Energy Access and Microentrepreneurship in Developing Countries

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Abstract

We empirically evaluate the impact of off-grid solution on microentrepreneurship and income for households living in sub-Saharan African countries. The World Bank multi-tier frame-work household surveys for five sub-Saharan African countries: Ethiopia; Kenya; Liberia; Niger; and Nigeria are used to create our dataset for the off-grid solution effect on microentrepreneurship, measured by the propensity to become self-employed, and income. By using a binary indicator variable as an IV, our average treatment effect is identified and estimated as a local average treatment effect, a quasi-experimental estimation technique. From the main estimation, we find that the off-grid solution effect is significantly positive on microentrepreneurship and negative on income but statistically negligible. These estimates have, however, very different patterns of the estimated coefficients, and the presence and

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direction of the selection bias by country and estimation methods whether observational or quasi-experimental.

Keywords: Energy Access, Off-grid Solution, Impact Evaluation, Quasi-Experiment

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1. Introduction

Having a decent amount and quality of energy access at home is essential, regardless of the economic situations individual households have or their country has. Despite the global effort to provide sustainable energy access to the unelectrified population in the world, not to mention the United Nations' Sustainable Development Goal # 7.1: "Ensure Access to Affordable, Reliable and Modern Energy for All" a substantial portion of the total population does not have access to energy and electricity, especially in African countries. International Energy Agency (2022) report that 600 million people, or 43% of the total African population have no access to electricity, and mostly living in sub-Saharan Africa.

In addition to grid solutions, distributed renewable energy (DRE) technologies, including standalone off-grid solar systems (OGS) and mini/micro grids, play a crucial role in enhancing energy access in numerous countries. These DRE technologies can reach populations where grid solutions are either too costly or impractical. In 2022, OGS systems were responsible for over 50% of the increase in electricity access in Sub-Saharan Africa. (Energy Sector Management Assistance Program (ESMAP), 2024).

The energy access literature has not examined the impact of OGS on household economic outcomes, despite the important role that OGS plays.

Bayer et al. (2020) call for more impact evaluation studies on energy access by presenting inconsistent empirical findings for the energy access. Lee et al. (2020a) and Lee et al. (2020b) report that substantial benefits from electrification consistently reported in the previous literature do not hold in field experimental studies and relevant impact evaluation studies. To our best knowledge, there is no field-experimental research ever conducted specifically on the impact evaluation of off-grid solution.

We empirically evaluate the impact of off-grid solution on microentrepreneurship and income for households living in sub-Saharan African countries. The World Bank multi-tier framework (MTF) household surveys for five sub-Saharan African countries: Ethiopia; Kenya; Liberia; Niger; and Nigeria are used to create our dataset for the off-grid solution effect on microentrepreneurship, measured by the propensity to become self-employed, and income.[1] The average treatment effect (ATE) of having off-grid solution is estimated using a grid access indicator variable from the MTF household surveys as an instrumental variable (IV). Since the MTF survey randomized sample household collection with the 50-50 distribution of grid users and non-users, the grid access indicator is supposed to be independent of all

[1] Jayachandran (2021) defines microentrepreneurship as small-scale entrepreneurship in low-income countries. This idea might come from the empirical fact that over half of employed workers in low- and middle income countries are self-employed. Jayachandran (2021) adds that the vast majority of microentrepreneurs have no employees other than their family members may be because of potential costs to fire unproductive workers. Therefore, promoting self-employed in low- and middle income countries can contribute overall employment even in part.

other attributes than electrification and energy access. By using the binary indicator variable as an IV, our ATE is identified and estimated as a local average treatment effect (LATE), a quasi-experimental (QE) estimation technique.

Our identification strategy is to use the grid access indicator as an IV that aims to control for the endogeneity, or sample selection bias, from non-randomly assigned off-grid solution ownership. The key to the IV become vaild is that; i) it is correlated with off-grid solution, the treatment indicator, and target outcomes, self-employed indicator and income; and ii) it is uncorrelated with unobserved error terms. Since our IV is a binary indicator variable, correlations with other variables could be examined through the mean differences. And the exogenous error term condition for the IV could be examined by ensuring those mean differences of other control variables are not substantial. The mean difference of the treatment indicator variable, off-grid solution, by grid-access IV seems to be substantial, and the mean differences of the control variables do not seem to be very substantial, except the MTF-tier. This could be explained by which households with off-grid solution have better energy access quality so that they have higher MTF-tier. Overall, our IV do not seem to break balances of the control variables and is expected to play a role as a valid IV. We therefore estimate the off-grid solution effect with grid access IV and carefully examine test statistics for their endogeneity and first-stage F-test.

From the main model estimates, we find that the ATE estimates with the IV and without the IV are substantially different. The LATE estimate for microentrepreneurship is about ten times greater than that of ATE estimate.

This could be strong observable evidence of the presence of selection bias due to the non-random assignment of households having off-grid solutions. In other words, observational studies such as OLS, logit or probit model estimations can seriously undermine the off-grid solution effect on microentrepreneurship, the propensity to be self-employed in developing countries with respect to off-grid solution ownership. The off-grid solution effects on income are the same but the direction is opposite. The ATE estimate using OLS about three times greater than the LATE estimate using the IV. This is another empirical evidence of the selection bias but the bias is positive for income. This might indicate that off-grid solution effect on income could be seriously overestimated without using valid QE methods to control for the selection bias. The substantial differences between the ATE and LATE estimates of the off-grid solution effects on both microentrepreneurship and income indicate also that our IV, the grid access indicator variable, works well controlling for the selection biases.

Overall, we find that the off-grid solution effect is significantly positive on microentrepreneurship and negative on income, but this effect on income is not statistically significant. The MTF-tier effect, on the other hand, is opposite where it is significantly positive on income and negative on microentrepreneurship, but the effect is statistically insignificant. The implications of our finding are: i) having off-grid solution at home motivate or promote people to be self-employed; but ii) this off-grid solution effect does not increase their income level; instead, iii) the quality of the electricity supply to their home are likely to be (positively) correlated with their income level; but iv) this electricity supply quality is unlikely to be correlated with

microentrepreneurship.

However, our findings from the main estimation should be interpreted in a limited way. From the ATE and LATE estimations of off-grid solution separated by country, we find that every country has very different patterns of the estimated coefficients, and the presence and direction of the selection bias. In other words, one unified LATE parameter estimate using stacked data from different countries may not be relevant to apply for each country. The LATE estimate for the off-grid solution effect from the main estimate is consistent only with the Ethiopian sample households. This finding may point out the importance of external validity to the impact evaluation research using QE methods. Empirical studies on development economics have used field-experiment to evaluate causal relationships between policy interventions and the associated outcomes, and lack of external validity is one of the critical points for the field experiment research done in a small village or town. As an alternative, recent studies have done their field-experiments in more than one village or town, called a multi-site field-experiment.

Wagner et al. (2021) is one of the most closely related previous works on the impact evaluation of energy access done in Africa. They conducted a stratified random sample of 1,048 Kenyan households with 528 solar home system (SHS) owners as the treatment group and 520 non-SHS owners as the control group, and estimate the ATEs of SHS ownership on various outcome variables such as energy use, energy consumption and costs. Wagner et al. (2021) find that the SHS ownership increases the use of LED lamps that lead to the reduction of dirty lamp usages with the reduction of kerosene uses. Mahn et al. (2024) is another closed work on energy access. They

use the same data, the World Bank MTF household survey, not only for African countries but 11 countries from Asia and Central America to perform a discrete choice model estimation for solar energy adoption. Mahn et al. (2024) empirical analysis is more of exploratory to find determinants of solar energy adoption in developing countries. Best (2023) is a very similar work estimating a discrete model for solar and battery adoption for Kenyan households.[2]

This paper is organized as follow: In section 2, we discuss the main background. In section 3, we introduce our empirical framework including data, identification strategy and estimation for our main parameter of interest. In section 4, we show and discuss our estimation results. In section 5, we discuss another main focus of this paper as a seperated discussion section. Then we conclude in section 6.

2. Background

Improving access to electricity serves multiple purposes. Electricity is important for reducing poverty, promoting economic growth, enhancing education, and enhancing living standards. Microentrepreneurship, or self-employment, provides a significant source of jobs in developing countries. Poverty is often linked to lack of employment and low earning capacity, so

[2]Best (2023) seems to use the World Bank MTF household survey for Kenya, but did not mention the specific word 'MTF' in the paper. Instead, Best (2023) mentioned that "The survey used for this paper was conducted by the World Bank. It includes a nationally representative core group of around 3,300 households which covers all of Kenya's 47 counties."

increasing earnings through labor can help alleviate poverty. While regular income from employment is preferred, limited job opportunities in developing countries make self-employment an essential alternative.

The main goal is to empirically evaluate the impact of off-grid solution on microentrepreneurship in the five SSA's developing countries. There are two distinctive research focuses from the literature, off-grid solutions and microentrepreneurs. The off-grid solution is referred to as distributed renewable energy (DRE) technologies, including standalone off-grid solar systems (OGS) and mini/micro grids. The DRE technologies can reach populations where grid solutions are either too costly or impractical and play a crucial in enhancing energy access in developing countries (Sovacool, 2012). The microentrepreneurs, the target population that we attempt to analyze, are self-employed or small business owners in developing countries.

