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The impact of solar mini-grids on Kenya's rural enterprises☆

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ABSTRACT

Off-grid, renewable based electricity systems are becoming increasingly competitive for remote rural communities. When the electricity supplied is used productively by micro and small enterprises (MSE), it has the potential to contribute to income generation and poverty reduction. MSE are prevalent in rural Kenya to complement agricultural activities. However, most of them struggle to survive and they provide insufficient income to escape poverty. This paper investigates if the provision of electricity through solar mini-grids could contribute to improving business performance in rural Kenya. We use a difference-in-differences approach to compare business outcomes before and after electrification in regions with and without mini-grids. Outcomes include opening hours, number of enterprises, profits, sales, and expenses. Our results show that nearly two years after the implementation of mini-grids, these have not had the intended effect of improving business performance. Electricity consumption has remained low and demand for the products and services sold by local businesses has not picked up after the arrival of mini-grids. We recommend adjusting the size of the systems to the actual demand and implementing complementary measures to improve agricultural productivity and access to external markets.

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Introduction

With a per-capita income of 1340 USD in 2015 and sustained economic growth in the past decade, Kenya has recently graduated as a middle income country. However, many development challenges persist. Kenya's economy is predominantly rural, with 74% of its population living in rural areas and 75% of national employment coming from agriculture. Rural people are poorer than their urban counterparts and their dependence on subsistence agriculture makes them very vulnerable to erratic weather. To diversify their sources of income, many rural households participate in micro and small enterprises (MSE), which are prevalent in Kenya. But the income MSEs provide is not enough to cover basic household needs and most of them struggle to grow and survive (Daniels, 1999). MSEs in rural Kenya are very small, most with just one or two workers and operate informally in the services sector (KIPPRA, 2016). 50% of MSEs do not survive beyond the first three years of operation (Liedholm, 2001) and, like in other developing countries, the vast majority of surviving MSEs never expand beyond four employees (Nichter & Goldmark, 2009).

The literature has pointed at many causes behind low rates of growth and survival of microenterprises in developing countries. These can be classified in terms of a lack of business opportunities and a lack of capabilities (Nichter & Goldmark, 2009). Accordingly, actors could enhance MSE growth by expanding profitable business opportunities and enhancing firms' resources, skills and technology to harness these opportunities. The provision of electricity has the potential to support MSEs growth by making possible a new range of products and services and by improving the productivity of existing activities. Improved lighting can also attract more customers to a business or keep it open for longer hours. These potential benefits and the interest in transitions towards low carbon development models have made the provision of universal access to sustainable energy a priority for international development. In fact, the Sustainable Development Goals agreed by world leaders in 2015, include a specific Goal on "ensuring access to affordable, reliable, sustainable, and modern energy for all".[1]

Academic literature has so far been inconclusive about the impact of electricity for rural development. Existing evidence shows that the use of electricity does not automatically lead to improved business profits or to the creation of new enterprises (Banerjee, Singh, & Samad, 2011; Harsdorff & Bamanyaki, 2009; Neelsen & Peters, 2011; Obeng & Evers, 2010; Peters, Sievert, & Vance, 2013; Peters, Vance, & Harsdorff, 2011). The final outcome depends on complementary conditions, including access to markets that absorb additional production, access to finance

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[1] United Nations Sustainable Development Goals https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

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to buy electrical equipment, and the skills of the entrepreneur. A robust study about micro-manufacturers in Benin showed that firms created after electrification to execute activities critically depending on electricity perform much better than firms created before grid access (Peters et al., 2011). However, there were no positive impacts of electrification for pre-existing firms as compared to their matched counterparts in non-electrified regions. Some reasons behind poor performance were a limited local market and no access to external markets, which did not provide an exit for additional production; and the lack of a robust business plan to back the investment in electrical equipment.

The literature has also noted that the benefits of electrification for agriculture and small-scale industries largely go to the better-off. Evidence from Burkina Faso, for example, shows that benefits from electricity accrue to businesses in the highest quantiles of revenues (Grimm, Hartwig, & Lay, 2013). Evidence from the Chinese rural electrification programme also shows that electricity has a higher impact on the most economically developed provinces, whereas in poor provinces the impacts are limited (Yang, 2003).

Grid extension to remote villages with low demand is an expensive investment that can drain the finances of national utilities in developing countries. Decentralised, off-grid renewable based generation could therefore be an economically viable solution for rural communities, especially after the dramatic cost reductions experienced in the last decade. Some sources describe off-grid, renewable generation of electricity as the most economical solution for remote and isolated communities (IRENA, 2015). However, other authors indicate that solar PV in particular remains extremely costly for the majority of the rural poor in Sub-Saharan Africa (Baurzhan & Jenkins, 2016). What is clear is that without income generation, rural consumers will be unable to pay for the cost of electricity provision in rural areas, which is more expensive than in urban areas. Therefore, either subsidisation or the promotion of productive uses of energy is required to pay for modern energy services in poor rural areas. Productive uses of energy are likely to deliver a more efficient and financially sustainable outcome for rural electrification, and are the focus of this paper.

