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How does energy matter? Rural electrification, entrepreneurship, and community development in Kenya

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ABSTRACT

We examine the impact of rural electrification on individuals and businesses within a community in order to test a resource-based theory of entrepreneurship. We show that access to electricity increases average households' income and entrepreneurial activities. The impact of electricity on entrepreneurial activity has wide-ranging implications for development policy in countries where access to electricity is sparse. Results show a significant difference in entrepreneurial opportunities with respect to firm formation, with the electrified site reporting more new micro-enterprises (33) than the control site (20) after implementation. Electrification affects both households' income, individuals' perceptions of their social position, and opportunities for business development. Individuals' future expectations and entrepreneurial activities are enhanced in the community that receives electricity. We also find evidence that women-led households benefit from electrification more than men-led ones, but this benefit does not eliminate the difference in income between women and men-led household. We discuss implications of the study for entrepreneurship and community social development interventions.

1. Introduction

Poverty persists in many parts of the world, particularly in Sub-Saharan Africa, where the majority of people live on an income of less than $2 per day, and entrepreneurship in the form of microenterprise development is seen as a key tool in the fight against poverty (Bruton et al., 2013; George et al., 2016; Khavul and Bruton, 2013). Innovative schemes are now being tested, for example, cash transfers that provide people in poverty with cash they can spend without any restrictions, with a goal to encourage investment in income-generating opportunities. The intuition behind such schemes is that those in situ know their opportunities best. The provision of resources better allows individuals to act to improve their situation than schemes elaborated by policymakers or international agencies. In parallel, research has found that infrastructure is a major constraint to firm performance (Harrison et al., 2014) and development in Africa. Thus, scholars have suggested that providing infrastructure facilities such as electricity and roads may have a great impact on poverty alleviation (Parikh et al., 2015; Rud, 2012).

In a comprehensive 17-year study of village-level effects of electricity in India, van de Walle et al. (2016) found that electrification brought significant consumption gains for households who acquired electricity for their own use. They also found evidence of a dynamic effect of village connectivity for households without electricity. Khandker et al. (2012) used household survey data from India and found that rural electrification improves labor supply, education opportunities, and general welfare of the electrified communities. Labor-productivity improvement, especially for women, has been found in other contexts, including Niacaragua and India (Grogan and Sadanand, 2013; Khandker et al., 2012; van de Walle et al., 2016). By contrast, evidence on the effect of electrification on microenterprise business creation or growth is limited. For example, in rural Benin, Peters et al. (2011) found that despite labor-productivity improvements after electrification, microenterprises performed no better than their counterparts in non-electrified regions. This "electrification trap," they suggest, requires more careful analysis. Hence, the focus of this study is on the provision of electricity in rural Kenya to analyze the impact of rural electrification on entrepreneurship and community growth.

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Three decades ago, Low and MacMillan (1988) identified process, context, and outcomes as the three elements indispensable to an understanding of entrepreneurship. Tremendous progress has been made since in our understanding of each of these elements; however, the subject of how entrepreneurs use specific types of resources, namely, infrastructure, to pursue entrepreneurial ventures has received less attention. This lack of focus on infrastructure is not surprising, because most entrepreneurship research has focused on the developed world, where access to infrastructure such as broadband, roads and railways, and electricity are a given. One notable exception is the work of Audretsch et al. (2015) on infrastructure and entrepreneurship. They specifically study the impact of highways, railways and broadband on the regional rate of entrepreneurship in Germany. This work provide support for the role of infrastructure in entrepreneurship. However, it's macro nature leaves mechanisms that explain how infrastructure leads to entrepreneurship at the individual level unexplored. This is where our study contributes. To understand infrastructure's influence on entrepreneurship and development, one needs a context where infrastructure provision is not a given. This question is an important one because knowing about the effect of infrastructure provision is crucial for local and national governments in developing countries when making policy decisions about resource allocation.

In this study, we empirically examine the impact of electricity provision on the local business community and households in a village in rural Kenya. We designed this study uncover the effect of rural electrification on entrepreneurial activities and households' outlook. We selected two villages that are similar in demographics and size in rural Kenya. We surveyed all businesses and all households in these communities prior to electrification, hereafter "baseline." Following this first survey, we provided one community with electricity, through the installation of a solar micro-grid at the trading center of this community. As a result of the installation of the micro-grid, members of this community could access services requiring electricity, such as lighting and phone charging. We surveyed all businesses and all households again two years after the electrification effort, hereafter "follow-up," in order to understand the effect of electrification on businesses and the community. This design allows us to compare the development path of the two communities to assess the impact of electricity.

Our results show electrification affects community development: both businesses and households benefit from the provision of electricity. Specifically, electrification increases both opening hours for businesses and diversification in offerings. With respect to households, electricity increases optimism about future income and individuals' perception of their social standing. This study contributes to the existing literature on rural electrification and entrepreneurship in two main ways. First, the existing literature on rural electrification has focused on the impact and benefits to households and community welfare, for example, education and health (Barnes et al., 2002; Bernard, 2012; Gustavsson, 2007; Gustavsson and Ellegard, 2004; Wamukonya and Davis, 2001), whereas research on the benefits of rural electrification to businesses has received limited attention (Peters et al., 2011; Rud, 2012; Schillebeeckx et al., 2012). While rural electrification efforts continue, scholars have noted the link between energy supply and income generation is still lacking (Kooijman-van Dijk, 2012). In other words, our knowledge of ways in which energy supply facilitates income generation, entrepreneurship, and community development remains relatively underexplored. We contribute to the rural-electrification literature by providing empirical evidence of the link between energy supply and income generation through microenterprises. Second, emerging economies have been described as possessing distinctive characteristics with respect to their historical development,