Relevant impact evaluation studies specifically for off-grid electrification are difficult to find. Aklin et al. (2017) is one of the few field experimental studies on off-grid electrification. They carry out RCTs to examine the causal effect of solar microgrids in the Barabanki district of the state of Uttar Pradesh, India. Several economic and non-economic outcomes are examined with respect to off-grid solution adoption in Aklin et al. (2017) and reported that household electrifications are substantially improved but no other economic/non-economic outcomes are changed. Radley and Lehmann-Grube (2022) collected 125 studies on off-grid solar and economic development published from 2001 to 2020, performed a systematic review, and reported that the majority of those published works concluded that there is a significant development gain from off-grid solar adoption. However, most

of the 125 papers are either macro-level or observational studies.

Several empirical studies have examined the causal relationship between electricity supply and labor market outcome, and those studies primarily focused on grid electrification for electricity supplies. Dinkelman (2011) is one of earlier empirical studies on the labor market impact of grid electrification. She collected and matched administrative data from rural KwaZulu-Natal, a southeastern province in South Africa, and examined the effect of grid connection on local employment rate. Dinkelman (2011) focuses specifically on gender differences in the grid connection effect, and reports that there is a positive effect of electrification on employment. This reported grid connection effect on employment is much stronger for female labor forces, but the wage gains vary by gender. The main rationale for this grid connection effect is that having electricity at home lowers the cost of producing new, home-based services for the market, and provide individuals alternative ways of utilizing their labor in self employment and micro enterprises.

Labor market outcomes that might be affected by electrification or energy access quality extend beyond mere employment figures, particularly in developing countries. Most job creation may instead take place among the self-employed in those countries. Jayachandran (2021) defines microentrepreneurship as small-scale entrepreneurship in low-income countries. This idea might come from the empirical fact that over half of employed workers in low- and middle income countries are self-employed. Jayachandran (2021) adds that the vast majority of microentrepreneurs have no employees other than their family members may be because of potential costs to fire unproductive workers. Therefore, promoting self-employed in low- and

middle income countries can contribute overall employment even in part.

To our best knowledge, however, our work is the first to empirically examine the imapact of having off-grid electricity solution and microentrepreneurship. We hypothesize that having off-grid solutions can bring the labor market impact to the households, which is distinctive from that of electricity supplies from grid. Households without grid access may benefit from off-grid solutions, which could also enhance the reliability of electricity supply for those already connected to the grid.

3. Empirical Framework

In this section, we introduce our dataset, what to identify and estimate, and discuss the validity and relevancy of our empirical framework. Our main goal is to demonstrate the potential selection bias that may occur when we estimate the ATE of off-grid solution in a way that observational studies estimate. We then show our IV can work to control for the selection bias and consistently estimate the ATE. This demonstration to show the presence of selection bias is mainly a recitation of Oladipo and Shim (2022). The only difference is to use the treatment indicator variable for having off-grid solution, instead of microentrepreneurs' gender. The background contexts of LATE are from Imbens and Angrist (1994) and Angrist and Imbens (1995), but the notations and terminologies are mainly from Angrist and Pischke (2009).

3.1. Identification

Our identification strategy is similar to that of Oladipo and Shim (2022) for the effect of having off-grid energy solution on microentrepreneurship and

income as local average treatment effects (LATE), and estimate them using instrumental variable (IV) probit and two-stage least squares (TSLS). In our analysis, the treatment indicator variable is whether households have off-grid solutions at home. The LATE parameter of an ATE can be estimated by IV estimation (or TSLS) of ATE with a binary IV.

Consider the cost-minimization of a potential microentrepreneur, as in Hamermesh (1996) to derive labor demand, denoted L.[3] An observable form of the labor demand function is $L^* = L^d(w, r, Y)$, where w is wage, r is interest, and Y is output level. Consider a binary indicator variable $D_i = \{0, 1\}$ for having off-grid solution at home. We use D_i as a treatment indicator variable. That is $D_i = 1$ if household i has off-grid energy solution at home, and zero otherwise. For any microentrepreneur, there are two potential labor demand variables:

$$\begin{aligned} L_i &= \begin{cases} L_{1i} & \text{if } D_i = 1 \\ L_{0i} & \text{if } D_i = 0 \end{cases} \\ &= L_{0i} + (L_{1i} - L_{0i}) \cdot D_i. \end{aligned} \tag{1}$$

The observable labor demand for microentrepreneur i consists of two potential labor demand. That is L_{1i} if microentrepreneur i has off-grid solution at home, and L_{0i} if she or he has no off-grid solution at home. Our causal effect

[3]The potential microentrepreneurs we refer to are people who could be self-employed, paid employees, or not to work. And their labor demand primarily comes from themselves for their own businesses. In other words, becoming self-employed implies that the potential microentreprenuer demands her/his own labor to open up his/her own business.

of interest is $L_{1i} - L_{0i}$, the difference in labor demand by off-grid solution, but it is not directly observable. What we can observe with L_i and D_i is

$$\underbrace{\mathrm{E}[L_i|D_i=1] - \mathrm{E}[L_i|D_i=0]}_{\text{Observed difference in average}} = \underbrace{\mathrm{E}[L_{1i}|D_i=1] - \mathrm{E}[L_{0i}|D_i=1]}_{\text{average treatment effect on the treated}} + \underbrace{\mathrm{E}[L_{0i}|D_i=1] - \mathrm{E}[L_{0i}|D_i=0]}_{\text{selection bias}}.$$

We predict that the selection bias is negative because microentrepreneurs without off-grid solution spend less on interest costs, and thus, for given wage w and output Y,

$$L_{1i}(w, r_1, Y) \leq L_{0i}(w, r_0, Y) \tag{2}$$

where r_1 and r_0 are the interest cost for microentrepreneurs with and without off-grid solution respectively. Note that the selection bias term can be eliminated if the treatment assignment is done at random. In other words, households have identical interest costs with and without off-grid solutions at home. A simple mean comparison between treatment and control groups might be enough if our study is a field experiment with randomized control trials (RCT). The MTF household surveys are observational data, and the off-grid solution assignments are hardly done at random.

An additional interest cost is incurred when the microentrepreneur decides to have off-grid solution. And this off-grid solution can be used for both their house and business. In other words, non-microentrepreneurs, either not to work or paid employees, can also have off-grid solution for their house, not for their business. An off-grid solution is necessary to incur installation costs, and thus $r_1 \geq r_0$. Note that household decisions to have off-grid energy solution has little impact on labor market, so wage level w is the same for both

microentrepreneurs with and without off-grid solution. The $\mathrm{E}[L_{0i}|D_i = 1]$ is a counterfactual of an average labor demand for microentrepreneur with off-grid solution under financial condition of microentrepreneur without off-grid solution. Likewise, $\mathrm{E}[L_{0i}|D_i = 0]$ implies an average labor demand for microentrepreneur without off-grid solution under financial condition of microentrepreneur without off-grid solution. For financial institutions that firm i would like to borrow capital from, L_{1i} and L_{0i} are unobservable so that they apply r_1, and r_0 by looking at the treatment status D_i. Therefore,

$$\begin{aligned}\mathrm{E}[L_{0i}|D_i = 1] - \mathrm{E}[L_{0i}|D_i = 0] & \\ &= \mathrm{E}[L_{0i}|D_i = 1, r = r_1] - \mathrm{E}[L_{0i}|D_i = 0, r = r_0] \\ &\leq 0\end{aligned}$$

In the same way as demonstrated in Oladipo and Shim (2022), we make use of the interest cost assignments r_1, r_0 to justify that our estimation strategy can identified and consistently estimate the LATE parameter. One of the four crucial assumptions for LATE is monotonicity, where the treatment assignment is accepted in the same way by all individuals. That is $D_{1i} \geq D_{0i}$ or $D_{1i} \leq D_{0i}$ for all i. In our case, $D_{1i} \leq D_{0i}$ meaning that microentrepreneurs prefer to be treated as one without off-grid solution because of because of low installation and interest costs $r_1 \geq r_0$.

3.2. Estimation

We use an indicator variable for having grid access at home as an IV. It is 1 if the household has grid access, and 0 otherwise. In order for this indicator variable to be a vaild IV, grid connection is correlated with the decision to install off-grid solutions and uncorrelated with unobserved error

terms from microentrepreneurship and income.[4] The MTF global survey is designed to randomly assigned sample households with equal allocation between rural and urban areas; and the 50-50 distribution of grid users and non-users. Therefore, the grid access indicator variable is supposed to be exogenous to unobserved household characteristics other than the location of house. We argue that the IV is valid for following reasons: i) the decision to have grid-access is correlated with interest cost r, so with D_i; and ii) and it is uncorrelated with wage level and product demand shock.[5] Since the MTF survey randomized sample household collection with the 50-50 distribution of grid users and non-users, the grid access indicator is supposed to be independent of all other attributes than electrification and energy access. In other words, the selection bias that can possibly be caused by having off-grid solution, which can cost additional interest charge, can be ruled out by the grid-access indicator as an IV because the IV is uncorrelated with those interest costs.

With the IVs, the off-grid solution effect on labor demand can be identified and consistently estimated as local average treatment effect (LATE). To show

[4]Here, microentrepreneurship that we mean by is the propensity to become a microentrepreneur or self-employed.

