Environment for Development

Discussion Paper Series

March 2022 ■ EfD DP 22-04

The Impact of Rural Electrification on Business Enterprise Creation

Panel Data Evidence from Ethiopia

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Abstract

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Keywords: non-agricultural business; electrification; rural Ethiopia; panel data

JEL Codes: D00, D22, Q40

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1. Introduction

There is increasing evidence that access to modern energy sources is a prerequisite for economic growth, development of local industrialization, agricultural up-scaling, and improving the welfare of the poor. This understanding underpins the formulation of goal number seven of the sustainable development goals of the United Nations and the Sustainable Energy for All (SE4ALL) initiative, which aims to improve the lives of the poor by ensuring access to modern energy services such as electricity (SE4ALL, 2014). However, it is challenging for governments of developing countries to provide access to modern energy. About 590 million people in Africa live with limited access to modern energy (IEA, 2013). This situation needs to be changed because there is a growing need for development in the region.

In this regard, Ethiopia has been undertaking remarkable development in the energy sector in general and the electric sector in particular since 2000. Through the country's Universal Electricity Access Program, several off-grid villages and regions have been connected to the national electricity grid through public investment. The national grid coverage to rural towns increased from 13% in 2002 to 55% in 2016, and the percentage of households that are actually connected to grid electricity also increased from 7% in 2002 to 33% in 2016. In terms of energy production, in 2005, the country was producing about 2900 MW of electricity; in 2017, the total electricity production reached about 4180 MW. The grid expansion program will continue in the country's second Growth and Transformation Plan period (GTPII) (FDRE, 2011).

Given this background of the increasing rate of rural electrification, it is vital to obtain empirical evidence on the impact of rural electrification on development outcomes. One of the potential benefits of creating access to electricity in rural areas is the creation of business enterprises, which provide opportunities for alternative income-generation activities outside agriculture.

Extra electric lighting provides opportunities to set up businesses by allowing more time to work at night, compared to fuel-based lighting sources. There is a growing body of research that examines the effects of electrification on various development outcomes, including economic development (e.g., Lipscomb et al., 2013), female employment (e.g., Dinkelman, 2011; Lewis, 2014), and poverty (e.g., ESMAP, 2003). Nonetheless, we find little evidence on the impact of rural electrification on enterprise creation in sub-Saharan African Countries.

Most of the empirical evidence on the impact of electrification on development outcomes is from Asia and Latin America (e.g., ESMAP, 2003; Lipscomb et al., 2013). There is little empirical evidence from Africa, and the available studies are mostly based on descriptive statistics (exceptions are Bensch et al., 2011, Tegene et al., 2015; Lenz et al 2017). However, the findings of the few quantitative studies in Africa are not consistent. For example, using firm-level data from Benin, Peters et al. (2011) found that electrification has a significant effect on firm creation. However, Lenz et al. (2017) did not find a change in the income-generating activity of households following electrification in Rwanda. To our knowledge, there is no empirical study that examines the impact of rural electrification on enterprise creation in Ethiopia. The findings of this study will complement the few existing studies in sub-Saharan Africa. This study uses three rounds of panel data, with about 3000 rural households, which was collected by the World Bank and Ethiopian Central Statistical Agency in the years 2011, 2013 and 2016.

Access to grid and/or off grid electricity at the community level is not randomly determined. The decision to provide electricity access for a certain community depends on observable and unobservable characteristics. For example, access to grid electricity at the community level may be determined based a feasibility study, implying that villages (communities) that have access to grid electricity are different from those that do not have such grid access. In addition, households may self-select and get connected to grid electricity provided that there is grid electricity in their community. Hence, applying OLS or maximum likelihood to simple probit will likely result in biased estimates. Instead, we first apply propensity score matching method (PSM) to find control groups (grid unconnected households) that look similar to the treatment group (grid connected households) based on the baseline socio-economic characteristics. We then apply a Difference in Difference approach on the matched households using the baseline (2011) and the last wave (2016) survey data. Using this method, we find that household connection to grid electricity increased rural households' opening of businesses by 4.8%.

The rest of the paper is organized as follows: Section 2 provides a brief review of the literature in the area of electrification and rural development. In Section 3 we discuss the data source and sampling strategy of the study. Section 4 discusses the empirical strategy of the paper. In Sections 5 and 6, we present the descriptive and econometric analysis of the study. The last section concludes.

2. LITERATURE REVIEW

Rural electrification plays a critical role in achieving the ambitious environmental and sustainable development goals of the least-developed countries. Access to electricity increases the productivity of both farm and non-farm activities, facilitates household tasks, and enables the provision of social services (Peters, 2009; Peters and Sievert, 2015; Barness et al., 2016). Despite increasing access to grid electricity, policy relevant impact evaluation studies on rural electrification are very limited in developing countries. Most of the impact studies on rural electrification face methodological challenges to estimating the effects on social, environmental and economic indicators (Peters and Sieviert, 2015). Ethiopia, as stated in its Climate Resilient Green Economy (CRGE) strategy and Growth and Transformation Plan (GTP), envisions becoming a climate-resilient, carbon-neutral and lower-middle income country by 2025. Empirical studies on the impact of climate and energy policy interventions have a critical role in tracking the implementation of these national plans and helping policy makers arrive at knowledge-based decisions.

