OXFAM
RESEARCH BACKGROUNDER

Linking Electrification and Productive Use

James Morrissey

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Author information and acknowledgments

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EXECUTIVE SUMMARY

This report examines the literature on electrification and productive use. Productive uses are those that increase incomes, either by generating new incomes or by creating opportunities for savings. The imperative for the report stems from a cursory reading of the literature, which suggests that electrification has highly variable impacts on productivity. Assuming that such variability can be explained by the context in which electrification takes place, the specific intent of report is to address the question, *Are there are complementary policies that can be pursued in tandem with electrification to increase the likelihood of generating productive uses*?

Notably, although this work has a narrow focus on productive use and economic impacts, such impacts do not constitute the only benefits of electrification; there is general agreement that access to electricity can provide a host of welfare benefits. That said, productive impacts are particularly important and therefore constitute the focus of this work. The findings of the work show that the impacts of electrification can be significantly positive, yet they are also highly variable—and small or even negative in some cases. In seeking to explain this variability the report found the following:

- Complementary services (such as access to credit, training, and supportive infrastructure) have the potential to increase the likelihood that productive impacts will be realized.
- Despite this, among very poor populations being connected in very remote and isolated contexts,[1] it will be particularly difficult to achieve productive impacts.

Such findings create significant challenges to the sustainability of investments aimed at connecting the poorest and most remote populations. As such, the work recommends the following:

1. Wrap electrification efforts in complementary services to the extent possible.
2. Take issues of financial sustainability seriously by (a) exercising caution when anticipating productive impacts of electrification efforts, (b) ensuring long-standing financial support in cases where subsidies are required, and (c) ensuring that electrification programs are sufficiently flexible to allow for adjustments if initial impacts on productive use prove disappointing.

1. At no point was this work able to work out thresholds at which issues of poverty, remoteness, and isolation begin to pose particular challenges to sustainability. All the work was able to establish was that these factors appear to matter, and as one increases them, the likelihood of seeing productive impacts decreases, regardless of the wraparound services available.

3. Undertake further research that (a) controls suitably for contextual factors and endogeneity in electrification efforts, (b) seeks to explain variability across cases, and (c) tests the specific value of complementary services in driving productive use

The findings of the review can be summarized as follows:

Although current approaches to development place a significant focus on electrification, efforts promoting electrification as a means to improve the human condition and drive economic growth have been pursued since the early 20th century. However, many of these efforts produced outcomes considered disappointing by electrification proponents, and it is not clear that contemporary efforts at electrification have fully learned from the challenges of realizing productive use. Much of the literature consulted in this review considers electrification through grid extension, whereas new technologies (namely distributed renewable energy generation systems) create new opportunities for providing electricity. Still, on their own, these new technologies are not likely to ameliorate the conditions that drove disappointing results from previous electrification efforts. There is therefore a need to learn from past experiences.

Overall the literature suggests that electrification can have significant positive impacts on productivity. At the same time, however, the literature makes clear that such impacts vary significantly across cases and contexts. Where positive impacts do arise, they tend to occur in areas that are better off in terms of existing service provision and economic opportunity, and these impacts tend to be captured by wealthier households and individuals. In general, there is little evidence that electrification results in increases in either income or productivity among the poorest populations in the most remote and underserviced areas. Especially concerning is the lack of evidence of productive impacts in sub-Saharan Africa (outside of South Africa), where the challenge of energy poverty is most acute. An important potential exception to this trend is the extent to which women have been identified as benefiting disproportionately from increased labor force participation and income-earning opportunities as a result of electrification.

Although the explanations for variability across studies are under-researched, speculation in the literature points to the idea that there are a host of contextual factors that increase the likelihood that electrification will drive increases in productivity. These include

1. Access to credit
2. Education about or awareness of the benefits of electricity and capacity building on how to use electrical appliances
3. Existing markets for appliances (and supportive supply chains surrounding them)
4. The length of time people have been connected
5. The quality and reliability of electricity supply

6. Access to road and information and communication technology (ICT) infrastructure
7. Access to markets.

Access to markets and/or the delivery of electricity to an area with an already thriving economic base was repeatedly found to be the greatest determinant of whether electrification drove increases in productivity. This is thought to explain the limited impacts of electrification on productivity in low-income, poorly serviced areas.