[5]From the previous section, we demonstrate that labor demand for microentrepreneur depends on interest cost, wage level, and output. The product demand shock is an unobserved error term that changes output level beside all other demand factors.

this, consider a simple linear regression model from (1)

$$\begin{aligned} L_i &= L_{0i} + (L_{1i} - L_{0i}) \cdot D_i \\ &= \mathrm{E}[L_{0i}] + (L_{1i} - L_{0i}) \cdot D_i + (L_{0i} - \mathrm{E}[L_{0i}]) \\ &= \alpha + \rho_i \cdot D_i + \eta_i, \end{aligned}$$

where ρ_i is a random coefficient representation of the ATE, and η_i is an error term. Let Z_i be the grid-access indicator. The LATE parameter, denote ρ as an average of the random coefficient ρ_i can be identified

$$\begin{aligned} \mathrm{E}[\rho_i | D_{1i} < D_{0i}] &= \frac{\mathrm{Cov}(L_i, Z_i)}{\mathrm{Cov}(D_i, Z_i)} \\ &= \rho. \end{aligned} \tag{3}$$

We estimate the off-grid solution effect ρ from (3) with the grid-access IV. The dependent variable in (1) is an indicator variable for self-employed, and we use probit and IV probit estimations for the LATE parameter ρ. With a relevant IV, the LATE parameter ρ could be estimated using the IV estimation for just-identified models, where the number of endogenous covariates and the number of IVs are the same, or two-stage least squares (TSLS) for over-identified models. In our labor demand model (1), the observable labor demand $L_i$is an indicator variable for self-employed, and linear model estimations such as the IV estimation or TSLS may not be relevant. Instead of using those two linear model estimations with IVs, we use binary indicator model estimations with and without IVs.

3.3. Data

We use the World Bank multi-tier framework (MTF) household surveys for five sub-Saharan African countries: Ethiopia; Kenya; Liberia; Niger; and

Nigeria to create our dataset for the off-grid solution effect on microentrepreneurship. The first round of the MTF surveys conducted and collected household level data for energy access and cooking solutions from 16 countries across continents, Africa, South Asia, South America etc. We choose the five SSA countries among the 16 MTF surveyed countries that are; i) in African continent, and ii) available for performing empirical analysis on off-grid solution and microentrepreneurship.[6]

The MTF is a multi-country survey in a unified data structure, and thus the MTF survey data may not be perfectly identical in terms of survey format and the associated survey items. However, the survey data collection was conducted in a consistent way under the MTF global survey guidelines. Specifically, the sample households in each country were chosen under the MTF global survey stratification guidelines that are; i) "equal allocation between urban and rural areas," and "50-50 distribution of grid users and non-users."[7] The most notable stratified sampling criterion is household residential area. The MTF survey stratified the highest geographical unit such as state, province, or region. Within those highest geographical unit, the primary sampling unit (PSU) is defined. The PSUs in a state, or the highest geographical unit, are divided into urban and rural PSUs. In other words, each state has both urban and rural PSUs. Each PSU have twelve sample households that have the 50-50 distribution of grid users and non-grid users.[8]

[6]Note that the availability for performing the empirical analysis means that all the necessary survey questions are available in the data files.

[7]There are a few more stratified sampling criteria in detail. Please see World Bank (2025).

[8]The PSU can be village, community block, or enumeration areas (EA). Some PSU

The survey year and total number of sample households in our dataset are following: i) Ethiopian MTF have 4,317 households surveyed in 2017; ii) Kenyan MTF have 3,300 households surveyed between 2016 and 2018; iii) Liberian MTF have 3,504 households surveyed in 2011; iv) The MTF for Niger have 4,071 households surveyed in 2018; and v) Nigerian MTF have 3,668 households surveyed between 2011 and 2018.

Table 1 reports descriptive statistics for the MTF household surveys for the five SSA countries, separated by grid/non-grid access households. The first three columns are for households with grid access, the next three are for households without grid access, and the three columns from right are their differences. The first two rows are for our target outcome variables, self-employed indicator and income. Note that the income variable is the monthly household total expenditure in 2019 U.S. dollar adjusted for purchasing power parity. Off-grid solution on the third row is the treatment indicator variable. MTF-tier is a categorical variable from 0 to 5 for the quality of household energy access. Female and married are indicator variables for the genders and marital status of household heads. Home ownership and land ownership are also indicator variables.

The validity of IV for LATE estimation can be evaluated by comparing outcome variables or other covariates across groups defined by the binary IV. In other words, our choice of IV can be empirically validated if descriptive statistics tabulated by the binary IV are statistically the same or similar at

have 100% grid-electrification, and some others have 0%. The MTF survey considered this village or state level electrification to achieve the 50-50 distribution of grid and non-grid users. Please see World Bank (2025).

Table 1: Descriptive Statistics by Grid-Access

	Grid Access[#]			No-Grid Access[#]			Differences[##]		
	# Obs	Mean	Std	# Obs	Mean	Std	# Obs	Difference[*]	T-Statistics
Self-employed	10,712	0.369	0.48	16,760	0.491	0.50	27,490	0.012	(1.933)
Income (Log of)	9,087	7.829	1.34	15,054	7.136	1.61	24,159	-0.931	(-52.074)
Off-grid Solution	10,712	0.082	0.27	16,760	0.260	0.44	27,490	0.174	(43.118)
MTF-tier	10,712	4.356	1.10	16,760	1.183	0.47	27,490	-3.147	(-268.805)
Household Size	10,712	4.655	2.95	16,760	5.164	2.63	27,490	0.334	(9.861)
Age	10,700	43.107	14.19	16,740	44.572	14.42	27,458	0.924	(5.194)
Female	10,712	0.227	0.42	16,760	0.146	0.35	27,490	-0.023	(-4.681)
Married	10,712	0.760	0.43	16,760	0.827	0.38	27,490	-0.074	(-13.127)
Education	10,712	0.845	0.36	16,760	0.637	0.48	27,490	-0.112	(-21.197)
Home Ownership	10,712	0.550	0.50	16,760	0.764	0.42	27,490	0.033	(5.411)
Land Ownership	10,712	0.332	0.47	16,760	0.666	0.47	27,490	0.083	(13.979)

[#] The descriptive statistics for households with grid and without grid, reported in the first six columns, are weighted statistics by the MTF global survey household sampling weight.

[##] The statistics for differences, reported in the three columns from right, are unweighted statistics to be calculated two-sample t-test statistics.

[*] This column reports the mean differences between households with grid access and households without grid access. These mean differences are different with the differences of means reported on the left because they are unweighted means.

least. This is the same way in which Angrist and Pischke (2009) introduce the basic empirical characteristics of data from RCTs.[9] The t-statistics in Table 1 show that our outcome variables and other covariates are relatively well-balanced compared to the off-grid solution and MTF-tier, which are our main treatment indicator and the associated electricity quality measure. And this characteristics hold in the descriptive statistics by country reported from Table A.7 to A.11 in Appendix.

Another way to interpret findings in Table 1 is that the mean difference of the treatment indicator variable, off-grid solution, by grid-access IV seems to be substantial. The mean difference is a percentage difference as well, and it is 17.4%, which is well above 10%. The mean difference of one of the target outcome variable, the self-employed indicator, seems to be weaker than that of income variable. The mean differences of the control variables do not seem to be very substantial, except the MTF-tier. This could be explained by which households with off-grid solution have better energy access quality so that they have higher MTF-tier. Overall, our IV do not seem to break balances of the control variables and is expected to play a role as a valid IV. We therefore estimate the off-grid solution effect with grid access IV and

[9]Our identification strategy is to use the grid access indicator as an IV that aims to control for the endogeneity, or sample selection bias, from non-randomly assigned off-grid solution ownership. The key to the IV become a vaild IV is that; i) it is correlated with off-grid solution, the treatment indicator, and target outcomes, self-employed indicator and income; and ii) it is uncorrelated with unobserved error terms. Since our IV is a binary indicator variable, correlations with other variables could be examined by looking at the mean differences. And the exogenous error term condition for the IV could be examined whether those mean differences of other control variables are not substantial.

carefully examine test statistics for their endogeneity and first-stage F-test.

4. Empirical Results

From the main model estimates, reported in Table 2, we find that the ATE estimates with the IV and without the IV are substantially different, which could be strong observable evidence of the presence of selection bias. The ATE estimate of off-grid access on microentrepreneurship, reported in column (1), is 0.0428, whereas the LATE estimate, reported in column (2), is 0.4871. This ten times greater LATE estimate is empirical evidence of the presence of the negative selection bias due to non-random assignment of households with and without off-grid access. In other words, observational studies such as OLS, logit or probit model estimations can seriously undermine the off-grid solution effect on microentrepreneurship, the propensity to become self-employed in developing countries with respect to off-grid solution ownership. The off-grid solution effect on income, reported in column (3) and (4), is the same but the direction is opposite. The ATE estimate using OLS in column (3) is 0.1521 with strong statistical significance, whereas the LATE estimate using TSLS in column (4) is -0.3036. This is another empirical evidence of the selection bias but the bias is positive for income. Again, the off-grid solution effect on income could be seriously overestimated without using valid quasi-experimental methods to control for the selection bias.

