 5-6 are profits from the past year (Ethiopian 2013/Gregorian 2020). Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0. Level refers to amounts in ETB, winsorized at 99th percentile. Outcomes indicated with "Level" are in 100 Ethiopian birr (100 ETB = 3.4 USD at baseline and 2.2 USD at endline). Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table A5: Impacts on Labor Use

	Number of employees		Number of hours respondent works per week	
	(1)	(2)	(3)	(4)
	(Unconditional)	(Conditional)	(Unconditional)	(Conditional)
Treatment (0/1)	-0.626 (0.62)	-0.922 (0.70)	6.942 (5.84)	3.005 (5.49)
Psychometric score above median (0/1)	1.293** (0.57)	1.476** (0.66)	7.247 (5.67)	-2.879 (5.48)
<b>ANCOVA</b>	✓	✓	✓	✓
Observations	124	105	124	105
Control mean	2.606	3.358	40.33	50.23
$R^2$	0.44	0.51	0.027	0.0089
Randomization inference p-value	0.28	0.16	0.24	0.62
Sharpened q-value	0.83	0.83	0.83	0.83

Notes: Outcomes 1-2 includes full-time, part-time, temporary, unpaid and family workers currently working for the main business. Outcomes 3-4 are self-reported hours spent per week on the main business by the respondent on average. Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0. Number of employees and hours are winsorized at 99th percentile. Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table A6: T-tests between Early and Late test-takers

	Early test-takers	N	Late test-takers	N	Difference
	Mean		Mean		
Treatment (0/1)	0.45	64	0.45	67	-0.039
Psychometric score	399.8	64	399.8	67	2.44
<b>Respondent Characteristics:</b>					
Age	38.0	63	38.0	67	3.80***
Married	0.56	64	0.56	67	-0.079
Respondent has never married	0.16	64	0.16	67	-0.053
Respondent is divorced/separated/widowed	0.28	64	0.28	67	0.13*
Has children	0.86	64	0.86	67	0.053
Household size	4.19	62	4.19	62	-0.016
Respondent is household head	0.52	62	0.52	62	0.16*
Number of people who work in the household	2.13	62	2.13	62	0.18
Income from female workers in the household (100 ETB)	276.4	62	276.4	62	7.70
Total household income (100 ETB)	409.4	62	409.4	62	-34.9
Number of household assets	5.19	62	5.19	62	0.45*
Respondent's household has a car	0.21	62	0.21	62	-0.032
Respondent's household has a house	0.32	62	0.32	62	0.032
Completed university education	0.078	64	0.078	67	-0.16**
Completed secondary education	0.36	64	0.36	67	-0.13
Number of businesses owned in life	2.05	64	2.05	65	-0.25
Years of business related experience	3.15	62	3.15	65	-0.32
Is the sole owner of her main business	0.98	62	0.98	62	0
<b>Business Characteristics:</b>					
Number of years business has been operating	6.73	64	6.73	67	1.38*
Main business is in manufacturing	0.065	62	0.065	62	0
Main business is in services	0.35	62	0.35	62	0.065
Main business is in agriculture	0.048	62	0.048	62	0.032
Main business is in trade	0.50	62	0.50	62	-0.13
Starting capital (100 ETB)	406.3	62	406.3	62	-47.4
Started business because of an opportunity (=0 if necessity)	0.56	62	0.56	62	0.31***
<b>Outcomes:</b>					
Number of loans received	0.098	64	0.098	67	0.0015
Largest loan received (100 ETB)	456.9	64	456.9	67	-119.9
Largest loan received (IHS)	2.14	64	2.14	67	-1.04
Amount still owed (100 ETB)	0.16	64	0.16	67	0.15
Amount still owed (IHS)	0.25	64	0.25	67	0.041
Have account or loan with other institutions	1	64	1	67	0.030
Years have had other bank account	14.9	64	14.9	65	-0.77
Able to arrange 5000 ETB in 2 weeks for emergency	0.61	61	0.61	62	-0.35***
Max amount able to borrowed in unexpected emergency	18090.2	61	18090.2	62	-66.7
Average monthly profit from main business (100 ETB)	246.8	64	246.8	67	-4.57
Average monthly profit from main business (IHS)	10.4	64	10.4	67	-0.12
Average monthly profit from all businesses (100 ETB)	359.8	64	359.8	67	101.5
Average monthly profit from all businesses (IHS)	10.6	64	10.6	67	-0.047
Average monthly sales from main business (100 ETB)	651.4	64	651.4	67	-211.8
Average monthly sales from main business (IHS)	11.2	64	11.2	67	-0.47***
Average monthly sales from all businesses (100 ETB)	704.9	64	704.9	67	-182.2
Average monthly sales from all businesses (IHS)	11.3	64	11.3	67	-0.44**
Number of employees in main business	2.04	64	2.04	67	0.54
Number of employees in all businesses	2.15	64	2.15	67	0.58
Number of hours worked in a week	55.9	64	55.9	67	-9.56***
F-stat of joint significance					

Notes: Assessments were done from April 2nd 2018 until March 3rd 2020, and the median assessment date used as a cut-off is December 15th 2018. 64 individuals from the IE sample took the test before the median date, while 67 took the test after the median date. Income, loan amounts, profit and sales are in 100 Ethiopian birr (100 ETB = 3.4 USD at baseline). Table presents 99th percentile winsorized continuous variables and Inverse Hyperbolic Transformed (IHS) continuous variables measured in ETB. Bottom row presents the F statistic of joint significance of all the t-tests. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table A7: Impacts by Baseline Profits