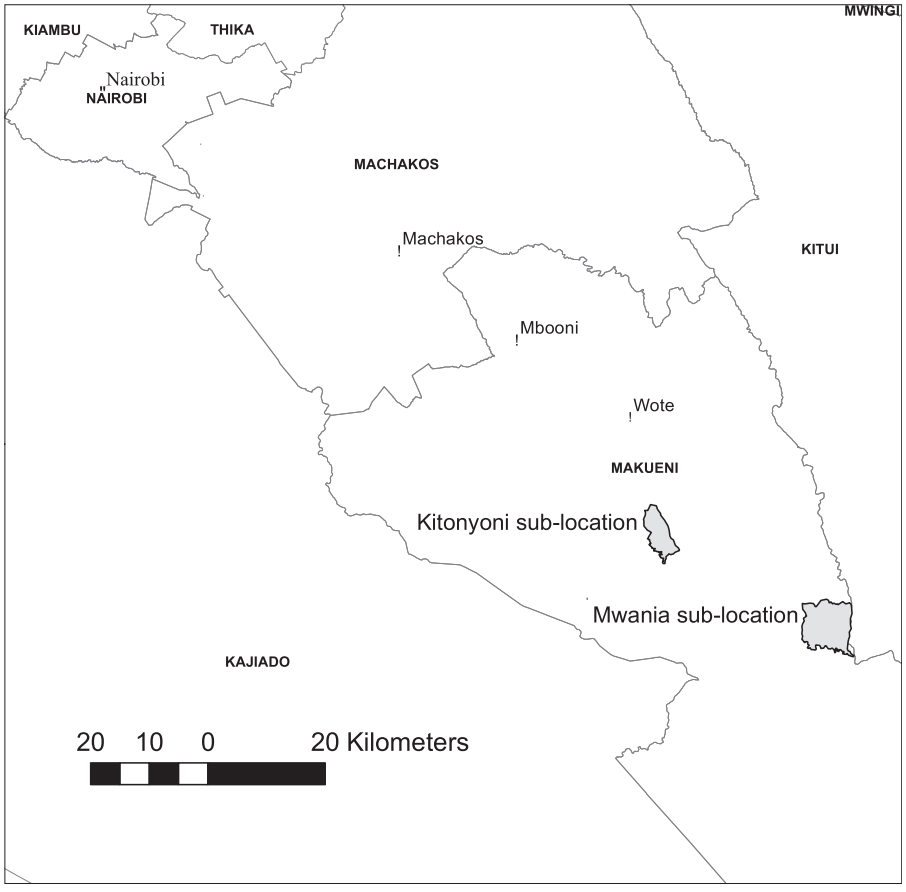

Fig. 1. Map of Makueni County.

economic development, political systems, capital markets, skilled labor, infrastructure, and environmental munificence, making them unique research grounds (Blattman et al., 2014; Bruton et al., 2008; DeMel et al., 2008). Entrepreneurship is recognized as key to economic development. Although the literature on the provision of microfinance capital for enterprises is growing, how the provision of key infrastructure (i.e., rural electrification) affects development in these settings remains underexplored (Peters et al., 2011; Rud, 2012). Our study explores the effect of infrastructure provision on the general outlook of a community and perceived well-being of community members.

2. Research site

The project was funded by the UK's Engineering and Physical Sciences Research Council (EPSRC) in partnership with the Department for International Development (DFID) under a grant for the implementation of a solar energy rural-electrification project in Kenya (EP/G06394X/1). The data used in this study was collected as part of this larger research project on rural electrification in the communities of Mwania and Kitonyoni, sub-locations in Makueni County, Kenya (Fig. 1). To be included in the project, the selected communities had to fulfil the following conditions: be densely populated, have no electricity, and have a trading center, school, and health clinic. In addition, these two communities needed to be similar in terms of size and socio-economic status. The constraints of the project only allowed us to conduct the research in two communities, and the chosen communities were the most suitable we could identify.

The E4D project implemented an off-grid electricity project at Kitonyoni's trading center in 2012 while Mwania remained as the control site with no electricity. In this paper, we refer to Kitonyoni as the experimental community and to Mwania as the control community. This solar electrification project provides electricity directly to more than 40 businesses at Kitonyoni trading center, the council building/Assistant Chief's office, a school, and a health center. Following electrification, households within the experimental community have benefited from the E4D project through charging electrical devices such as lanterns and mobile phones at businesses that are connected to the micro-grid.

Baseline data was collected from households, entrepreneurs, health clinics, and schools in both the experimental and control communities between March and May in 2011 (before electrification), whereas follow-up data was collected between June and August in 2014 (two years after electrification of the experimental community). To assess the robustness of our setting, we ran some tests on key variables using the baseline data. We used the following variables to evaluate the extent of similarity in basic characteristics of households in these the two communities before implementation of electrification: gender, age, and basic concerns. Basic concerns measure the extent to which the household head is concerned about providing for the basic needs of the household for the next 12 months and was measured on a 4-point Likert scale (1 = *very concerned*, 4 = *not concerned at all*). We used an F-test for gender and basic concerns, and a *t*-test for age. Our results reveal no significant differences (at the 0.05 level) between the two communities at the start of the experiment (Table 1). This similarity makes us confident that the households in the two communities were similar prior to electrification.

For the business survey, we tested for similarity of characteristics of entrepreneurs and their businesses, using entrepreneurs' age, marital status, number of children, access to electricity (prior to the installation of the micro-grid, some entrepreneurs accessed electricity, mainly through fuel generators), daily income at wave 1, daily expenditure at wave 1, daily profits at wave 1, and the proportion of customers from outside the village. The results of our analysis of the baseline survey show no difference between the entrepreneurs in both communities in terms of age, marital status, number of children, and access to electricity (Table 2). The results further reveal no significant difference among businesses in both communities with respect to the proportion of customers from outside their communities, daily income, daily expenditure, and daily profits from their businesses before the installation of the microgrid (Table 3).

In this setting, we can assess the effect of electricity through *t*-tests and F-tests to measure the differences between the two communities or between each wave of data in each community. In addition, we can perform difference-in-differences analysis to understand how electricity

Table 1
Ex-ante similarity in household survey between the experimental (Kitonyoni) and control (Mwania) villages.

		Kitonyoni	Mwania	Fisher/*t*-test p value
Gender	Male	1260	1605	0.734
	Female	1375	1720	
Age	Household age	24.391	24.035	0.551
Concerns	Very concerned	353 (74%)	435 (74%)	0.076*
	A little concerned	80 (17%)	100 (17%)	
	Not too concerned	17 (3.5%)	34 (6%)	
	Not concerned at all	27 (5.5%)	18 (3%)	

*p < 0.1, **p < 0.05, ***p < 0.01. N = 1064 households, 477 in Kitonyoni and 587 in Mwania (3 households have been omitted due to missing data on some variables). For gender and age, N = 5960 as all individuals within a household are captured.

Table 2
Ex-ante similarity in business survey between the experimental (Kitonyoni) and control (Mwania) villages.

		Kitonyoni	Mwania	Fisher test/*t*-test p value
Marital Status wave 1	Single	3	3	1
	Married	24	21	
Age wave 1		37.04	38.88	0.625
Number of children wave 1		3.56	4	0.623
Access to electricity in wave 1		0.19	0.24	0.638

*p < 0.1, **p < 0.05, ***p < 0.01. N = 53. There was 1 non-response on this question among the entrepreneurs interviewed in Mwania.

Table 3
Variation in entrepreneurial opportunities and outcomes in the experimental and control villages.