The substantial differences between the ATE and LATE estimates of the off-grid solution effects on both microentrepreneurship and income are evidence that our IV, the grid access indicator variable, works well controlling for the selection biases. The χ^2 and F statistics for exogenous covariates,

Table 2: Main Model Estimates

	Self-Employed		Log of Income	
	Probit	IV Probit	OLS	TSLS
	(1)	(2)	(3)	(4)
Off-grid Access	0.0428	0.4871***	0.1521***	-0.3036
	[0.032]	[0.136]	[0.019]	[0.208]
MTF-tier	-0.0063	-0.0036	0.1519***	0.1491***
	[0.006]	[0.006]	[0.012]	[0.013]
Province Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
# of Obs	22,192	22,192	24,127	24,127
Adjusted {Pseudo} R^2	{0.2165}	NA	0.7263	0.7131
Exogenous F $\{\chi^2\}$ (df)	NA	{11.0791}(1)	NA	6.5802 (1)
(P-value)		(0.0009)		(0.0127)
1^{st}-Stage F	NA	NA	NA	37.6750

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels. Other control variables and covariates such as household size, and household head's age, gender, marital status, education, home and land ownerships were included in the model estimations. Their coefficient and standard error estimates are reported in table A.12 in the appendix.

reported in the third row from the bottom, and their p-values, reported in the second row from the bottom indicate that the off-grid access indicator, which is our treatment indicator variable, is unlikely to be exogenous, and the ATE estimates by probit and OLS are likely to be biased.[10] On the other hand, the MTF-tier effect estimates, which is a measure of the quality of household energy access, are quite similar in both quasi-experimental and observational studies.[11]

Overall, we find that the off-grid solution effect is significantly positive on microentrepreneurship and negative on income, but this effect on income is not statistically significant. The MTF-tier effect, on the other hand, is opposite where it is significantly positive on income and negative on microentrepreneurship, but the effect is statistically insignificant. The implications of our finding are: i) having off-grid solution at home motivate or promote people to be self-employed; but ii) this off-grid solution effect does not increase their income level; instead, iii) the quality of the electricity supply to their home are likely to be (positively) correlated with their income level; but iv) this electricity supply quality is unlikely to be correlated with

[10]Note that The χ^2 and F statistics for exogenous covariates have the null hypothesis that the covariates, or the control variables, are exogenous, and the non quasi-experimental estimation methods can estimate the target ATE consistently. Under the null hypothesis, observational studies like OLS, logit, or probit are more efficient estimations giving smaller standard errors, and therefore they are superior than quasi-experimental methods such as IV estimation.

[11]The other covariates' estimated coefficients are also not substantially differed by quasi-experimental and observational studies. The full model estimation results are reported in Table A.12 in the appendix.

Table 3: Probability Model Estimates: Self-Employed

	Probit					IV Probit				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Off-grid Access	0.0554	0.1132**	-0.2330***	0.0414	0.1792	0.5754**	0.0786	-0.2681	1.8061**	-6.6440***
	[0.062]	[0.048]	[0.082]	[0.167]	[0.158]	[0.267]	[0.157]	[0.177]	[0.822]	[0.544]
MTF-tier	-0.0401**	0.0215*	0.0316	-0.0207*	-0.1203***	-0.0220	0.0210	0.0356	-0.0233*	0.0333
	[0.017]	[0.013]	[0.033]	[0.012]	[0.017]	[0.020]	[0.013]	[0.037]	[0.012]	[0.036]
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs	3,876	3,937	3,493	4,059	3,618	3,876	3,937	3,493	4,059	3,618
Pseudo R^2	0.1878	0.0378	0.1365	0.2346	0.0828	NA	NA	NA	NA	NA
χ^2 Test (df)	NA	NA	NA	NA	NA	3.8702(1)	0.0529(1)	0.0494(1)	4.9825(1)	4.8898(1)
(P-value)						(0.0492)	(0.8181)	(0.8241)	(0.0256)	(0.0270)

Notes: Heteroskedasticity robust standard errors are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels.

microentrepreneurship.

Then we estimate the ATE and LATE of off-grid solution separated by country. The most remarkable finding from this estimation by country is that every country has very different patterns of the estimated coefficients, and the presence and direction of the selection bias. The ATE and LATE estimates on microentrepreneurship are reported in Table 3. Ethiopia and Niger have statistically negligible off-grid solution effects in the probit estimation reported in columns (1) and (4), but these effects are significantly positive in IV probit estimation in columns (6) and (9). Kenya and Liberia are opposite, where their ATEs, the off-grid solution effect in probit estimation in column (2) and (3), are strongly significant but they turn out to be

statistically negligible in the LATE estimations using IV probit in columns (7) and (8). In the estimation results for Nigeria in columns (5) and (10), the off-grid solution effects exhibit the most drastic changes. The ATE estimate is positive but statistically insignificant, and the LATE esitmate is negative with very strong statistical significance.

One unified LATE parameter estimate using stacked data from different countries may not be relevant to apply for each country. The LATE estimate for the off-grid solution effect from the main estimate in Table 2 is consistent only in Ethiopia. This finding may point out the importance of external validity to the impact evaluation research using QE methods. Empirical studies on development economics have used field-experiment to evaluate causal relationships between policy interventions and the associated outcomes, and lack of external validity is one of the critical points for the field experiment research done in a small village or town. As an alternative, recent studies have done their field-experiments in more than one village or town, called a multi-site field-experiment.

These ATE estimates, reported in Table 3 from column (1) to (5), and the LATE estimates from column (6) to (10) show that the selection bias can mislead researchers and policy makers in all five SSA countries. None of the five countries have consistent patterns of ATE and LATE estimates in terms of size, sign, and statistical significance. For Ethiopia, both the ATE and LATE are positive but the LATE estimate is about ten times greater than the ATE, and statistically significant. Niger's ATE and LATE estimates are both positive, and the LATE estimate is much greater than that of ATE with statistical significance. The LATE estimate for Nigeria is significantly neg-

Table 4: Main Model Estimates: Log of Income (Total Expenditure)

	OLS					TSLS				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Off-grid Access	0.0995**	0.0662	0.1341**	-0.1315	0.3667**	-0.7165*	-0.5400***	-0.1363**	3.7790**	49.7104
	[0.032]	[0.050]	[0.051]	[0.092]	[0.124]	[0.397]	[0.098]	[0.057]	[1.541]	[54.026]
MTF-tier	0.0763***	0.1197***	0.1701***	0.1546***	0.1941***	0.0508***	0.1111***	0.2015***	0.1481***	-0.2564
	[0.011]	[0.022]	[0.020]	[0.029]	[0.026]	[0.016]	[0.021]	[0.018]	[0.025]	[0.441]
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs	3,873	3,937	3,378	4,059	3,618	3,873	3,937	3,378	4,059	3,618
Adjusted R^2	0.2792	0.2025	0.5081	0.3833	0.2091	0.0806	0.0926	0.4991	0.1266	NA
1^{st}-Stage F	NA	NA	NA	NA	NA	5.8382	60.9212	273.9556	10.6565	0.7086
Exogenous F (df)	NA	NA	NA	NA	NA	31.5283(1)	31.8941(1)	16.5946(1)	7.4351(1)	118.0349(1)
(P-value)	NA	NA	NA	NA	NA	(0.0002)	(0.0008)	(0.0010)	(0.0295)	(0.0000)

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels.

ative while it's ATE estimate is insignificantly positive. Kenya and Liberia seem to be a special case where the χ^2 statistics for endogeous covariate test yield substantially big p-values, which are greater than 0.8. Kenya's ATE and LATE estimates are both positive but the LATE is not statistically significant and much smaller than the ATE estimate. Liberia's ATE and LATE estimates are both negative.

The ATE and LATE estimates for the off-grid solution effect on income, reported in Table 4, also show that observational studies such as OLS, logit, or probit could be bias substantially and mislead researchers and policy mak-

Table 5: Main Model Estimates: Log of Income by Self-Employed

	Self-Employed					Non Self-Employed				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Off-grid Access	-0.3284**	-0.5930***	-0.2745*	3.7188***	25.7243	-1.0915***	-0.4983***	-0.0990	3.2589***	97.4920
	[0.136]	[0.150]	[0.160]	[0.970]	[25.054]	[0.264]	[0.126]	[0.087]	[1.198]	[196.764]
MTF-tier	0.0729***	0.0709***	0.2360***	0.1266***	-0.0317	0.0243*	0.1257***	0.1822***	0.2080***	-0.7833
	[0.011]	[0.013]	[0.029]	[0.007]	[0.248]	[0.014]	[0.009]	[0.020]	[0.014]	[2.008]
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs	1,681	1,254	1,667	3,010	2,374	2,192	2,683	1,711	1,049	1,244
Adjusted R^2	0.2439	0.0266	0.5114	0.0247	NA	NA	0.1350	0.4766	0.4272	NA
1^{st}-Stage F	107.5571	179.1282	103.5354	24.3853	1.0225	59.4734	240.1794	306.7125	13.5145	0.2398
Exogenous F (df)	11.4729(1)	22.9136(1)	6.0316(1)	64.2162(1)	53.4320(1)	35.6246(1)	25.2059(1)	10.3155(1)	19.5849(1)	88.1585(1)
(P-value)	(0.0007)	(0.0000)	(0.0142)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0013)	(0.0000)	(0.0000)

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels.

ers in the wrong direction. As shown in Table 4, the ATE estimates for Ethiopia, Kenya, and Liberia are all positive but thier LATE estimates are all negative with strong statistical significance. Niger's ATE and LATE estimates are opposite. What these ATE and LATE estimates implying is that energy policy evaluations in those countries might conclude that off-grid solution is likely to increases income, if they use observational studies to estimate the policy impacts.