Comprehensive studies have been conducted by different researchers on the effects of rural electrification in developing countries (ESMAP, 2003; EnPoGen, 2003a; EnPoGen, 2003b; Gouvello and Durix, 2008; Rud, 2009; Bensch et al, 2011; Bensch et al, 2015). Rural electrification enhances income, employment, and educational outcomes (Khandker et al., 2009; Gouvello and Durix, 2008; Bensch et al, 2011; Dinkelman, 2011; Grogand and Sadanand, 2013), leads to industrialization (Rud, 2009), and increases the participation of women in the labor market (Dinkelman, 2011). There are also both quantitative and qualitative studies on the role of rural electrification on non-farm activities in developing countries including Ethiopia (Davidson and Mwakasonda, 2004; Lulie, 2012; EEP, 2015).

Empirical studies on the impacts of rural electrification in Ethiopia are not only few but also have tended to be cross-sectional studies, which did not show the dynamics of the impact of rural electrification programs. For example, a study by Ethiopian Electric Power (EEP, 2015) assessed the economic and social impact of the Universal Electrification Access Program (UEAP) using cross-sectional data on energy consumption, cost of energy, household income, and so on, by applying propensity score matching and qualitative analysis. The study compared connected and non-connected households and found that the program significantly improved the welfare of rural households. Other studies such as Lulie (2012) and Tegene et al. (2015) used cross-sectional data to investigate the impact of electrification on poverty reduction, income, health, and education. Both studies found that rural electrification significantly contributes to poverty reduction. Peters (2009) reviewed methodological approaches for impact evaluation of rural electrification projects and reported that there have been studies conducted by the World Bank that assess the impact of electrification by comparing connected and non-connected households in the same region.

Unlike most empirical studies, which employ cross-sectional data, this study will apply panel data to compare the effect of rural electrification on non-agricultural business creation between connected and non-connected households using panel data analysis. To the best of the researchers' knowledge, there is no study of this sort that investigates the effect of rural electrification on non-agricultural business creation in Ethiopia. Since energy access for the rural poor is one of the key development targets of Ethiopia, this empirical work will guide policy makers in designing sound rural electrification policies.

3. **Data source**

This study is based on the Ethiopia Socioeconomic Survey (ESS), which was conducted jointly by the Central Statistics Agency of Ethiopia (CSA) and the World Bank (Living Standards Measurement Study). It is intended to collect multi-topic panel household level data with a focus on agriculture and the link between agriculture and other household income-generating activities. It also contains information on households' access to different forms of energy and the use of energy-efficient cooking technologies. The survey was conducted in three waves. Wave-1 of the survey was designed to be representative of rural and small town areas of the country. Wave-2 and Wave-3 of the survey add urban areas in addition to rural and small town areas covered in Wave-1. The key objective of the urban expansion was to ensure that the Wave-2 and subsequent surveys were able to provide inferences for the whole country.

The ESS sample households were selected in a two-stage probability sampling method. The first stage of sampling entailed selecting enumeration areas (EA) (i.e., the primary sampling units). The EAs were selected based on probability proportional to size of population (PPS). For the rural sample, 290 EAs were selected from EAs in an earlier World Bank survey called the Agricultural Sample Survey (AgSS). For small-town EAs, a total of 43 EAs were selected by PPS. Similarly, for Waves-2 and 3, a total of 100 EAs were selected and added to the Wave-1 sample.

The second stage of sampling was the selection of households to be interviewed in each EA. For rural EAs, a total of 12 households were sampled in each EA. Of these, 10 households were randomly selected (SRS) from the sample of 30 AgSS households. The AgSS households are involved in farming or livestock activities. Another two households were randomly selected from all other households in the rural EA (those not involved in agriculture or livestock). The final number of households interviewed in Wave-1 was 3,969 households. Of these 3,969 households in Wave-1, Wave-2 successfully re-interviewed 3,776 households. This implies a panel attrition rate of 5 percent, or a successful follow-up rate of 95 percent. In Wave-3, 3,726 households were interviewed during the agriculture post-planting visit (first visit of Wave-3). However, 27 households were not available for the second visit. Therefore, the total number of Wave-1 households with complete interviews in Wave-3 is 3,699. Out of the 27 that were not available in the second visit, 12 were in one enumeration area that could not be visited for security reasons. The remaining 15 were in different places and no respondent was available in the second visit (ESS, 2015/2016).

We used Wave-1 and Wave-3 of the rural households to analyze the long-run effect of rural households on business creation. The reason we choose the two waves is to have a large time gap between the waves. The impact of an intervention is likely to be seen over a long period of time. We also used the Wave-1 and Wave-2 data to assess the short-run effect of access to grid electricity.