		Kitonyoni	Mwania	Fisher test/*T* test p value (two-tailed)
Entrepreneurial Opportunities				
Firm older than 2 years in 2014	No	33	20	0.034**
	Yes	14	22	
Number of business activities in 2012		1.46	1.37	0.59
Number of business activities in 2014		1.55	1.83	0.132
Number of extended hours of operation in the past 2 years		3.88	2.16	0.03**
Entrepreneurial outcomes				
Daily income at wave 1		1474.444	721.6	0.366
Daily income at wave 2		2711.702	1000	0.004***
Daily expenditure at wave 1		1255.556	528.6	0.295
Daily expenditure at wave 2		2235.106	513.095	0.002***
Daily profit at wave 1		343.704	193	0.351
Daily profit at wave 2		476.6	753.57	0.13
Customers from village (%) at wave 1		82.593	80.08	0.648
Customers from village (%) at wave 2		67.708	85.952	0***
Self-rated performance at wave 2		3.184	3.473	0.058*

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

provision changed the development trends in the treated communities by comparison to the control site.

Nearly all businesses at the Kitonyoni and Mwania trading centers are microenterprises operating informal activities such as selling vegetables, grains and fruits, general groceries, hair dressing, restaurants and cafés, bars, dress-making/tailoring, m-pesa (money-transfer service), mobile phone charging, computer services, and video shows. These businesses are open throughout the day, serving customers as they come and go. Given that most people work during the day, activity at the trading centers tends to be low during the day and concentrated in the evenings when customers are on their way home from their daily activities. For this reason, electricity provision has the potential to benefit businesses by allowing them to stay open later because electric light is available. At both centers, Saturdays tend to be busy throughout the day because most customers have more time to do their shopping then. The trading centers, therefore, are an important part of the life of the community, providing not only the day-to-day household essentials and services, but also entertainment and socialization through video shows, bars, and restaurants.

Business researchers (Shane and Venkataraman, 2000; Shane, 2003) have identified the discovery and exploitation of entrepreneurial opportunities as key to the entrepreneurial process. In this study, we postulate that the electrification process leads to the discovery and exploitation of entrepreneurial opportunities that did not exist previously. Electricity facilitates development and technological changes, because most equipment requires electricity to operate (Kooijman-van Dijk and Clancy, 2010). As a result, we expected the experimental community to exhibit more entrepreneurial opportunities than the control community. Indeed, due to access to electricity, the experimental community discovered and/or exploited new business opportunities, for example, mobile phone and battery charging, the ability to show videos, hair salons and barbers, and posho mills, among others. The new opportunities have led to greater diversification of activities by existing firms and/or the creation of new businesses. Additionally, in rural areas, electricity facilitates entrepreneurial processes by enabling business owners to extend their working hours due to improved lighting, and facilitates the operation of activities such as cooking, ironing, and tailoring, thus facilitating the production of goods (Bastakoti, 2003; Neelsen and Peters, 2011).

In this study, we investigate the facilitative role of electricity in the generation of entrepreneurial opportunities and subsequent entrepreneurial outcomes. We compare data from households and business owners in the electrified and the non-electrified communities to understand whether and how electricity changed the development path of the treated community. We present the data and results in two parts: The first part focuses on our survey of businesses, and the second part relates to our survey of households.

3. The business survey

3.1. Sample and data-collection procedures

Data for this paper come from a larger research project on rural electrification in the communities of Mwania and Kitonyoni, Makueni County, Kenya (Fig. 1). The data was collected at two time periods: between March and May in 2011 (before electrification) and between June and August in 2014 (2 years after the electrification of the experimental village). Our setting allows us to test for the effect of electrification by observing changes (a) before and after electrification and (b) between the electrified and non-electrified communities.

Data for the business survey was gathered through face-to-face interviews with business owners at the experimental and control sites using a semi-structured questionnaire administered by four trained research assistants. Given the small number of businesses at the data-collection sites, we opted to interview all business owners at the two trading centers. During the baseline data collection in 2011, we interviewed 27 businesses in the experimental community and 25 in the control community. In the follow-up data collection, in 2014, after two years of operation of the micro-grid, we interviewed 48 respondents in Kitonyoni's trading center alone, and 42 within Mwania's trading center and its surroundings. Thus, we interviewed a total of 52 respondents for the baseline and 90 respondents for the follow-up. The increase in the number of interviews during the follow-up reflects the net growth in the number of businesses in both communities.

3.2. Measures

To examine the influence of electrification on business development, we use a number of key variables, namely, access to electricity, entrepreneurial opportunities, extended working hours, and entrepreneurial outcomes. Below is a description of how we measured our key variables.

3.2.1. Access to electricity

We used a dummy variable to indicate whether the entrepreneur had access to electricity (1 if the entrepreneur has access to electricity and 0 otherwise).

3.2.2. Entrepreneurial opportunities

Using Shane's (2003) proxy, we measured the existence of entrepreneurial opportunities by firm formation. Hence, we counted the number of new firms created in both research sites after the installation of electricity at the experimental site, that is, all firms that were up to two years old at the time of the survey. We also included an additional variable, business diversification (measured as a count of the number of different business activities undertaken by each entrepreneur), to capture the diverse entrepreneurial opportunities that are exploited in the research sites.

3.2.3. Extended working hours

To measure extended working hours following electrification, we asked respondents to indicate the number of extended business opening hours per day compared to two years ago (before electrification of the trading center). The electrification of the trading center gives access to electrical lighting, allowing businesses to reach more customers and expand. Measuring extended working hours allows us to check whether businesses took advantage of this opportunity.

3.2.4. Entrepreneurial outcomes

A common way to measure entrepreneurial outcomes is to analyze firm performance. Given the difficulty of getting performance data from small firms, we decided to use various performance proxies, particularly financial measures (amount of daily income, daily expenditure, and daily profit in Kenya shillings), self-rated performance (where respondents rated their average performance in comparison to their three most important competitors on a 5-point scale [1 = *much lower*, 5 = *much higher*] on various firm outputs), and the proportion of customers from within and outside the village (reflecting the ability to attract and serve customers from different places).

3.3. Results of business survey

Our descriptive statistics (Table 4) reveal overall low correlations between location and our variables of interest (-0.26 to 0.31). The rest of the correlations among variables show low to moderate correlations, with the exception of age and number of children (0.81) and expenses and income (0.96), both of which are expected to be highly correlated. To test the impact of electricity on business outcomes, we perform two types of analysis: (a) *t*-tests and F-tests to compare the differences between our two communities at baseline survey and endline, and (b) difference-in-differences regression analysis to estimate the effect of electrification on the experimental community. The rationale behind

Table 4
Descriptive statistics for the business survey.