Table 5 report the LATE estimates on income by self-employed and non self-employed subsamples. We find that the off-grid solution effects on in-

come are consistent with both self-employed and non self-employed in terms of signs and statistical significances; Ethiopia, Kenya, and Liberia exhibit negative LATE estimates while they are positive in Niger and Nigeria. The negative off-grid solution effect on income is difficult to understand in such a way that having off-grid solutions at home reduces the household income. Instead, this could be interpreted with the MTF-tier effect estimates reported in the second row. The estimated MTF-tier effects are also consistent in both self-employed and non self-employed subsamples and mostly positive with strong statistical significances. The household energy supply quality effect, measured by MTF-tier, on income is quite consistent also with different countries. These might indicate that the quality is more important than just having additional energy access channels or tools, in order to give positive impact on income.

5. Discussion: Internal vs. External Validity

One of our motivations for this paper is to find a niche between field experiments and observation studies for the energy access literature. Bayer et al. (2020) report that only 31 out of 7,247 energy access related papers performed impact evaluations, and only seven among 31 papers performed field experimental techniques such as randomized control trials (RCT). Bayer et al. (2020) find further that the observational studies on energy access have routinely overestimated the effect of energy acceess on household economic outcomes in developing countries. The observational studies are about 1.6 times more likely to conclude the positive impact of energy accesss on household economic outcomes.

This overestimation issue could be understood by looking at the modern development economics literature. RCT have become the golden standard in modern development economics. Banerjee and Duflo (2017) argue that "in development economics, the non-experimental literature was completely transformed by the existence of this large RCT movement." In this regard, the energy access literature has still used the outdated empirical method by not adopting RCT, the golden standard method. But, the questions that remain for the researchers in energy access are: i) can an empirical finding from a relatively small village in a developing country to other villages, towns, provinces, and countries?; and ii) can we perform RCTs for energy access related infrastructures such as power plants, national grid lines, etc? In other words, can energy access related infrastructures be assigned to the treatment and control groups at random? Randomizing energy infrastructure assignments may not be absolutely impossible. But one can easily imagine how costly it is to construct power plants and national grid lines and provide to the selected households at random.

The first question refers to the issue of external validity in the RCT literature. Simply, external validity is that the empirical finding of a causal inference from a small part of a population holds in any other parts of the population. Banerjee and Duflo (2017) cite a short introduction of the concept of the external validity from Athey and Imbens (2017) that "external validity is concerned with generalizing causal inferences, drawn for a particular population and setting, to others, where these alternative settings could involve different populations, different outcomes, or different context." This issue extends beyond the RCT literature, every empirical study faces

this external validity concern. Because RCT studies used relatively small sample sizes, the external validity debate might become more serious in the literature.

In this paper, we attempt to take an alternative approach that could assess the impact of energy access similarly to RCT, and yet no excessive costs of conducting field experiments will incur. We can learn from environmental economics literature that QE methods work well. Empirical research on the health impact of air quality and energy access encounter many similar challenges. Dominici et al. (2014) provide several relevant examples from the environmental economics literature and show how inconsistent the estimations of the health impact of airborne particulate matter from the observational studies have been. Different combinations of covariates (explanatory variables in regression models) and data subsets yield very different PM effect on health from one another. As shown in Chen et al. (2013) and Ebenstein et al. (2017), QE evaluation techniques can improve this inconsistent impact evaluation using observational study methods. Dominici et al. (2014) assert that "The key difference with an observational study in this setting is that the QE approach is devoted to identifying treatment-induced variation in particulates that plausibly mitigates confounding or omitted variable bias in the estimated relation."

6. Conclusion

We empirically evaluate the impact of off-grid solution on microentrepreneurship and income for households living in sub-Saharan African countries. The World Bank multi-tier framework (MTF) household surveys for five sub-

Saharan African countries: Ethiopia; Kenya; Liberia; Niger; and Nigeria are used to create our dataset for the off-grid solution effect on microentrepreneurship, measured by the propensity to become self-employed, and income. The average treatment effect (ATE) of having off-grid solution is estimated using a grid access indicator variable from the MTF household surveys as an instrumental variable (IV).

Overall, we find that the off-grid solution effect is significantly positive on microentrepreneurship and negative on income, but this effect on income is not statistically significant. The MTF-tier effect, on the other hand, is opposite where it is significantly positive on income and negative on microentrepreneurship, but the effect is statistically insignificant. The implications of our finding are: i) having off-grid solution at home motivate or promote people to be self-employed; but ii) this off-grid solution effect does not increase their income level; instead, iii) the quality of the electricity supply to their home are likely to be (positively) correlated with their income level; but iv) this electricity supply quality is unlikely to be correlated with microentrepreneurship.

While access to off-grid solution has a positive impact on microentrepreneurship, it does not significantly affect household income, indicating a positive selection bias for income. Consequently, the impact on income might be overestimated without employing valid quasi-experimental methods. Enhancing the quality of electricity supply, as measured by the MTF tier, improves household income and welfare. Therefore, to maximize the benefits of off-grid solution on income and livelihood, it is essential to improve both access to and the quality of the electricity supply provided by off-grid solution.

Establishing quality standards for off-grid solution will be crucial to ensure that the minimum quality is met, thereby maximizing the benefits of access to off-grid solution. Improving the quality of off-grid solution could potentially amplify the positive impact of access to these systems. Future research should investigate how various MTF attributes relate to outcomes such as entrepreneurship and household income. These insights could aid governments in devising policies to further enhance the benefits of off-grid solution.

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Table A.6: Main Model Estimates: Self-Employed

	Probit			IV Probit					
				Grid-Access IV			Rural/Urban IV		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Off-grid Access	-0.5268***	-0.3973***	0.0428	0.1225	-0.5251***	0.4871***	-0.0021	-1.7441***	3.1898***
	[0.022]	[0.024]	[0.032]	[0.089]	[0.067]	[0.136]	[0.117]	[0.081]	[0.182]
Control Variables	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Country Fixed	No	No	Yes	No	No	Yes	No	No	Yes
Province Fixed	No	No	Yes	No	No	Yes	No	No	Yes
# of Obs	27,490	27,458	22,192	27,490	27,458	22,192	27,490	27,458	22,192
Pseudo R^2	0.0163	0.1389	0.2165		NA			NA	
Exogenous χ^2 (df)		NA		54.74(1)	4.09(1)	11.08(1)	20.34(1)	176.08(1)	26.13(1)
(P-value)				(0.0000)	(0.0432)	(0.0009)	(0.0000)	(0.0000)	(0.0000)

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels.

Appendix A. Appendix

Table A.7: Descriptive Statistics by Grid-Access: Ethiopia

	Grid Access[#]			No-Grid Access[#]			Differences[##]		
	# Obs	Mean	Std	# Obs	Mean	Std	# Obs	Difference	T-Statistics
Income (Log of)	2,355	9.253	0.60	1,518	8.868	0.62	3,873	-0.437	(-21.674)
Self employed	2,358	0.378	0.48	1,518	0.689	0.46	3,876	0.327	(20.988)
Off-grid Solution	2,358	0.081	0.27	1,518	0.342	0.47	3,876	0.254	(19.296)
Household Size	2,358	4.258	2.03	1,518	5.079	2.11	3,876	0.804	(11.818)
MTF-tier	2,358	4.308	0.94	1,518	1.171	0.39	3,876	-3.176	(-143.938)
Age	2,358	43.494	14.65	1,518	43.488	13.05	3,876	-2.865	(-6.212)
Female	2,358	0.344	0.48	1,518	0.109	0.31	3,876	-0.272	(-20.698)
Married	2,358	0.695	0.46	1,518	0.884	0.32	3,876	0.239	(18.458)
Education	2,358	0.740	0.44	1,518	0.478	0.50	3,876	-0.293	(-18.842)
Home Owner	2,358	0.617	0.49	1,518	0.968	0.18	3,876	0.443	(37.297)
Land Ownership	2,358	0.273	0.45	1,518	0.879	0.33	3,876	0.663	(53.442)

[#] The descriptive statistics for households with grid and without grid, reported in the first six columns, are weighted statistics by the MTF global survey household sampling weight.

[##] The statistics for differences, reported in the three columns from right, are unweighted statistics to be calculated two-sample t-test statistics.

[*] This column reports the mean differences between households with grid access and households without grid access. These mean differences are different with the differences of means reported on the left because they are unweighted means.