4. Empirical strategy

The main objective of this study is to investigate the effect of the households' connection to grid electricity on the opening of rural business enterprises. Conditional on a household's status of connection to grid electricity, a household's opening of rural enterprise is expressed as

$$Y_{ijt} = \alpha + \theta E_{ijt} + \lambda C_{ij} + \beta X_{ijt} + \eta_{ij} + u_j + \varepsilon_{ijt} \qquad 1$$

where Y_{ijt} is a binary variable indicating whether or not household i living in community j is operating a non-farm business at time t. E_{ijt} is a binary variable that denotes the household's status of connection to electricity at time t, C_{jt} is a vector of observable community characteristics, X_{ijt} represents a vector of observed household-level characteristics, and h_{ij} and u_j are unobserved time-invariant household-level and community-level characteristics, respectively. e_{ijt} is unobserved time-varying household and community characteristics; it is normally distributed, with mean zero and variance s_e^2.

Using the 2011 and 2016 panel data, we used a Difference in Difference (DID) approach to estimate the long-run effect of connection to electricity on households' opening of businesses. The DID approach has the advantage of differencing out the existing differences between households that are connected to grid electricity and those that are not connected. The treatment is household-level connection to the grid. The method would work best if communities were randomly assigned to have access to the grid, and if households were randomly assigned to be connected to a grid once it exists in their community. It also would be desirable if observable characteristics could be used to control for both community and household grid connection. However, households/communities were not randomly selected to get access to grid electricity or to actually connect. Households may self-select and get connected to electricity provided that there is electricity in their community. Placement of electricity at the community level is also not randomly determined. The decision to provide electricity for a certain community depends on observable and unobservable characteristics. For example, access to electricity at the community level may be determined based some feasibility study, implying that villages (communities) that have access to electricity are different from those that do not have electricity. In addition, those households in the control group (without household connection to electricity) may not be similar to treated households and may not satisfy the basic condition of

DID. Thus, to obtain a control group that is not systematically different from the treatment group, we select it using propensity score matching method (PSM). In what follows, we present how we apply these two methods to get our estimates.

Using the 2011 survey data (baseline data) we apply kernel propensity matching method to select control households that are similar to the treated households based on their propensity score. PSM uses a logistic regression (the dependent variable is equal to 1 for households that are connected to electricity and 0 otherwise) in which the independent variables consist of characteristics (as of 2011) that may affect the propensity of a household to get connected to electricity. We used households' socio-economic characteristics such as income (expenditure), education level, gender, age, marital status, household size, and prices of alternative fuels and community-level fixed effects. After matching treated and control households based on socio-economic characteristics, we obtain 222 treated households matched with 1392 untreated households. There were no treated households that were off the common support; however, 127 untreated households were off the common support.

Table-1: Number of control and treatment households on and off the common support

	Off support	On support	Total
Untreated	127	1,265	1,392
Treated	0	222	222
Total	127	1,487	1,614

A test of balance of the treated and control households is conducted using the control variables. Table-2 shows the test of the balance. If the ratio of variance of treated households to the variance of control households (V(T)/V(C)) is outside [0.77; 1.30], the matched treated and control households are not balanced with respect to the variable. Alternatively, if the p-value of the variable is less than 10%, matched treated and control households are not balanced. The results in Table-2 show that the control and treatment households are balanced with respect to the control variables used in the main regression.

Table-2: Matching Balance test of the Control and Treatment Households

	Mean			t-test		V(T)/V
Variable	Treated	Control	%Bias	t	p>t	
Age of the household head	43.05	42.64	2.7	0.29	0.771	1
Marital status	0.74	0.72	3.6	0.36	0.717	.
Education of the household head	3.58	3.36	4.8	0.43	0.665	0.92
Total monthly expenditure	2873.50	2944.60	-3.3	-0.3	0.765	0.86
Household size	4.98	5.03	-2.1	-0.22	0.828	0.94
Price of kerosene	22.98	22.95	0.0	0	0.997	0.88
Whether vehicles can pass through the village all year (1= yes, 0=no)		0.89	-1.4		0.856	.
Whether there is a microfinance service in the village (1= yes, 0=no)		0.23	1.5		0.875	.
Do people migrate to the community for work?		0.43	-6.6		0.489	.

- if variance ratio outside [0.77; 1.30]

For these matched treated and untreated households, we used the 2011 and 2016 survey data and applied the Difference in Difference approach to estimate the long-run effect of rural electrification. Because the time gap between 2011 and 2013 is short, we apply the DID to estimate the short-run effect of access to electricity. We also combined all the years and made one the regression. A result shown in the appendix shows that the combined and separate regression results are the same. For ease of presentations and comparison, we prefer the separate regressions.