	Mean	S.d	Min	Max	1	2	3	4	5	6	7
1. Location	1.48	0.50	1.00	2.00							
2. Age	36.93	11.78	18.00	70.00	0.17*						
3. Marital Status	1.17	0.43	1.00	3.00	−0.12	−0.21*					
4. Children (count)	3.50	2.89	0.00	16.00	0.14	0.81***	−0.21*				
5. Local customers (%)	78.02	18.38	6.00	100.00	0.31***	0.09	0.03	0.07			
6. Income	1637.68	3034.52	50.00	21,000.0	−0.23**	−0.11	0.07	−0.16	−0.13		
7. Expenses	1254.02	2712.57	0.00	18,000.0	−0.26**	−0.08	0.07	−0.14	−0.14	0.96***	
8. Profit	408.08	814.52	−5600.0	3500.00	−0.03	−0.12	0.02	−0.12	−0.05	0.51***	0.26**

*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

difference-in-differences analysis is to assess how the path of change of a community has been influenced by the treatment applied to it (Gelman and Hill, 2007). To measure the effect of electricity provision in a reliable way and be able to make causal statements, we use the control community as a counterfactual. Thus, we assume the difference in the two communities should remain sensibly the same if the intervention has no effect. If that difference changes, we can be confident the change is an effect of the intervention, because of our study design.

We examine whether electrification results in significant variation in entrepreneurial opportunities. Comparing the experimental and control sites, results (Table 3) show a significant difference ($p < 0.05$) in entrepreneurial opportunities with respect to firm formation, with the experimental site reporting more new firms (33) than the control site (20) after the implementation of electrification. We find no significant difference between the two sites for business diversification.

A key input in the entrepreneurial process that is facilitated by electricity is the number of operating hours. Our results indicate respondents in the experimental community significantly ($p < 0.01$) extended their working hours by an average of 3.88 h per day after electrification compared to the control site (2.16 h per day).

We investigated a number of entrepreneurial outcomes: amount of daily income, daily expenditure, and daily profit in Kenyan shillings, self-rated performance, and proportion of customers from within the village. Following electrification of the experimental site, daily income was significantly higher in the experimental community (KSh 2712 vs. KSh 1000, $p < 0.01$) and daily expenditure was higher in the experimental community (KSh 2235 vs. KSh 513, $p < 0.01$). We find no significant difference for daily profits between businesses in the two communities ($p > 0.1$). These results are also shown in Fig. 2. The difference-in-differences analyses of differences in income, expenses, or profit, however, do not show any significant change in the trajectory of businesses in the treated community compared to the control community between the two waves of the survey (Table 5). All the models control for the age of the respondent, the number of children, and marital status.

The proportion of customers from the village was lower in the experimental community (68% vs. 86%, $p < 0.01$). The difference-in-differences results (Table 5) indicate a significant change in the proportion of local customers served by respondents in both communities, with the experimental community serving significantly fewer local customers than the control community at wave 2 ($p < 0.001$). These results reveal the businesses at the experimental community were able to attract more distant customers than the businesses in the control community.

People in the experimental community rated their performance higher than in the control community (3.47 vs. 3.18, $p < 0.1$). We were not able to conduct difference-in-differences analyses for self-rated performance, because we did not ask this question during the baseline survey.

Furthermore, we explored differences in income, expenses, and profit at wave 2 between businesses that were older than two years and businesses that were younger than two years (new firms) across the two research communities (Table 6) and also only in the experimental community (Table 6). Overall, we find no differences in entrepreneurial outcomes between older and newer businesses in both communities (Table 6). Nevertheless, when we restrict ourselves to the experimental group, we find that older businesses reported significantly higher income and expenses at wave 2, but no statistically significant differences in profit (Table 6).

These results offer a nuanced view of the effect of electrification on businesses. Electricity seems to help attract more distant customers; however, this ability does not translate into higher profits, perhaps because electricity favors growth in both turnover and expenditures. Two years might also be too short a period to detect increased profits if businesses are still amortizing the costs of their electricity-powered equipment.

4. The household survey

4.1. Sample and data-collection procedures

The household survey utilizes data from the same research project on rural electrification in the communities of Mwania and Kitonyoni, Makueni County, Kenya. Data was collected from all households in the experimental and control communities through two waves of surveys: between March and May in 2011 (before electrification) and between June and August in 2014 (2 years after electrification). The first survey, referred to as the baseline survey, was administered to all the households in both communities through face-to-face interviews in order to gather information on the socio-economic well-being of the households before electrification. We did not interview all households during the second survey, referred to as the endline survey, due to the failure to track some households (e.g., because they had moved outside the community). We interviewed about 92% as many households in the endline survey as in the baseline survey. The baseline survey was administered by 10 trained research assistants, whereas the endline survey was administered by 12 trained research assistants. During the baseline survey, we completed 1067 household surveys: 479 in Kitonyoni (the experimental community) and 588 in Mwania (the control community). During the endline survey, we completed 982 surveys: 461 in Kitonyoni and 522 in Mwania.

4.2. Measures

To analyze the impact of electrification on households within the experimental community, we use the following key variables: total monthly income of the households, household position on the social ladder, financial situation in the past three years, projected financial situation, basic concerns, and life satisfaction. We measure the total monthly income of the households in the two communities before and