Table A.8: Descriptive Statistics by Grid-Access: Kenya

	Grid Access[#]			No-Grid Access[#]			Differences[##]		
	# Obs	Mean	Std	# Obs	Mean	Std	# Obs	Difference	T-Statistics
Income (Log of)	1,689	7.145	0.78	2,244	6.630	0.74	3,951	-0.518	(-21.516)
Self employed	1,689	0.336	0.47	2,244	0.331	0.47	3,951	0.020	(1.367)
Off-grid Solution	1,689	0.132	0.34	2,244	0.422	0.49	3,951	0.249	(18.457)
Household Size	1,689	3.648	1.89	2,244	4.420	2.12	3,951	0.755	(11.122)
MTF-tier	1,689	4.941	0.97	2,244	1.332	0.67	3,951	-3.631	(-136.332)
Age	1,681	41.406	13.78	2,238	46.769	15.23	3,937	5.598	(12.267)
Female	1,689	0.190	0.39	2,244	0.170	0.38	3,951	-0.020	(-1.583)
Married	1,689	0.735	0.44	2,244	0.801	0.40	3,951	0.065	(4.783)
Education	1,689	0.948	0.22	2,244	0.781	0.41	3,951	-0.176	(-15.322)
Home owner	1,689	0.468	0.50	2,244	0.931	0.25	3,951	0.450	(33.178)
Land Ownership	1,689	0.406	0.49	2,244	0.681	0.47	3,951	0.300	(19.692)

[#] The descriptive statistics for households with grid and without grid, reported in the first six columns, are weighted statistics by the MTF global survey household sampling weight.

[##] The statistics for differences, reported in the three columns from right, are unweighted statistics to be calculated two-sample t-test statistics.

[*] This column reports the mean differences between households with grid access and households without grid access. These mean differences are different with the differences of means reported on the left because they are unweighted means.

Table A.9: Descriptive Statistics by Grid-Access: Liberia

	Grid Access[#]			No-Grid Access[#]			Differences[##]		
	# Obs	Mean	Std	# Obs	Mean	Std	# Obs	Difference	T-Statistics
Income (Log of)	494	7.430	0.62	2,888	6.636	0.77	3,382	-0.845	(-27.822)
Self employed	520	0.316	0.47	2,977	0.493	0.50	3,497	0.173	(7.592)
Off-grid Solution	520	0.014	0.12	2,977	0.119	0.32	3,497	0.080	(8.597)
Household Size	520	5.479	2.61	2,977	5.280	2.52	3,497	0.009	(0.080)
MTF-tier	520	3.042	0.66	2,977	1.322	0.73	3,497	-1.721	(-54.208)
Age	520	44.582	11.97	2,973	45.576	14.16	3,493	1.994	(3.430)
Female	520	0.283	0.45	2,977	0.225	0.42	3,497	-0.049	(-2.341)
Married	520	0.000	0.00	2,977	0.000	0.00	3,497	0.000	(.)
Education	520	0.877	0.33	2,977	0.692	0.46	3,497	-0.182	(-10.731)
Home Owner	520	0.504	0.50	2,977	0.694	0.46	3,497	0.236	(10.063)
Land Ownership	520	0.046	0.21	2,977	0.231	0.42	3,497	0.212	(19.396)

[#] The descriptive statistics for households with grid and without grid, reported in the first six columns, are weighted statistics by the MTF global survey household sampling weight.

[##] The statistics for differences, reported in the three columns from right, are unweighted statistics to be calculated two-sample t-test statistics.

[*] This column reports the mean differences between households with grid access and households without grid access. These mean differences are different with the differences of means reported on the left because they are unweighted means.

Table A.10: Descriptive Statistics by Grid-Access: Niger

	Grid Access[#]			No-Grid Access[#]			Differences[##]		
	# Obs	Mean	Std	# Obs	Mean	Std	# Obs	Difference	T-Statistics
Income (Log of)	1,930	6.021	0.83	2,129	5.091	1.12	4,059	-0.546	(-18.799)
Self employed	1,930	0.715	0.45	2,129	0.811	0.39	4,059	0.069	(5.034)
Off-grid Solution	1,930	0.030	0.17	2,129	0.011	0.11	4,059	0.017	(4.444)
Household Size	1,930	4.861	2.85	2,129	5.123	2.77	4,059	-0.342	(-3.744)
MTF-tier	1,930	4.622	1.15	2,129	1.038	0.28	4,059	-3.645	(-126.201)
Age	1,930	43.069	13.02	2,129	42.790	14.46	4,059	-1.025	(-2.359)
Female	1,930	0.078	0.27	2,129	0.078	0.27	4,059	0.019	(2.103)
Married	1,930	0.851	0.36	2,129	0.894	0.31	4,059	-0.039	(-3.547)
Education	1,930	0.455	0.50	2,129	0.159	0.37	4,059	-0.197	(-13.289)
Home owner	1,930	0.687	0.46	2,129	0.890	0.31	4,059	-0.023	(-1.642)
Land Ownership	1,930	0.385	0.49	2,129	0.843	0.36	4,059	0.080	(5.128)

[#] The descriptive statistics for households with grid and without grid, reported in the first six columns, are weighted statistics by the MTF global survey household sampling weight.

[##] The statistics for differences, reported in the three columns from right, are unweighted statistics to be calculated two-sample t-test statistics.

[*] This column reports the mean differences between households with grid access and households without grid access. These mean differences are different with the differences of means reported on the left because they are unweighted means.

Table A.11: Descriptive Statistics by Grid-Access: Nigeria

	Grid Access[#]			No-Grid Access[#]			Differences[##]		
	# Obs	Mean	Std	# Obs	Mean	Std	# Obs	Difference	T-Statistics
Income (Log of)	1,679	6.897	0.84	1,953	6.222	1.17	3,632	-0.818	(-23.926)
Self employed	1,679	0.580	0.49	1,953	0.783	0.41	3,632	0.199	(12.769)
Off-grid Solution	1,679	0.044	0.21	1,953	0.007	0.08	3,632	-0.030	(-5.867)
Household Size	1,679	6.322	4.59	1,953	6.221	3.66	3,632	-0.161	(-1.302)
MTF-tier	1,679	3.443	0.98	1,953	1.032	0.24	3,632	-2.505	(-98.220)
Age	1,675	45.173	14.07	1,943	44.574	14.77	3,618	-0.414	(-0.858)
Female	1,679	0.073	0.26	1,953	0.039	0.19	3,632	-0.029	(-3.437)
Married	1,679	0.909	0.29	1,953	0.951	0.22	3,632	0.027	(2.801)
Education	1,679	0.913	0.28	1,953	0.889	0.31	3,632	-0.068	(-6.739)
Home owner	1,679	0.783	0.41	1,953	0.878	0.33	3,632	0.106	(8.051)
Land Ownership	1,679	0.462	0.50	1,953	0.808	0.39	3,632	0.285	(18.009)

[#] The descriptive statistics for households with grid and without grid, reported in the first six columns, are weighted statistics by the MTF global survey household sampling weight.

[##] The statistics for differences, reported in the three columns from right, are unweighted statistics to be calculated two-sample t-test statistics.

[*] This column reports the mean differences between households with grid access and households without grid access. These mean differences are different with the differences of means reported on the left because they are unweighted means.

Table A.12: Main Model Estimates: Log of Income (Total Expenditure)

	Self-Employed		Log of Income	
	Probit	IV Probit	OLS	TSLS
	(1)	(2)	(3)	(4)
Off-grid Access	0.0428	0.4871***	0.1521***	-0.3036
	[0.032]	[0.136]	[0.019]	[0.208]
MTF-tier	-0.0063	-0.0036	0.1519***	0.1491***
	[0.006]	[0.006]	[0.012]	[0.013]
Household Size	0.0216***	0.0198***	0.0830***	0.0866***
	[0.004]	[0.004]	[0.004]	[0.004]
age	-0.0155***	-0.0154***	0.0011*	0.0011*
	[0.001]	[0.001]	[0.001]	[0.001]
female	-0.1928***	-0.1893***	-0.0240	-0.0233
	[0.033]	[0.032]	[0.022]	[0.022]
married	0.3138***	0.2938***	0.1819***	0.2144***
	[0.035]	[0.035]	[0.026]	[0.030]
educ	-0.3195***	-0.3281***	0.1995***	0.2154***
	[0.024]	[0.024]	[0.025]	[0.027]
home owner	0.0970***	0.0862***	-0.0280	-0.0185
	[0.025]	[0.025]	[0.034]	[0.035]
Land Ownership	0.4776***	0.4552***	-0.2017***	-0.1834***
	[0.024]	[0.025]	[0.042]	[0.046]
cons	0.9309***	0.9602***	5.2142***	5.3154***
	[0.071]	[0.071]	[0.059]	[0.079]
Province Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
# of Obs	22,192	22,192	24,127	24,127
Adjusted {Pseudo} R^2	{0.2165}	NA	0.7263	0.7131
Exogenous F $\{\chi^2\}$ Test (df)	NA	11.0791	NA	6.5802 (1)
(P-value)		(0.0009)		(0.0127)