This study looks at the electrification of rural enterprises in Kenya through private solar PV mini-grids to understand their impact on the rural economy. The topic is particularly relevant as Kenya looks to provide universal access to electricity in a cost-efficient manner. In its latest generation and transmission Plan, the Government set a target to connect over one million new customers every year to achieve 70% electrification by 2017 and universal access by 2020 (Lahmeyer International, 2016). Kenya is on track to achieve this ambitious target, having rapidly increased electricity access rates from 18% in 2000 to 65% in 2016 (IEA, 2017). However, electricity consumption per capita remains very small and stagnant at just 167 kWh p.c. per year in 2014, compared to 480 kWh in the Sub-Saharan Africa region, or 3125 kWh globally (World Bank, 2018). The fact that consumption per capita is not increasing as fast as access rates suggests that improved electricity access, often understood as connections, does not equate to improved electricity use in Kenya.

Grid extension has traditionally been the preferred approach to provide electricity in Kenya, but off-grid solutions such as solar home systems (SHS) and mini-grids are playing and increasingly important role. Mini-grids are particularly attractive for donors[2] as they enable a wider set of productive activities than the more widespread individual solar systems. Therefore they have a higher potential to generate income and reduce poverty among off-grid communities. Through this study, we seek to understand if that was actually the case. Specifically, our research addresses three questions: 1. what is the impact of electricity access on the performance of Kenya's rural microenterprises, measured in terms of: sales, profits, costs, assets, and opening hours? 2. Does the provision of electricity lead to the creation of new enterprises, and what types of enterprises are these? and 3. Which barriers prevail to support enterprise growth in rural Kenya?

We gathered empirical evidence by surveying six communities that would be connected to mini-grids before and after connection, and six control communities which would not receive a mini-grid during our study period. We interviewed in total 735 enterprises in two stages between September 2014 and June 2016. Our empirical strategy consisted of a difference-in-differences approach that compared the before-and-after outcomes for the enterprises that received the micro grid installation (the first difference) and the before-and-after outcomes for the communities that did not receive the project but were exposed to a similar set of economic and environmental conditions.

The remainder of this article is structured as follows. First, we provide some background information about electrification and mini-grids in Kenya and specifically about the mini-grids implemented in our target villages. Second, we explain in detail our empirical strategy. Third, we present our results on various firm level outcomes. Finally, we discuss the results and draw conclusions.

Background: mini-grids in Kenya

There are three different types of mini-grids in Kenya according to ownership: public, private and community-owned (World Bank, 2017). Public mini-grids are developed by the Rural Electrification Authority (REA) and operated on exclusive concession by the national distribution utility Kenya Power. They apply the uniform national tariffs, so that mini-grid customers pay the same as their grid-connected urban counterparts. Because electricity supply to remote areas with mini-grids is more expensive than supply to urban areas through the main grid, the use of uniform national tariffs involves a transfer of funds from urban to rural consumers. Private mini-grids, on the other hand, typically apply higher tariffs than the main grid. Although they can operate under a variety of business models, including Power Purchase Agreements (PPAs) with Kenya Power and off-grid feed-in tariffs, existing private mini-grids in Kenya apply their own cost-recovery tariffs. Finally, community mini-grids are typically operated with NGO support and subsidised.

Public mini-grids are the most common type in Kenya. As of October 2015, there were 15 mini-grids operated by the national utility Kenya Power, with sizes between 184 and 3400 kW serving 80 to 4100 customers each. All the systems were diesel-based but 9 of the 15 sites had been hybridized with solar and/or wind generators. The largest off-grid sites in Kenya have been electrified through this model, leaving only small-scale opportunities (<100 kW) for private mini-grid development (Carbon Africa Limited et al., 2015).

The Government of Kenya, and the donors on which it depends, are showing an increasing interest in private sector driven models for mini-grid development and operation, as a way to leverage more finance to meet universal electrification targets. Private sector business models typically consist of a small connection fee as compared to Kenya Power fees, but significantly higher monthly electricity costs. A consultancy report commissioned by Kenya's Energy Regulatory Commission indicated that only around 10 to 15% of the rural customers, those with the highest willingness and ability to pay, can be served by fully private models (Carbon Africa Limited et al., 2015). Hence, private developers would typically target those communities and consumers within communities with the higher potential to pay for the system.

The solar mini-grids analysed in our study have been developed and are managed by a private company. The technology consists of an array of solar-electric (PV) panels with around 4 kW peak to generate electricity; a bank of lead-acid batteries to store electricity for night-time use; and an inverter to convert the DC voltage from the PV array to the local AC mains voltage (240 V in Kenya) so that customers can use

[2] See for example the World Bank's "Kenya off-grid solar access project for underserved counties" http://documents.worldbank.org/curated/en/212451501293669530/Kenya-Off-grid-Solar-Access-Project-for-Underserved-Counties; DfID's "Green Mini-Grids Africa" https://devtracker.dfid.gov.uk/projects/GB-1-203990; GIZ's "Promotion of solar-hybrid mini-grids" https://www.giz.de/en/worldwide/25332.html.

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