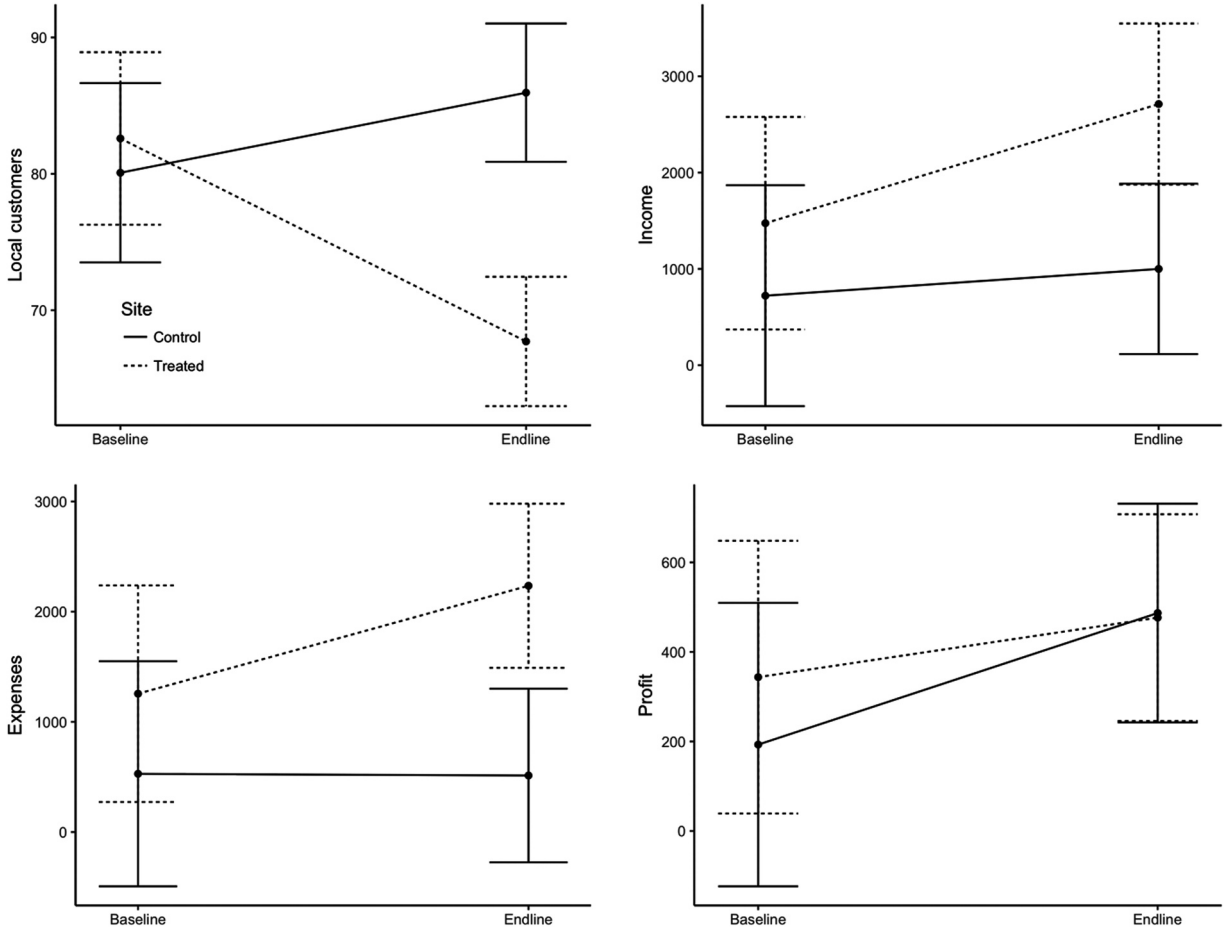

Fig. 2. Differences between businesses in the treated and control site in the two surveys: percentage of local customers, income, expenses and profit.

Table 5
Difference-in-differences between Kitonyoni and Mwania, Business Survey.

Dependent variable	**Income**	**Expenses**	**Profit**	**Local Customers**
Wave 2	221.535	−69.289	290.594	6.261
	(770.176)	(685.545)	(213.141)	(4.363)
Location (Kitonyoni)	770.038	773.640	134.737	1.644
	(854.254)	(760.385)	(236.410)	(4.839)
Age	22.918	30.533	−4.307	0.113
	(37.846)	(33.687)	(10.474)	(0.214)
Number of Children	−211.529	−203.880	−14.584	0.212
	(155.721)	(138.610)	(43.095)	(0.882)
Single	−186.327	−206.577	13.040	10.401**
	(843.310)	(750.642)	(233.381)	(4.777)
Widowed	621.462	759.556	−159.221	−4.824
	(1793.863)	(1596.744)	(496.440)	(10.162)
Differences-in-differences	832.892	884.763	−180.227	−20.009***
	(1070.611)	(952.967)	(296.285)	(6.065)
Constant	721.821	198.328	423.500	73.762***
	(1262.032)	(1123.353)	(349.259)	(7.149)
N	137	137	137	137
R-squared	0.088	0.095	0.032	0.200
Adj. R-squared	0.039	0.046	−0.021	0.157
Residual Std. Error (df = 129)	2984.776	2656.793	826.018	16.909
F Statistic (df = 7; 129)	1.780*	1.944*	0.602	4.613***

*** p < 0.01.
** p < 0.05.
* p < 0.1.

after the introduction of electricity by adding up monthly income of all members of a household.

With respect to household position on the social ladder, in order to estimate individuals' perception of their relative situation, we asked them to situate their position on a 10-step social ladder. In aggregated form, this measure provides an average of the perception of relative position in the community. We measured respondents' financial situation in the past three years by inquiring whether the situation had become worse or better on a 5-point Likert scale (1 = *improved a lot*, 5 = *deteriorated a lot*). Before analysis, we inversed this variable, so a higher number means greater well-being. To measure respondents' projected financial situation, we asked them to indicate on a 5-point Likert scale how they expected their financial situation to evolve in the next 12 months (1 = *improve a lot*, 5 = *deteriorate a lot*). We measured basic concerns of respondents using a 4-point Likert scale (1 = *very concerned*, 2 *a little concerned*, 3 = *not too concerned*, 4 = *not concerned*

Table 6
Difference in income, expenses and profit between businesses that are older or younger than 2 years.

	More than 2 years old businesses	Less than 2 years old businesses	p.value
Mwania			
Daily income at wave 2	2694.29	1416.98	0.091*
Daily expenses at wave 2	2222.86	920.75	0.064*
Daily profit at wave 2	471.43	496.23	0.915
Kitonyoni			
Daily income wave 2	5538.46	1678.79	0.034**
Daily expenses wave 2	4823.08	1283.33	0.028**
Daily profit wave 2	715.38	395.45	0.157

* $p < 0.1$.
** $p < 0.05$.

at all) to indicate the extent of their concerns about providing basic necessities (food and other essential items) for their household in the next 12 months. The final variable, life-satisfaction, measured the extent to which respondents were satisfied with their life on a 5-point Likert scale (1 = *very unsatisfied*, 5 = *very satisfied*). We distinguish Kitonyoni and Mwania locations using a dummy variable (1 for Kitonyoni and 0 for Mwania).

In addition, we run analyses that use data from households matched in both waves of the survey to analyze whether electrification reduces gender inequalities regarding income. We use the total monthly expenditure of the household, the number of days worked by the household head in the previous year, age of the household head, education (a dummy equal to 1 if the household head attended school at all), whether the household head has ownership of the deed for his or her land, the total number of children in the household, and the distance to the village center in kilometers.