Thus, using these survey data, we used the following DID model to estimate our parameter of interest.

$$Y_{ijt} = \alpha + \phi(E_{ijt}\ X\ year) + \theta E_{ijt} + \delta year + \beta X_{ijt} + \eta_{ij} + \upsilon_j + \varepsilon_{ijt} \qquad 2$$

where year is a dummy variable taking a value of one if the year is 2016 and zero for 2011, while all other variables are explained above. Because our dependent variable is binary, it is difficult to apply the DID approach with a probit model.[1] We used the DID approach with a linear probability model. In fact, Angrist and Pischke (2010) documented that OLS estimation of LPM produces coefficients that are mostly statistically indistinguishable from the marginal effects of probit model. As a robustness check, we also use random effect probit model.

4. Descriptive statistics

In this section we discuss the descriptive statistics of key socio-economic characteristics of the households covered in the survey. Table-3 presents the trend of rural households' business ownership and connection to grid electricity. In the rural areas of the least-developed countries, households and enterprises are indistinguishable. Most of the businesses in rural areas are home-based, i.e., the household runs businesses such as food sales, restaurants, mobile and electronics shops, barbering, etc. within their residence. For example, Naglar and Naude (2017), using the World Bank's Living Standard Measurement Survey of Sub-Saharan African Countries, documented that rural households operate enterprises predominantly in easy-to-enter activities, such as sales and trade, rather than in activities that require higher starting costs such as transport services, or educational investment such as professional services.

[1]Because of convergence and concavity problems, we could not apply the conditional logit fixed effect method.

Figure-1: Business ownership and connection to electricity (Before matching, N=3222 for each year

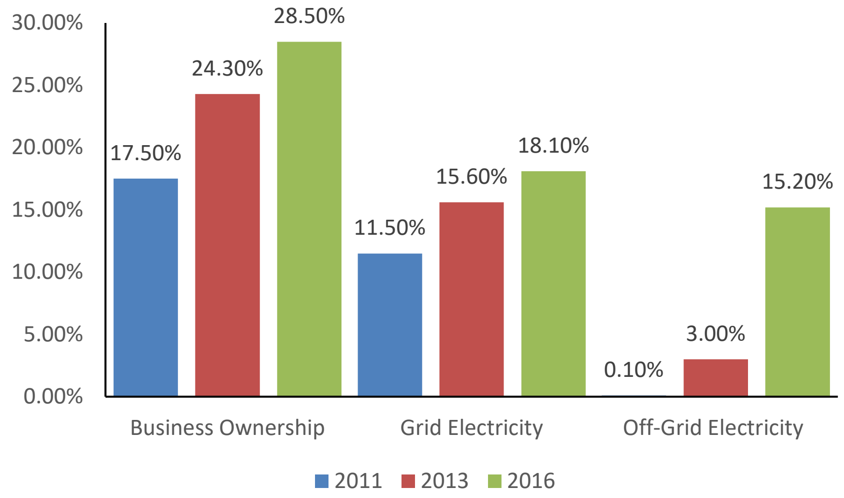

Figure-1 shows the trend of rural households' participation in non-farming business activities during the three waves before the matching exercise was conducted. As shown in this figure, rural households' business ownership increased from 17.5% in 2011 to 28.5% in 2016, which is about an 11 percentage-point (38.5%) increment over five years. This is consistent with the overall economic improvement in this country during this time and before. For example, the World Bank (2018) report shows that Ethiopia's economy experienced strong, broad-based growth averaging 10.3% a year from 2006/07 to 2016/17, compared to a regional average of 5.4%. Further, the share of the population living below the national poverty line decreased from 30% in 2011 to 24% in 2016.

Although there could be several factors for the increase in rural business enterprises, the increase in access to electricity could be one factor. Figure-1 also shows the trend in access to grid and off-grid electricity in rural areas. Access to grid electricity increased from 11.5% in 2011 to 18.1% in 2016. Access and connection to off-grid electricity, mainly through solar technologies, increased from 0.1% in 2011 to 15.2% (connection) in 2016. The expansion of off-grid electric sources increased total access to electricity to about 33% in 2016. This is consistent with the overall increase in access to electricity in the country. The World Bank

(2018) online database also shows that the percentage of the rural population in Ethiopia with access to electricity increased from 15% in 2012 to 26.5% in 2016. Further, under the country's second Growth and Transformation plan, the national grid coverage to rural towns increased to 55% in 2016 and the percentages of households in the country that actually connect to grid electricity also increased to 30% in 2016, which implies consistency of survey results with the government and international reports of access rate. The matched data also results in similar trends of business ownership and access to grid and off-grid electricity.