Table A.13: Probability Model Estimates: Self-Employed

	Probit					IV Probit				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Off-grid Access	0.0554	0.1132**	-0.2330***	0.0414	0.1792	0.5754**	0.0786	-0.2681	1.8061**	-6.6440***
	[0.062]	[0.048]	[0.082]	[0.167]	[0.158]	[0.267]	[0.157]	[0.177]	[0.822]	[0.544]
Household Size	0.0609***	0.0385***	0.0046	0.0493***	0.0049	0.0543***	0.0391***	0.0046	0.0494***	0.0031
	[0.012]	[0.011]	[0.010]	[0.011]	[0.007]	[0.013]	[0.011]	[0.010]	[0.011]	[0.005]
MTF-tier	-0.0401**	0.0215*	0.0316	-0.0207*	-0.1203***	-0.0220	0.0210	0.0356	-0.0233*	0.0333
	[0.017]	[0.013]	[0.033]	[0.012]	[0.017]	[0.020]	[0.013]	[0.037]	[0.012]	[0.036]
Age	-0.0176***	-0.0061***	-0.0157***	-0.0289***	-0.0093***	-0.0173***	-0.0061***	-0.0157***	-0.0283***	-0.0036
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Female	-0.3637***	0.0763	0.0954*	-1.5019***	0.0423	-0.3444***	0.0765	0.0958*	-1.4362***	0.2528*
	[0.072]	[0.070]	[0.055]	[0.107]	[0.136]	[0.072]	[0.070]	[0.056]	[0.116]	[0.141]
Married	0.0361	0.0795	NA	0.1332	0.4815***	0.0296	0.0818	NA	0.1387	0.3237**
	[0.075]	[0.067]		[0.088]	[0.118]	[0.074]	[0.068]		[0.088]	[0.139]
Education	-0.1202**	-0.0708	-0.4684***	-0.7792***	-0.1733**	-0.1421**	-0.0676	-0.4676***	-0.7776***	-0.0604
	[0.055]	[0.063]	[0.056]	[0.054]	[0.076]	[0.056]	[0.065]	[0.056]	[0.054]	[0.074]
Home Owner	0.0580	0.0880	0.1690***	0.2943***	0.0797	0.0393	0.0903	0.1684***	0.2977***	0.0625
	[0.061]	[0.063]	[0.054]	[0.059]	[0.059]	[0.061]	[0.063]	[0.054]	[0.058]	[0.045]
Land Ownership	0.6667***	0.3320***	0.8185***	0.1686***	0.4960***	0.6026***	0.3352***	0.8182***	0.1642***	-0.0014
	[0.062]	[0.050]	[0.065]	[0.060]	[0.049]	[0.072]	[0.052]	[0.065]	[0.059]	[0.112]
Constant	0.0598	-0.3213**	0.6977***	1.9383***	0.3066*	-0.0028	-0.3222**	0.6932***	1.8055***	-0.1215
	[0.151]	[0.134]	[0.159]	[0.143]	[0.167]	[0.153]	[0.134]	[0.161]	[0.163]	[0.165]
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs	3,876	3,937	3,493	4,059	3,618	3,876	3,937	3,493	4,059	3,618
Pseudo R^2	0.1878	0.0378	0.1365	0.2346	0.0828	NA	NA	NA	NA	NA
χ^2 Test (df)	NA	NA	NA	NA	NA	3.8702(1)	0.0529(1)	0.0494(1)	4.9825(1)	4.8898(1)
(P-value)						(0.0492)	(0.8181)	(0.8241)	(0.0256)	(0.0270)

Notes: Heteroskedasticity robust standard errors are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels.

Table A.14: Main Model Estimates: Log of Income (Total Expenditure)

	OLS					TSLS				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
Off-grid Access	0.0995**	0.0662	0.1341**	-0.1315	0.3667**	-0.7165*	-0.5400***	-0.1363**	3.7790**	49.7104
	[0.032]	[0.050]	[0.051]	[0.092]	[0.124]	[0.397]	[0.098]	[0.057]	[1.541]	[54.026]
Household Size	0.0890***	0.0727***	0.0863***	0.0764***	0.0689***	0.0978***	0.0816***	0.0865***	0.0797***	0.0548**
	[0.010]	[0.011]	[0.007]	[0.013]	[0.006]	[0.008]	[0.012]	[0.006]	[0.014]	[0.025]
MTF-tier	0.0763***	0.1197***	0.1701***	0.1546***	0.1941***	0.0508***	0.1111***	0.2015***	0.1481***	-0.2564
	[0.011]	[0.022]	[0.020]	[0.029]	[0.026]	[0.016]	[0.021]	[0.018]	[0.025]	[0.441]
Age	0.0001	0.0010	0.0020**	-0.0009	0.0036**	0.0000	0.0015	0.0021***	-0.0014	0.0145
	[0.001]	[0.001]	[0.001]	[0.003]	[0.001]	[0.000]	[0.001]	[0.001]	[0.003]	[0.012]
Female	-0.0347	-0.0289	0.0182	0.0244	0.1003	-0.0553*	-0.0276	0.0216	0.0874	-1.6988
	[0.038]	[0.054]	[0.037]	[0.096]	[0.171]	[0.029]	[0.062]	[0.033]	[0.096]	[1.720]
Married	0.1165**	0.1790***	NA	0.2282*	0.2661	0.1279***	0.2186***	NA	0.2475**	-1.3146
	[0.039]	[0.038]		[0.119]	[0.163]	[0.044]	[0.037]		[0.117]	[1.398]
Education	0.1901***	0.1579	0.1925***	0.1814***	0.2476	0.2273***	0.2140**	0.1984***	0.1398**	0.4040
	[0.018]	[0.101]	[0.041]	[0.049]	[0.151]	[0.027]	[0.093]	[0.039]	[0.064]	[0.512]
Home owner	0.0616	-0.1061	0.0046	-0.1400**	-0.0471	0.0895	-0.0674	0.0012	-0.1175*	-0.3757
	[0.089]	[0.074]	[0.033]	[0.058]	[0.083]	[0.086]	[0.078]	[0.036]	[0.069]	[0.555]
Land owner	-0.2792***	-0.0180	-0.0914***	-0.3686***	-0.2798**	-0.1937***	0.0375	-0.0945***	-0.3669***	0.5642
	[0.066]	[0.044]	[0.023]	[0.092]	[0.095]	[0.058]	[0.049]	[0.023]	[0.104]	[0.670]
Constant	8.4297***	5.8351***	5.2591***	5.6230***	5.1871***	8.8788***	5.7769***	5.6921***	4.9256***	4.5614***
	[0.081]	[0.128]	[0.090]	[0.190]	[0.406]	[0.132]	[0.138]	[0.079]	[0.261]	[0.974]
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs	3,873	3,937	3,378	4,059	3,618	3,873	3,937	3,378	4,059	3,618
Adjusted R^2	0.2792	0.2025	0.5081	0.3833	0.2091	0.0806	0.0926	0.4991	0.1266	NA
1^{st}-Stage F	NA	NA	NA	NA	NA	5.8382	60.9212	273.9556	10.6565	0.7086
Exogenous F (df)	NA	NA	NA	NA	NA	31.5283(1)	31.8941(1)	16.5946(1)	7.4351(1)	118.0349(1)
(P-value)	NA	NA	NA	NA	NA	(0.0002)	(0.0008)	(0.0010)	(0.0295)	(0.0000)

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels.

Table A.15: Main Model Estimates: Log of Income by Self-Employed

	Self-Employed					Non Self-Employed				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Off-grid Access	-0.3284**	-0.5930***	-0.2745*	3.7188***	25.7243	-1.0915***	-0.4983***	-0.0990	3.2589***	97.4920
	[0.136]	[0.150]	[0.160]	[0.970]	[25.054]	[0.264]	[0.126]	[0.087]	[1.198]	[196.764]
Household Size	0.0849***	0.0653***	0.0906***	0.0664***	0.0790***	0.1097***	0.0824***	0.0824***	0.1014***	-0.0851
	[0.008]	[0.011]	[0.006]	[0.006]	[0.024]	[0.009]	[0.007]	[0.006]	[0.011]	[0.364]
MTF-tier	0.0729***	0.0709***	0.2360***	0.1266***	-0.0317	0.0243*	0.1257***	0.1822***	0.2080***	-0.7833
	[0.011]	[0.013]	[0.029]	[0.007]	[0.248]	[0.014]	[0.009]	[0.020]	[0.014]	[2.008]
Age	0.0029**	0.0028	0.0028**	0.0016	0.0048	-0.0013	0.0013	0.0012	-0.0011	0.0383
	[0.001]	[0.002]	[0.001]	[0.002]	[0.006]	[0.001]	[0.001]	[0.001]	[0.002]	[0.068]
Female	-0.1361**	-0.1620**	0.0288	0.1666	-1.4262	-0.0251	0.0251	0.0210	0.2587**	-0.9368
	[0.058]	[0.074]	[0.033]	[0.108]	[1.611]	[0.044]	[0.051]	[0.036]	[0.103]	[3.464]
Married	0.0808	0.0598	NA	0.2403***	-1.0469	0.1495***	0.2707***	NA	0.2105**	-0.3367
	[0.058]	[0.072]		[0.075]	[1.331]	[0.047]	[0.049]		[0.102]	[2.486]
Education	0.1388***	0.1009	0.1475***	0.1271***	0.1441	0.3157***	0.2717***	0.2406***	0.3190***	1.3385
	[0.032]	[0.069]	[0.030]	[0.036]	[0.239]	[0.039]	[0.049]	[0.038]	[0.069]	[2.045]
Home Ownership	0.0208	-0.1587**	-0.0091	-0.1617***	0.0632	0.1186***	-0.0384	0.0319	-0.0809	-2.0007
	[0.046]	[0.063]	[0.034]	[0.038]	[0.223]	[0.034]	[0.042]	[0.032]	[0.060]	[3.751]
Land Owner	-0.2912***	0.0481	-0.1053***	-0.3351***	0.3655	-0.0986*	0.0153	-0.0295	-0.4098***	0.2759
	[0.043]	[0.058]	[0.032]	[0.038]	[0.575]	[0.054]	[0.038]	[0.049]	[0.071]	[1.521]
Constant	8.8170***	6.3174***	5.6131***	4.9498***	4.7283***	8.9949***	5.6336***	5.7544***	4.5076***	4.3232
	[0.107]	[0.179]	[0.102]	[0.103]	[0.805]	[0.135]	[0.104]	[0.110]	[0.181]	[3.436]
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs	1,681	1,254	1,667	3,010	2,374	2,192	2,683	1,711	1,049	1,244
Adjusted R^2	0.2439	0.0266	0.5114	0.0247	NA	NA	0.1350	0.4766	0.4272	NA
1^{st}-Stage F	107.5571	179.1282	103.5354	24.3853	1.0225	59.4734	240.1794	306.7125	13.5145	0.2398
Exogenous F (df)	11.4729(1)	22.9136(1)	6.0316(1)	64.2162(1)	53.4320(1)	35.6246(1)	25.2059(1)	10.3155(1)	19.5849(1)	88.1585(1)
(P-value)	(0.0007)	(0.0000)	(0.0142)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0013)	(0.0000)	(0.0000)