4.3. Results of household survey

Our descriptive statistics (Table 7) reveal low correlations between location and the rest of the variables (-0.07 to 0.15). The remaining correlations are moderate (-0.33 to 0.65). To test the impact of electricity on households, we perform difference-in-differences regression analysis. The results of our difference-in-differences regression approach (Table 8) help us characterize the changes brought about by the electrification project to households in the experimental community. All models include the following controls: whether the household head has ownership of the deed for his or her land, whether the household purchases most of its items from the business center in the community (either in Mwania or in Kitonyoni), whether the household has a bank account, whether the household head runs a business he or she owns, and whether the household receives any money transfer from family members living in a city. Finally, we also control for the gender of the respondent and his or her relation to the household head. With regard to social-ladder position, our analysis shows that whereas the experimental community trailed the control group on that dimension at the baseline survey, it was significantly ahead of the control community after the introduction of the electricity with a difference-in-differences of 0.375 ($p < 0.05$) (Table 8). With regard to respondents' financial situation in the past three years, though the experimental community trailed the control group on that dimension in the baseline survey, it was significantly ahead of the control community after the treatment (difference-in-differences of 0.596, $p < 0.01$).

For the financial outlook for the next 12 months, the experimental community went from trailing behind the control community to being slightly ahead of it with a difference-in-differences of 0.775 ($p < 0.01$). With regard to basic concerns, we find no significant differences between the two communities (difference-in-differences = −0.061, *NS*). With life satisfaction, the perception of the treated community changed significantly between the baseline and the endline. Life satisfaction of the experimental community went from being lower than that of the control community during the baseline survey to being higher at the endline survey (difference-in-differences = 0.358, $p < 0.01$). In terms of total income, our results reveal no significant difference-in-differences between the two communities at the baseline survey and endline survey (difference-in-differences = 664.5, *NS*). These results are shown in Fig. 3 for ease of interpretation.

These results reveal that at the household survey, electrification seems to have shifted the perception of individuals significantly on a number of dimensions. Respondents in the experimental community positioned themselves as better off on the social-ladder scale. They were also more positive about their financial situation over the past three years and the coming year. The experimental community also reported higher life satisfaction. Electrification seems to have increased optimism in the community, despite the fact that we detect no significant shifts in relative income between the two communities.

Table 7
Descriptive statistics for the household survey.

	Mean	S.d	Min	Max	1	2	3	4	5	6	7	8	9	10
1. Sublocation	1.54	0.50	1.00	2.00										
2. Anticipated income	2.30	0.92	1.00	4.00	0.03									
3. Social ladder	3.77	1.68	1.00	10.00	0.00	0.24***								
4. Financial situation (past 3 years)	2.85	1.19	1.00	5.00	0.07***	0.33***	0.28***							
5. Financial situation (next year)	3.45	1.05	1.00	5.00	0.15***	0.53***	0.29***	0.48***						
6. Supply the basics (next year)	1.34	0.73	1.00	5.00	0.00	−0.02	0.03	0.04	−0.06*					
7. Life satisfaction	3.08	1.17	1.00	5.00	0.02	0.25***	0.28***	0.39***	0.32***	0.00				
8. Household income	10,023.67	15,333.73	0.00	30,0001	0.03	0.05*	0.13***	0.08***	0.06**	−0.05*	0.04			
9. Risk orientation compared to friends	2.79	1.03	0.00	4.00	0.07**	0.19***	0.12***	0.08***	0.14***	−0.03	0.02	0.11***		
10. Risk orientation compared to family	2.71	1.08	0.00	4.00	0.03	0.16***	0.11***	0.05*	0.14***	−0.07**	0.05*	0.10***	0.65***	
11. Risk orientation compared to business partner	3.95	1.89	1.00	6.00	0.04	−0.29***	−0.16***	−0.26***	−0.19***	0.06**	−0.33***	−0.08***	−0.19***	−0.22***

*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table 8
Difference-in-differences between Kitonyoni and Mwania Household Survey.

	Basic concerns	Financial situation (past 3 years)	Financial situation (next 12 months)	Position on social ladder	Life-satisfaction	Total income
Wave 2	−0.052	0.534***	0.211***	0.247**	0.750***	864.920
	(0.049)	(0.076)	(0.069)	(0.110)	(0.073)	(1021.400)
Location (Kitonyoni)	0.098	−1.056***	−1.453***	−0.476**	−0.562***	−1471.772
	(0.103)	(0.158)	(0.143)	(0.231)	(0.153)	(2133.581)
Ownership of Title Deed (Yes = 1)	0.029	−0.001	0.001	−0.304***	−0.163***	−278.541
	(0.036)	(0.055)	(0.049)	(0.080)	(0.053)	(738.625)
Most purchases in community center	0.011	−0.081	0.001	0.014	−0.099**	102.946
	(0.033)	(0.051)	(0.046)	(0.073)	(0.049)	(679.507)
Bank account (No)	−0.106***	−0.293***	−0.084*	−0.509***	−0.087	−4958.356***
	(0.037)	(0.056)	(0.051)	(0.082)	(0.055)	(757.850)
Bank account (Don't know)	0.307	−0.362	0.042	−0.749	−0.124	−10,260.830**
	(0.212)	(0.325)	(0.290)	(0.474)	(0.316)	(4390.630)
Own enterprise (Yes = 1)	0.001	−0.213***	−0.082	−0.572***	−0.087	−4228.696***
	(0.040)	(0.061)	(0.055)	(0.090)	(0.060)	(828.481)
Receives money from relatives (No = 1)	−0.053	−0.224***	−0.126***	−0.388***	−0.100**	2102.225***
	(0.034)	(0.051)	(0.046)	(0.075)	(0.050)	(692.161)
Relation to household head (spouse)	0.027	0.133	0.114	0.122	0.074	2492.439**
	(0.056)	(0.086)	(0.077)	(0.125)	(0.083)	(1160.945)
Relation to household head (other)	−0.021	0.062	0.033	0.241**	0.049	−423.962
	(0.044)	(0.067)	(0.060)	(0.097)	(0.065)	(898.076)
Gender (Female = 1)	−0.022	−0.051	−0.050	−0.083	0.066	−3293.588***
	(0.035)	(0.053)	(0.048)	(0.077)	(0.051)	(714.844)
Differences-in-differences	−0.061	0.596***	0.775***	0.375**	0.358***	664.465
	(0.065)	(0.100)	(0.091)	(0.146)	(0.097)	(1351.569)
Constant	1.505***	2.666***	3.467***	4.447***	2.230***	16,251.650***
	(0.096)	(0.147)	(0.133)	(0.214)	(0.142)	(1980.256)
N	2024	2008	1965	2024	2024	2025
R-squared	0.014	0.140	0.126	0.081	0.171	0.063
Adj. R-squared	0.008	0.135	0.121	0.076	0.166	0.058
Residual Std. Error	0.722 (df = 2011)	1.104 (df = 1995)	0.986 (df = 1952)	1.612 (df = 2011)	1.073 (df = 2011)	14,919.080 (df = 2012)
F Statistic	2.299*** (df = 12; 2011)	27.080*** (df = 12; 1995)	23.492*** (df = 12; 1952)	14.769*** (df = 12; 2011)	34.542*** (df = 12; 2011)	11.352*** (df = 12; 2012)