Figure-2: Business ownership and connection to electricity (Matched households, N=1487)

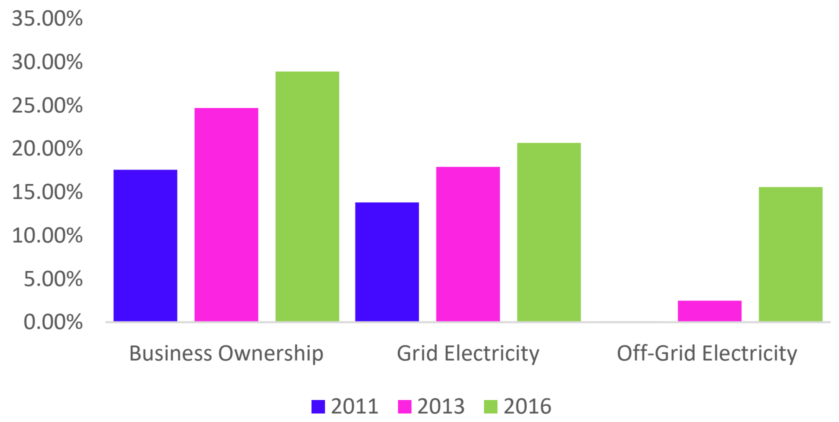

Table-4 shows the pooled descriptive statistics of the socio-economic characteristics of matched households using the three waves of survey data. As discussed above, there are about 1614 matched households with and without connection to electricity. The matching is done to create controls that are not systematically different with the treatment. As shown in table-2 above, the treatment and control variables are not systematically different at baseline (2011) with respect to socio-economic characteristics that are listed in Table-4. Overall, as shown in Table-4, on average about 23.7% of the matched households own a business and 17.4% of the matched households have access to grid electricity. On average, the household heads are 46.7 years old and have about two years of education. About 76.4% of them are married. The matched households have on average five household members, own about three Tropical Livestock

Units, and spend about 2720 ETB per month for consumables. At the community level, about 22.7% of the communities have access to microfinance. According to the 2015 World Bank Enterprise survey, lack of access to credit is one of the top ten constraining factors for running or opening a business in the country. In about 55% of the communities, there is seasonal immigration to the communities. The inflow of seasonal workers into the communities may motivate residents or others to open businesses such as restaurants, bars, and others.

Table-4: socio-economic characteristics (three waves)

VARIABLES	N	Mean	Sd.
Household level Characteristics			
Households that own business enterprises	4,842	0.237	0.425
Households connected to grid electricity	4,842	0.174	0.379
Grid and off-grid connection	4,842	0.235	0.424
Household head age	4,830	46.673	15.163
Household Head education level (in years)	4,842	1.939	3.963
Household Size	4,842	5.101	2.352
Marital status (1=married, 0=single)	4,815	0.764	0.425
Total household expenditure per month	4,838	2,720.60	2,762.16
Number of Livestock in TLU	4,817	3.180	3.524
Total hours of power outage in a week	1542	9.9	16.67
Community Level Characteristics			
Whether there is microfinance in the community (1=yes, 0=no)	4,842	0.227	0.419
Do people immigrate to the community for work? (= yes, 0=no)	4,842	0.549	0.498
Whether vehicles can pass through the village all year (1= yes, 0=no)	4,841	0.719	0.45
Price of kerosene per liter	4,718	19.685	19.415
Number of households	1614	1614	1614

5. Econometric Results

As discussed in the empirical strategy section, we estimate the effect of rural electrification on business creation using a difference in difference approach. Before we used the DID approach, we first created matched households using a propensity score matching method on the baseline data (2011). The difference in difference approach is applied on the 2011 and 2016 survey data for the long-run effect. We prefer to use these two sets of survey data rather than 2011 and 2013 or all three waves because the effect of the intervention is more likely to be visible if there is a large gap between the baselines and follow-up. However, to estimate the short-run effects of intervention, we also apply the DID on the 2011 and 2013 survey data. Further, in this section we include robustness and falsification tests of the estimated results. The robustness check is done by applying a non-linear probit random effect regression method, while the falsification test is done by running the difference in difference on an outcome variable that is logically unlikely to be related to rural electrification.

Before analyzing the DID results, the following discussion will give insight into what determines households' connection to electricity. The matching result of households' probability of getting connected to electricity is shown in Table-5.

Table 5: Matching regression result of connection to grid electricity

Variables	Coef.	Std. Err.
Age of the household head	-0.01	0.00
Marital status	0.26**	0.11
Education of the household head	0.04**	0.01
Total monthly expenditure	0.00***	0.00
Household size	-0.01	0.02
Price of kerosene	0.00	0.001
Whether vehicles pass through the community all the year	0.71***	0.11
Whether there is a microfinance service in the village (= yes, 0=no)	0.03	0.10
Do people immigrate to the community for work? (= yes, 0=no)	-0.30***	0.08
Constant	-1.54***	0.2
No. of observation	1487	

***= significant at 1% level of significance, **= significant at 5% level of significance and *=significant at 10% level of significance

The results shows that married households are more likely than unmarried households to be connected to electricity. This could be because married households are more likely to have their own house and more likely to care about their children's education. Households that have higher income or higher consumption expenditure also are more likely to be connected to electricity. The presence of other infrastructure such as all-season roads also increases the likelihood of community-level access to electricity.