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels.

Table A.16: Probability Model Estimates by Rural/Urban Residents

	Urban Residents					Rural Residents				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Off-grid Access	-0.3703	-0.4010	-0.2381	2.4676**	-5.2895***	0.0450	0.2236	6.0024***	1.0169	NA
	[1.120]	[0.467]	[0.176]	[1.063]	[0.919]	[0.253]	[0.147]	[0.762]	[1.384]	
Household Size	0.0591***	0.0340*	0.0223	0.0462***	0.0055	0.0581***	0.0435***	-0.0098	0.0482***	NA
	[0.018]	[0.019]	[0.014]	[0.014]	[0.008]	[0.018]	[0.013]	[0.012]	[0.016]	
MTF-tier	-0.0079	0.0032	0.0621	-0.0463***	0.0181	-0.0338	0.0241	-0.5557***	0.0342	NA
	[0.033]	[0.024]	[0.039]	[0.015]	[0.036]	[0.028]	[0.019]	[0.133]	[0.023]	
Age	-0.0202***	-0.0017	-0.0155***	-0.0321***	-0.0046	-0.0141***	-0.0084***	-0.0084**	-0.0254***	NA
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]	
Female	-0.3257***	0.1197	0.1941***	-1.1831***	0.3631**	-0.3974**	0.0246	-0.1070	-1.9126***	NA
	[0.078]	[0.107]	[0.075]	[0.136]	[0.171]	[0.201]	[0.094]	[0.085]	[0.213]	
Married	0.0226	0.1971*	NA	0.2533**	0.3875**	0.1985	0.0028	NA	-0.0127	NA
	[0.092]	[0.103]		[0.106]	[0.176]	[0.200]	[0.092]		[0.166]	
Education	-0.1897**	0.1118	-0.5422***	-0.8305***	-0.0062	-0.0054	-0.1597**	-0.2330***	-0.6139***	NA
	[0.086]	[0.129]	[0.089]	[0.070]	[0.098]	[0.080]	[0.076]	[0.077]	[0.099]	
Home Owner	0.0494	0.0092	0.0578	0.2424***	0.1224	0.0525	0.2405**	0.2255***	0.6510***	NA
	[0.073]	[0.082]	[0.072]	[0.064]	[0.078]	[0.192]	[0.112]	[0.080]	[0.140]	
Land Owner	0.2345**	0.2718***	0.5499***	0.0630	0.0318	0.7056***	0.3444***	0.3190*	0.4250***	NA
	[0.119]	[0.080]	[0.120]	[0.080]	[0.127]	[0.106]	[0.069]	[0.178]	[0.121]	
Constant	0.1314	-0.7977***	0.6323**	1.8889***	-0.3243*	-1.9063***	-0.1066	0.9787***	1.6412***	NA
	[0.226]	[0.235]	[0.280]	[0.197]	[0.181]	[0.401]	[0.176]	[0.224]	[0.418]	
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA
# of Obs	2,176	1,632	1,762	2,400	1,801	1,700	2,305	1,731	1,659	NA
χ^2 Test (df)	0.1377(1)	0.6282(1)	0.0006(1)	7.8493(1)	2.8996(1)	0.0272(1)	0.1893(1)	8.7525(1)	0.2457(1)	NA
(P-value)	(0.7106)	(0.4280)	(0.9805)	(0.0051)	(0.0886)	(0.8691)	(0.6635)	(0.0031)	(0.6201)	NA

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels. 3

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Table A.17: Main Model Estimates: Log of Income by Rural/Urban Residents

	Urban Residents					Rural Residents				
	Ethiopia	Kenya	Liberia	Niger	Nigeria	Ethiopia	Kenya	Liberia	Niger	Nigeria
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Off-grid Access	-2.7570***	-1.1924***	-0.1445*	2.7730***	40.5839	-0.0172	-0.2531***	-1.5118	4.2290***	-1132.1690
	[1.016]	[0.332]	[0.076]	[0.830]	[41.346]	[0.087]	[0.088]	[1.471]	[1.379]	[57363.536]
Household Size	0.0871***	0.0669***	0.0850***	0.0770***	0.0499	0.0944***	0.0890***	0.0834***	0.0733***	0.0787
	[0.012]	[0.013]	[0.006]	[0.006]	[0.057]	[0.007]	[0.007]	[0.007]	[0.009]	[0.995]
MTF-tier	0.0153	0.0636***	0.1963***	0.1400***	-0.1391	0.0625***	0.1105***	0.2343	0.1715***	10.8167
	[0.023]	[0.016]	[0.017]	[0.007]	[0.366]	[0.010]	[0.010]	[0.146]	[0.011]	[539.040]
Age	-0.0003	0.0041*	0.0030**	-0.0008	0.0160	0.0004	0.0012	0.0020*	-0.0050**	-0.2550
	[0.001]	[0.002]	[0.001]	[0.002]	[0.016]	[0.001]	[0.001]	[0.001]	[0.002]	[12.939]
Female	-0.0906*	0.0160	0.0238	0.0584	-2.2662	0.0481	-0.0687	-0.0169	0.0639	-7.6457
	[0.052]	[0.069]	[0.032]	[0.069]	[2.587]	[0.087]	[0.056]	[0.054]	[0.123]	[395.666]
Married	0.2117***	0.2602***	0.0000	0.2271***	-1.5302	0.1767**	0.2137***	0.0000	0.2102*	15.6565
	[0.068]	[0.065]	[.]	[0.061]	[2.058]	[0.089]	[0.055]	[.]	[0.116]	[775.229]
Education	0.3086***	0.4000***	0.2043***	0.2128***	-0.1403	0.0953***	0.1062**	0.1596***	-0.0694	-15.9513
	[0.054]	[0.086]	[0.037]	[0.031]	[0.651]	[0.030]	[0.045]	[0.038]	[0.067]	[827.075]
Home Ownership	0.2302***	-0.0214	0.0335	-0.0676**	-0.5028	-0.3130***	-0.0031	-0.0009	0.0340	11.9937
	[0.051]	[0.053]	[0.030]	[0.032]	[0.577]	[0.061]	[0.055]	[0.051]	[0.106]	[598.502]
Land Owner	-0.5082***	0.0114	-0.0681	-0.2101***	0.4320	0.0318	0.0607	-0.0385	-0.0623	-13.4258
	[0.080]	[0.055]	[0.052]	[0.042]	[0.692]	[0.041]	[0.040]	[0.035]	[0.073]	[676.853]
Constant	9.1864***	5.6957***	5.7758***	5.1182***	4.8515***	8.9016***	5.7167***	5.6531***	4.5219***	22.3114
	[0.245]	[0.211]	[0.116]	[0.091]	[1.455]	[0.126]	[0.105]	[0.209]	[0.198]	[906.042]
Province Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs	2,173	1,632	1,666	2,400	1,801	1,700	2,305	1,712	1,659	1,817
Adjusted R^2	NA	NA	0.3874	0.1954	NA	0.2635	0.1414	0.3217	0.0128	NA
1^{st}-Stage F	5.0870	0.1182	0.4177	5.2027	0.0403	18.0678	0.5807	30.2675	2.3153	2.3700
Exogenous F (df)	35.5694(1)	22.3619(1)	13.4018(1)	34.9292(1)	98.6265(1)	1.5891(1)	19.7917(1)	1.0733(1)	38.1281(1)	31.4759(1)
(P-value)	(0.0000)	(0.0000)	0.0003	(0.0000)	(0.0000)	0.2076	(0.0000)	0.3004	(0.0000)	(0.0000)

Notes: Heteroskedasticity robust standard errors clustered by province (United Nation administrative region level 1) are reported in square brackets. The symbols, *, **, and *** indicate respectively that the estimated coefficient is statistically significant at 10%, 5%, and 1% significance levels. 3

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