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

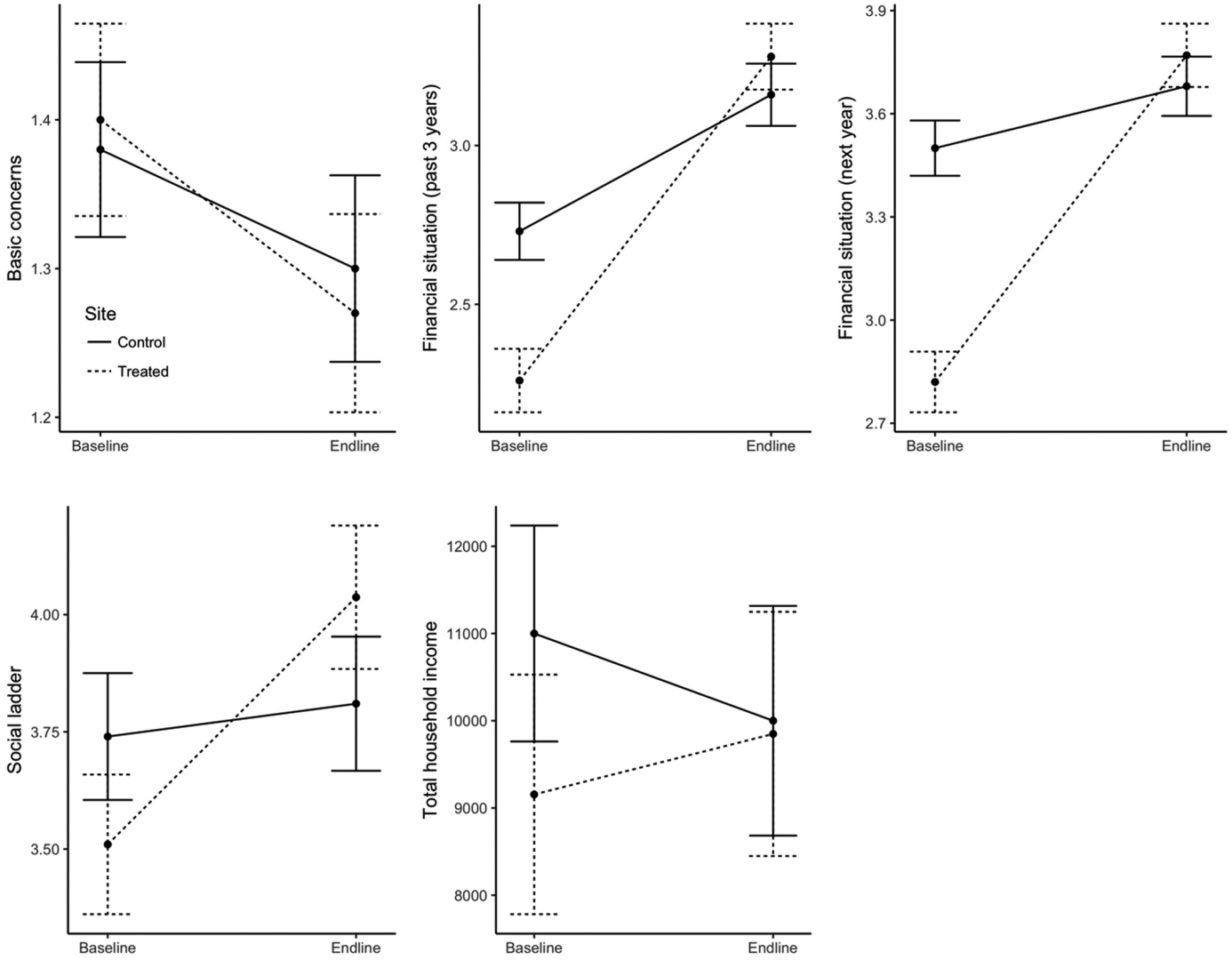

Fig. 3. Differences between households in the treated and control site in the two surveys: basic concerns, financial situation (Past 3 years), financial situation (next year), social ladder position and total household income.

Finally, we use data on household matched between the two waves of the survey. These households are ones in which the household head did not change between the two waves of the survey and for which we can say with certainty that it is the same household using various variables in the survey. This procedure yielded a sample of 497 households across both communities, 268 in the treated community and 229 in the control community. We use this sample to study whether electrification benefits men and women equally. To do so, we run OLS regressions. Table 9, shows the correlations between the variables in this sample. Overall, correlations are low. Table 10 shows the results of our analyses. Models 2 and 3 present an interesting picture. In model 2, we find evidence that electrification contributes to an increase in the revenue of household in the community (ß = 0.114, $p < 0.05$). However, in model 3, which includes the interaction between gender

Table 9
Correlations in the sample of households matched over wave 1 and 2.

	Variable	Mean (s.d.)	1	2	3	4	5	6	7	8	9	10	11	12
1	Total Income (2011, KSh)	9883.87 (15,603.7)	1											
2	Expenditure (2011, KSh)	7362.80 (12,922.2)	0.55**	1										
3	Days Worked	23.26 (43.72)	0.02	0.01	1									
4	Age	53.38 (16.78)	0.01	−0.02	0.01	1								
5	Life satisfaction	2.49 (1.18)	−0.02	0.01	0.01	0.02	1							
6	Education	0.80 (0.40)	0.08*	0.09*	0.04	−0.47**	0.02	1						
7	Own title deed	0.47 (0.50)	0.03	0.02	0.03	0.21**	−0.00	−0.07	1					
8	Number of children	0.76 (0.87)	−0.08	−0.00	0.08*	−0.18**	−0.05	0.05	−0.05	1				
9	Gender (Female = 1)	0.46 (0.50)	−0.17**	−0.08*	−0.04	−0.06	−0.03	−0.23**	−0.07	−0.10*	1			
10	Sub-location (Electrified = 1)	.46 (.50)	−0.04	−0.06	0.02	−0.03	−0.09*	−0.04	−0.05	0.03	0.02	1		
11	Distance to center (Km)	2.42 (1.12)	−0.05	0.02	0.02	0.03	−0.00	−0.04	−0.07	0.06	−0.03	−0.30**	1	
12	Total Income (Ln) (2014)	8.30 (20.08)	0.12**	0.11**	0.07	−0.06	−0.14**	0.10*	0.07	−0.05	−0.17**	0.12**	−0.10*	1

N = 497, statistical significance is denoted by *p < 0.05, **p < 0.01, ***p < 0.001.