Now, we discuss the long-run and short-run effects of connection to electricity on the operation of home-based businesses. Table 6 presents the long-run effect of connection to grid electricity. This long-run effect is estimated using OLS (Panel A), linear probability random effect (Panel B), and difference in difference estimates (Panel C). Because all these models are linear, the estimated coefficients are also marginal effects. Starting with the estimates of Panel A, i.e., pooled OLS estimates, connection to electricity in these rural areas is positively and significantly correlated with the rural households' operating home-based business enterprises. Quantitatively, this OLS results shows that rural households that are connected to grid electricity are about 27% more likely to open a business than are households that are not connected to grid electricity. However, because pooled OLS estimates do not control for the unobserved time-varying and time-invariant characteristics that may be correlated with the error term, the estimate is likely to biased. To control for the unobserved time-varying characteristics, we ran a random effect regression. Panel B shows the linear random effect estimate. Like the pooled OLS estimate, the random effect estimate is also positive and statistically significant; however, in terms of the magnitude of the estimate, the random effect estimate is about 11% lower than the OLS estimate, which implies that the pooled OLS estimate overestimates the true effect of electrification.

Table-6: The long run effect of rural electric grid connection on home-based business creation

	Panel A		Panel B		Panel C	
VARIABLES	Coef	se	Coef	se	Coef	se
Household level Connection	0.27***	0.02	0.24***	0.02	0.14***	0.04
Year	0.10***	0.02	0.10***	0.01	0.09***	0.01
Electricity # year					0.05*	0.03
Household head age	-0.00***	0.00	-0.00***	0.00	0.00	0.00
Household head education level (in years)	0.01***	0.00	0.01***	0.00	0.01**	0.00
Household size	0.02***	0.00	0.02***	0.00	0.01*	0.01
Marital status (1=married, 0=single)	-0.02	0.03	0.00	0.02	0.03	0.03
Total household expenditure per month	-0.00	0.00	0.00	0.00	0.00	0.00
Gender (1=female, 0-male)	-0.07***	0.03	-0.07***	0.02	-0.05	0.04
Whether there is microfinance in the community	0.10***	0.02	0.10***	0.02	0.02	0.06
Is there seasonal immigration to the community	0.03**	0.01	-0.01	0.02	0.00	0.03
Village dummies	YES		YES			YES
Constant	0.15***	0.03	0.19***	0.05	0.08	0.07
Observations	2,967		2,967		2,967	
R-squared	0.14		0.13		0.14	
Number of households	1487		1487		1487	

Panel A is Pooled OLS estimators, Panel B is linear random effect estimators and Panel C is DID long run estimators. SE is robust standard errors, ***= significant at 1% level, **= significant at 5% level, and *= significant at 10% level.

Although the random effect does control for unobserved characteristics, it does not remove the bias that comes from the correlation between households' connection to grid electricity and their unobserved characteristics (time-varying and time-invariant), such as individual households' motivation to get connected to grid electricity. Difference in Difference approaches reduce such bias by differencing out the unobserved time-invariant household characteristics.

The coefficient of the electricity variable in panel C is the estimated mean difference in business ownership between connected and unconnected households at the baseline (2011). It represents whatever baseline differences existed between the connected and unconnected groups. The estimated coefficient of this variable is positive and statistically significant at the 1% level of significance. This means that in 2011 households connected to grid electricity were 14% more likely to own business enterprises than households without electricity. If the electricity connection were introduced after 2011, the estimated difference could have been interpreted as a pre-existing difference that is not related to connection to electricity. But the treatment was introduced before 2011 and the estimated coefficient may also capture the effect of electricity and other factors.

Further, the coefficient of the year dummy variable reflects the expected mean change in the outcome variable between 2011 and 2016 among households without electricity. It reflects the effect of the passage of time in the absence of the treatment, i.e., in the absence of connection to electricity. The result shows that households' operation of business enterprises increased by 9% between 2011 and 2016 among households without a connection to grid electricity. This could be related to an improvement in access to other infrastructure such as road or finance in both groups (i.e treatment/connected and control/unconnected groups) of households.

The coefficient of the interaction term (Electrcity#year) is the difference in difference (DID) estimator. It measures the effect of grid electricity connection on rural households' operation of business enterprises. Accordingly, connection to grid electricity increased rural households of opening of business by 5%.

The short-run effect of access to grid electricity is shown in Table 7. Because the time gap between the baseline and follow-up is relatively short, the estimated DID coefficient is not statistically significant. This means that, in the short run, households' connection to grid electricity did not have a significant effect on business creation; however, in the long run (Table-6) rural electrification has a significant impact on firm creation.

Our results are consistent with literature on the impact of rural electrification in Africa. Using propensity score matching and firm-level data from Benin, Peters et al. (2011) found that electrification has a significant effect on firm creation. However, Lenz et al. (2017), using a DID approach and a three-year gap between the baseline and follow-up, did not find a change in the income-generating activity of households following electrification in Rwanda; the majority of households were found to be subsistence farmers both before and after electrification. This also consistent with our result that connection to grid electricity has no significant effect on business creation in the short run.