	Borrowing				Survival	Performance (Main business)		Inputs (Main business)		
	(1) Borrowed in the past 3 years (Yes 1; No 0)	(2) Borrowed from formal source in the past 3 years (Yes 1; No 0)	(3) Borrowed from informal source in the past 3 years (Yes 1; No 0)	(4) Total amount borrowed (Conditional) (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)	0.383*** (0.10)	0.562*** (0.098)	-0.255** (0.100)	1.215*** (0.37)	0.170 (0.12)	1.508 (1.24)	-0.01814 (0.40)	2.604** (1.22)	0.967 (1.42)	1.788 (1.17)
Baseline profits are above the median (0/1)	0.185 (0.12)	0.179 (0.12)	0.0699 (0.12)	1.613*** (0.46)	0.223* (0.12)	0.664 (1.69)	-1.427 (1.43)	3.370*** (1.28)	1.112 (1.44)	4.006*** (1.19)
Interaction term between baseline profits (0/1) and treatment	-0.202 (0.15)	-0.191 (0.15)	0.145 (0.16)	-0.926* (0.50)	-0.0306 (0.16)	0.201 (2.17)	1.210 (1.83)	-2.450 (1.72)	-0.388 (2.11)	-5.622*** (1.70)
<b>ANCOVA</b>	✓	✓	✓	✓	✗	✓	✓	✗	✗	✗
Observations	124	124	124	95	124	124	105	124	124	124
Control mean	0.515	0.333	0.303	11.57	0.545	8.715	11.98	7.051	6.938	1.527
$R^2$	0.16	0.30	0.081	0.31	0.12	0.052	0.033	0.13	0.030	0.12
Randomization inference p-value	0.22	0.23	0.39	0.058	0.84	0.92	0.44	0.16	0.84	0.01
Sharpened q-value	0.30	0.30	0.42	0.30	1	1	1	0.20	0.39	0.0140
Treatment + Interaction p-value	0.08	0.01	0.40	0.45	0.16	0.35	0.52	0.90	0.71	0.01

Notes: Baseline monthly profits ranged from 200 to 120000 ETB in the IE sample and the median value used for the cut-off is 18750 ETB. Outcome 1 takes the value of 1 if respondent borrowed formally or informally and 0 otherwise. Outcome 2 takes the value of 1 if the respondent borrowed any money for their business from Banks, Micro-Finance Institutions (MFI), or Credit Unions. Outcome 3 takes the value of 1 if the respondent borrowed any money for their business from their spouse, friends and relatives, and informal savings groups. Outcome 4 includes both formal and informal borrowing amounts reported by the respondent, conditional on borrowing. Outcome 5 takes the value of 1 if business was operating at the time of the endline survey (September 2021). Outcomes 6-7 are self-reported total profits of the main business from the year 2013 in the Ethiopian calendar (which is 2020 in the Gregorian calendar). Outcome 8 is the self-reported value of owned equipment, where the respondent was asked to estimate the replacement value of all owned equipment and machinery for the main business. Outcome 9 is the self-reported value of inventory stock, where the respondent was asked to estimate the value of final goods for sale that they currently have in stock for their main business. Outcome 10 is the self-reported value of raw materials, where the respondent was asked to estimate the value of product components and raw materials for their main business. Conditional amounts represent only those whose businesses were open, whereas unconditional amounts include those not operating any business with a value of 0. Only Inverse Hyperbolic Sine (IHS) transformed versions of borrowing amounts, profits and business inputs are presented. Psychometric scores in the IE sample ranged from 370 to 452, and the median score used a cut-off is 383 (note that 370 was the qualifying score to receive an uncollateralized loan). Includes a control for number of children in the households that was imbalanced between treatment and control at baseline, as well as if the respondent was above or below the median psychometric score cut-off. Observations represent number of individuals. Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

Table A8: Psychometric score predictiveness for repayment of uncollateralized loans

	Treatment group only			
	(1)	(2)	(3)	(4)
	WEDP-x loan amount (Level)	WEDP-x loan amount (Level)	Loan repayment overdue by at least 90 days (Yes 1; No 0)	Loan repayment overdue by at least 90 days (Yes 1; No 0)
Psychometric score	-586.6 (413.2)		-0.0051* (0.0027)	
Psychometric score above median (0/1)		-23151.4 (14332.5)		-0.15 (0.10)
Average monthly profit from main business (100 ETB)	166.9*** (39.0)	166.1*** (39.7)	-0.00011 (0.00021)	-0.00011 (0.00021)
Observations	58	58	58	58
$R^2$	0.283	0.288	0.0686	0.0454

Notes: Table only shows results for the IE treatment group. Outcomes 1-2 are the uncollateralized (WEDP-x) loan amounts disbursed according to Wasasa's administrative data. Outcomes 3-4 indicate if the entrepreneur was over 90 days late on their scheduled (WEDP-x) loan repayment according to Wasasa (0/1). Columns 1 and 3 present specifications with the continuous psychometric score measure and columns 2 and 4 present specifications with the binary (above or below the median psychometric score for the IE sample) measure. Observations represent number of individuals. Loan amounts are in 100 Ethiopian birr (100 ETB = 3.4 USD at baseline and 2.2 USD at endline). Robust standard errors are in parentheses. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$