Table 10
OLS regression on household income (2014).

Variable	Model 1	Model 2	Model 3
Constant	9.533***	10.924***	11.24***
Total Income (2011)	0.071 (0.000)	0.042 (0.000)	0.040 (0.000)
Expenditure (2011)	0.073 (0.000)	0.077 (0.000)	0.078 (0.000)
Days Worked	0.077† (0.002)	0.075† (0.002)	0.70 (0.002)
Age	−0.123* (0.007)	−0.182** (0.007)	−0.187*** (0.007)
Life Satisfaction (2014)	−0.123** (0.080)	−0.117 (0.078)	−0.110* (0.079)
Education (Attended school = 1)	0.001 (0.302)	−0.070 (0.312)	−0.077 (0.312)
Ownership of Title Deed (Yes = 1)	0.065 (0.191)	0.051 (0.187)	0.059 (0.188)
Total Children (Number)	−0.074† (0.106)	−0.098* (0.105)	−0.106* (0.105)
Gender (Female = 1)		−0.207*** (0.199)	−0.363** (0.545)
Sub-location (Electrified = 1)		0.114* (0.193)	0.025 (0.260)
Distance to center in km		−0.078* (0.087)	−0.101† (0.117)
Female*Sub-location			0.161** (0.385)
Female*Distance to center			0.076 (0.174)
Model Fit F-statistic	3.733***	5.871***	5.361***
R-square	0.057	0.117	0.126

Note: N = 497. Standardized coefficients are reported, standard errors are in parentheses.
† $p < 0.1$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

and electrification, the electrification variable becomes non-significant (ß = 0.025, *NS*), whereas the interaction between gender and electrification is significant (ß = 0.161, $p < 0.01$). This finding suggests that much of the benefits of electrification accrued to women-led households when considering income. However, the value of the main effect for gender is still larger than the value of the interaction (ß = 0.363, $p < 0.01$), suggesting men-led household were still financially better off on average.

5. Discussion and conclusion

Our study examined the socio-economic impact of electrification on a rural community. Using data from entrepreneurs and community members in two research sites, we examined how electrification facilitates business processes and outcomes. We focused on the extent to which electrification leads to increased entrepreneurial opportunities and entrepreneurial outcomes. Furthermore, we investigated how electrification changes community members' outlooks. Finally, we provided some evidence that electrification has the potential to reduce gender inequalities in terms of revenue between women- and men-led households.

Existing research on entrepreneurship in Africa has tended to identify determinants of business start-up and performance as access to finance, regulatory framework, entrepreneurial skills, market size (agglomeration), firm location, sector, and education level (Brixiová et al., 2015; Khayesi et al., 2014; McPherson, 1996; Naude et al., 2008; Nichter and Goldmark, 2009). Yet much of this work shies away from delineating the origins of microenterprise development, especially the basic social and community infrastructure necessary to trigger enterprise development. Our results further these earlier work by revealing that electricity plays a key role in business start-ups, particularly in poor contexts.

Our setting also allowed us to check whether electrification brings about significant variation in entrepreneurial outcomes, using the business-survey results. Our findings reveal no positive effect of electrification on overall profit of the businesses in the experimental community. In addition, no significant change occurred in the relative growth path of the treated business community in terms of income and expenses of businesses—despite the significant difference in the size of businesses, as measured by income and expenses, in the follow-up survey. This result may partly be attributed to increased competition arising from an increase in the number of businesses in the treated community. Additionally, most of the businesses in the experimental community were fairly young and had not yet reached their break-even points, because they still had start-up costs to reconcile. Our results of the differences in income, expenses, and profit between businesses that were older than two years and those that were younger than two years support this interpretation. These results show that in the experimental community, electrification benefited business growth and business creation but that, at the time of measurement, it did do not translate into increased profit for established businesses. This finding is further supported by the result that businesses in the experimental community attracted customers from a wider area than before. Some of the newly created businesses provided goods and services that the business community of the experimental community was not previously offering. In addition, those services were not readily available in neighboring villages, which explains the increase in non-local customers.

In conclusion, electricity facilitates income generation in rural areas by opening up entrepreneurial opportunities and facilitating business processes that lead to improved production output. However, in the short run, attracting more distant customers does not necessarily lead to growth of income or profits for individual businesses. Potentially, this increase in income and profit would happen at a later phase, more than two years after electrification. The findings of our study reveal the importance of electrification to rural entrepreneurship. We recommend that scholars studying entrepreneurship in rural areas, particularly in emerging economies, consider the moderating or mediating role of electricity, because it appears to play an important role in entrepreneurship in developing economies.

With respect to households, our results show that household heads in the two communities were similarly concerned about their ability to provide for their families both before and after the electrification. However, in the treated community, household heads perceived that their financial situation in the past three years had improved significantly after the electrification. They also felt more confident about their financial situation in the next 12 months. Those results paint a mixed picture of a community in which individuals still faced significant risks to their well-being. This observation is consistent with the fact that most households rely on sources of income susceptible to external shocks (e.g., poor harvest due to weather conditions).

In addition, household heads' perceptions of their position on the social ladder and of their life satisfaction grew faster in the treated community than in the control community. Despite a smaller difference in income after treatment, however, the treated community still trailed

the control community for household total income. Household heads' perceptions of the position of the household within the community and their own life satisfaction grew in the treated community more than in the control one. This observation reflects an overall increase in optimism in the treated community. However, income did not grow in the same way. This finding could be explained by the fact that income growth might need more than two years after electrification to manifest. Future research should investigate how long after the provision of infrastructure both business profits and household income start growing.

In addition, the results from the analyses of the effect of electrification within household head show that women-led households in the electrified community benefited more than men-led households in terms of increased income. This preliminary result offers some hope that access to infrastructure such as electricity might reduce gender inequalities. However, in our results, income inequalities between women- and men-led households remained large. This result calls for further study to focus on how infrastructure provision reduces gender inequalities.

The effects of electrification for the households were mainly visible in household heads' perceptions. This finding is important because perceptions of members of the community are going to shape how they identify and pursue opportunities. Recent research highlighted that optimism has a positive influence on the ability of people to identify and pursue opportunity and leads to higher rates of entry into entrepreneurship (Åstebro et al., 2014; Dawson et al., 2014). Building on this result, our study suggests electricity might lead to business creation through increasing optimism in communities that obtain electricity provision. Electricity is not an end in itself, but rather has the ability to change a community's development path through provoking a shift in how individuals within the community perceive themselves and their situation. Although our study focused on two communities in rural Kenya and it might not generalize, it indicates avenues for future research to focus on the effects of infrastructure provision on entrepreneurial activities, development, and inequalities.

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