The results in Table-7 show the effects of connection to off-grid electricity and power outages. Off-grid electricity does not have a significant effect on the creation of home-based businesses in either the short- or the long-run. Households mainly use solar lanterns for lighting as an off-grid technology. These types of simple technologies do not have enough power to run a business such as a barber shop. The Ethiopia MTF baseline survey report showed that mini-grids are rarely used in rural Ethiopia. Table 7 also shows that the intensity of power outages does not have a significant effect on the creation of home-based businesses in the study area.

Table-7: DID estimate of effect of connection to electricity and power outages on enterprise creation

	Grid [short run]		Off grid [long run]		Outage (hrs.)	
	Coef.	Se.	Coef.	Se.	Coef	Se
Grid/Off grid Electricity	0.10***	0.04	-0.06	0.25		
Hours grid power outage in a week					-0.00	0.00
Year (2016)	0.06***	0.01				
Grid/Off grid electricity # year			0.09***	0.02	0.04**	0.02
Household head age	0.02	0.02	-0.02	0.24		
Household head education level (in years)	0.00	0.00	0.00	0.00	0.00	0.00
Household size	0.01**	0.00	0.00	0.00	0.00	0.00
Marital status (1=married, 0=single)	0.01	0.01	0.02**	0.01	0.01	0.01
Total household expenditure per month	0.05*	0.03	0.06	0.05	-0.16**	0.07
Gender (1=female, 0-male)	0.00*	0.00	0.00	0.00	0.00	0.00
Whether there is microfinance in the community	-0.00	0.06	0.01	0.06	0.12	0.15
Is there seasonal immigration to the community	-0.02	0.03	-0.03	0.11	-0.04	0.14
Constant	-0.03	0.02	0.03	0.10	-0.02	0.16
Observations	0.06	0.07	-0.13	0.14	0.41*	0.23
R-squared	2,958		2,483		649	
Number of households	0.08		0.11		0.05	
1,487 1,247		395				

*** p<0.01, ** p<0.05, * p<0.1

Robustness Check

We conducted a robustness check of our linear probit regression by running a random effects probit regression. Table-8 shows the random effect probit regression of the result of the effect of rural electrification on business creation. The table also shows the marginal effects of the estimated random effect regression coefficients. Like the coefficients estimated by linear random effects, the estimated coefficient is positive and statistically significant. In terms of magnitude, the marginal effect coefficient is not significantly different from the linear random effect coefficients, i.e., the two coefficients are comparable. This implies the robustness of our linear regression models.

Table-8: Random effect probit regression result of the effect of rural electric grid connection on business operation

	RE-Probit		Marginal Effect	
VARIABLES	Coef.	se	Coef.	Se
Electricity	3.16***	0.45	0.20***	0.03
Year	0.77***	0.14	0.04***	0.01
Household head age	-0.03***	0.01	0.00***	0.00
Household Head education level(in years)	0.11***	0.03	0.01***	0.00
Household Size	0.29***	0.07	0.01***	0.00
Marital status(1=married, 0=single)	-0.46	0.38	-0.02	0.02
Total household expenditure per month	0.00	0.00	0.00	0.00
Gender(1=female, 0-male)	-0.52	0.40	-0.03	0.02
Whether there is microfinance in community	1.50***	0.45	0.08***	0.02
Seasonal immigration to comm. (1=yes, 0=no)	-0.02	0.32	0.00	0.02
logarithm sigma square	3.41***	0.10		
Constant	-4.43***	0.79		
Observations	2,921		2,921	
Number of households	1,471		1,471	

As shown in tables-6-8, in addition to electric grid connection, there are other socio-economic characteristics that have significant impact on rural households' operation of business enterprises. Households' education, income (expenditure) and access to credit are positively correlated with households' opening of business enterprises in rural areas.

Falsification test

Many observational studies conduct falsification tests to re-affirm the results. The falsification test is also a means of testing the quality of data used for the study. It may be the case that the data generates statistically significant coefficients for spuriously correlated variables. A falsification hypothesis is a claim, distinct from the one being tested, that researchers believe is highly unlikely to be causally related to the treatment in question. However, one must be careful in interpreting the absence or presence of an implausible association between variables. The absence of implausible falsification hypotheses does not imply that the primary association of interest is causal, nor does their presence guarantee that real relationships do not exist. However, when many false relationships are present, caution is warranted in the interpretation of study findings (Prasad and Jena, 2013).

Table-9: Falsification test: DID estimate of effect of electricity connection on livestock ownership

VARIABLES	Coef	Se
Electricity	-0.28	0.18
Year	-0.19***	0.07
Electricity #year	0.07	0.13
Household size	0.05	0.05
Household expenditure	0.00	0.00
Household age	0.02**	0.01
Land size (in hectare)	0.47***	0.13
Gender (1=female, 0-male)	-0.18	0.33
If the household face livestock's death shock	-0.29	0.29
Constant	1.78***	0.66
Observations	2,824	
R-squared	0.03	
Number of households	1,487	

*** p<0.01, ** p<0.05, * p<0.1

In this study, we used rural households' ownership of livestock measured in TLU for the falsification test. In rural areas, households' ownership of livestock does not directly depend on whether the household is connected to electricity. It depends on the household's land size, as larger farmland means more animal fodder. It also depends on the households' wealth (income), household head's age, household head's gender, whether the household faced a livestock death shock, etc.

Table-9 shows the DID estimation of the effect of household electric grid connection on livestock ownership. The result shows that household connection to electricity is insignificantly related to number of livestock the household owns. Unlike the results in Tables 6 and 7, the coefficients of the electricity variable, the year dummy, and the interaction variables are all statistically insignificant. The estimated coefficients of the electricity variable imply that, at the baseline (2011), there is no statistically significant estimated mean difference in the number of livestock between households connected and unconnected to grid electricity. Further, the estimated result of the year dummy is interpreted as the absence of a statistically significant difference in the number of livestock between 2011 and 2016 among households without electricity. The fact that the size of the livestock holding is not significantly increased between 2011 and 2016 is consistent with the government's zero grazing policy. Rural households were advised feed their cattle at home and were advised to have a small number of cattle.

The result of the interaction coefficient shows that household connection to electricity is insignificantly related to the number of livestock the household owns. These falsification results imply that the results shown in Table-3 are not spurious.

6. Conclusions

Better access to electricity is a prerequisite for any country's structural transformation and transition to higher economic and societal development. In the information age, almost every human activity requires access to electricity. In this regard, Ethiopia has been undertaking remarkable development in its electric sector since 2000. A significant number of rural towns are now within the national grid and significant percentages of rural households are connected to grid electricity. Of the multiple potential benefits of creating access to electricity in rural areas, the creation of non-agricultural business enterprises is one, because such enterprises provide opportunities for alternative income generation activities outside agriculture. Although there is a growing body of literature on the impact of electrification in general and rural electrification in particular, we found little research on the impact of rural electrification on enterprise creation in Ethiopia.

This study uses the 2011 and 2016 the World Bank's Living Standard Measurement Survey to study whether households' connection to grid electricity has helped them to start business enterprises. Originally, the Ethiopian World Bank's Living Standard Measurement Survey was conducted in three waves, 2011, 2013 and 2016. Because the time gap between 2011 and 2013 is relatively short for impact assessment, we used the 2011 and 2016 surveys to have a relatively large time gap for the impact assessment.

Methodologically, we used a Difference-in-Difference approach. The DID approach is used to remove preexisting differences between treatment and control households. The method is best when the treatment is randomly assigned. However, communities were not randomly selected to get access to grid electricity, and there is self-selection into household-level connection, which violates the balance requirement of the DID approach. Hence, before we applied the DID approach, we created control households that are not systematically different from the treated households, using Kernel propensity matching method. Households are matched using the baseline data (2011).

Using the above methods, the estimated result shows that households' operation of business enterprises increased by 9% between 2011 and 2016 among households without connection to electricity, whereas connection to grid electricity increased rural households' operation of businesses by 5%. However, the effect is insignificant in the short run. Off-grid electricity does not have a significant impact in either the short or the long run.

The validity of our main result is checked using robustness and falsification tests. The robustness check is done using random effect probit results. In terms of magnitude, the marginal effect coefficient of the random effect probit is not significantly different from the linear random effect coefficients, i.e., the two coefficients are comparable. This implies the robustness of our linear regression models.

Falsification tests are done to test the quality of the data used for the study. This is done by setting up a hypothesis where the treatment variable is not causally or theoretically related to a selected outcome variable. We did the falsification test by running a DID regression of the effect of electrification on the quantity of livestock that rural households own. We find an insignificant effect of households' connection to grid electricity, which implies that our result is not spurious.

The findings of this study are relevant from policy aspects. They have implications for the country's second Growth and Transformation Plan, which aspires to transform the country's agriculture-dominated economy into an industrial economy. If the government wants to speed up this structural transformation, rapid expansion of electricity is one of the key elements of infrastructure that should receive investment in the rural areas. If such electricity is generated from renewable energy sources, these efforts can simultaneously reduce greenhouse gas emissions.

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Appendix

Table-A1: DID estimate of effect of access to electricity and power outage on enterprise creation (All waves combined)

VARIABLES	Coef	se
1.electrcity_grid	0.12***	0.03
2013	0.06***	0.01
2016	0.09***	0.01
Electricity#2013	0.02	0.02
Electricity#2016	0.05*	0.03
Household head age	0.00	0.00
Household Head education level (in years)	0.01***	0.00
Household Size	0.01**	0.00
Marital status (1=married, 0=single)	0.02	0.02
Total household expenditure per month	0.00	0.00
Gender (1=female, 0-male)	-0.02	0.03
Whether there is microfinance in the community (1=yes, 0=no)	-0.01	0.03
Is there seasonal Immigration to the community (1=yes, 0=no)	-0.01	0.02
Constant	0.11**	0.05
Observations	4,438	
R-squared	0.10	
Number of household_id	1,487	

*** p<0.01, ** p<0.05, * p<0.1