The generally positive impacts of electrification on productivity (as well as welfare gains) mean that efforts at electrification should remain a priority in many contexts. That said, the variability of impacts and the challenges involved in realizing them among the poorest and most isolated populations also need to be taken seriously because they can create significant problems for the sustainability of investments.

Overall, electrification efforts should be accompanied by complementary services that can increase the likelihood of realizing productive impacts. To this end, any electrification effort should focus on providing a service that is sufficiently reliable and of appropriate quality to meet the needs of users. At the least, it should be accompanied by complementary services aimed at raising awareness of the benefits of electricity and ensuring access to the appliances necessary to obtain energy services. Wherever possible electrification should be accompanied by access to finance, business development support, and robust agricultural extension. Ideally, electrification should be bundled as part of a comprehensive rural development strategy so that it is paired with the delivery of other major services and infrastructure, such as education, health, and transport.

Still, the findings of this review highlight the challenges facing energy access efforts. First, the fiscal constraints and bureaucratic limitations apparent in developing countries make it unlikely that all of these services can simply be supplied to accompany electrification. Second, some of the most important conditions for achieving productive use—such as the existence of a dynamic economic context or access to markets—cannot be achieved simply by complementary policies. Consequently, instead of relying on increases in productive use to sustain electrification efforts, contingencies need to be built into electrification efforts to account for potentially limited impacts on productive use.

Further, electrification programs should be extremely conservative when estimating positive productive impacts. This is especially the case if the financial sustainability of any scheme is premised upon future economic growth and increased capacity to pay at some point in the future. Particular attention should be paid to cases where electrification is taking place among very poor, isolated, and underserviced populations. Although such populations have the greatest need for economic growth, it is not clear that providing access to electricity is always the best service for achieving this. That said, given the moral imperative to provide the poor with access to electricity, the findings from this report suggest that any efforts to meet the needs of the poorest should, rather than simply seeking to provide electricity access as quickly as possible, take an approach that is amenable to learning and flexible enough to incorporate the changes that might be necessary to realize productive benefits. Finally, more research is necessary to support an understanding of when and where productive impacts are likely to emerge, so that areas can be identified more effectively.

These findings come with several caveats. First, while increasing productivity is of significant importance to both poverty alleviation and the sustainability of electrification efforts, it is not the only reason for undertaking electrification. Access to electricity is generally thought to result in a host of positive welfare impacts, regardless of the direct economic impacts. All such impacts should be weighed when setting policies to meet national ambitions for rural electrification. Further, any disappointing findings on productive use should not be taken to mean that electricity access plays no role in rural development. Under certain conditions, electrification can indeed be catalytic. Thus the purpose of this review is not to undermine efforts at electrification, but rather to raise the salient question of how to provide electricity infrastructure when the issue of productive use might not be easily resolved.

1. INTRODUCTION

SITUATING THE REPORT

Globally, around 1.1 billion people lack access to electricity. While efforts to address this shortfall are seeing success (1.2 billion people have gained access since 2000), progress has been uneven: 500 million people gained access to electricity in India whereas sub-Saharan Africa as a whole saw limited progress in reducing its overall number of unelectrified households.[2] Importantly, in sub-Saharan Africa, more people live without electricity today than in 2000 (IEA 2017). Much of the current impetus behind achieving universal energy access stems from the efforts of the United Nations (UN) and the World Bank, in the form of the Sustainable Energy for All initiative, which recently helped incorporate issues of energy access into the Sustainable Development Goals (SDG7). The motivation for pushing energy access is the idea that modern energy holds catalytic promise for development. Sustainable Energy for All, for example, states, “Energy enables. From job creation to economic development, from security concerns to the full empowerment of women, energy lies at the heart of the Sustainable Development Goals (SDGs)” (SEforALL n.d.). Likewise the IEA describes “energy access [as] the ‘golden thread’ that weaves together economic growth, human development and environmental sustainability” (IEA n.d.). Accounts of this sort abound among advocates of energy access, and core to most of them is the idea that (among other things) access to electricity is central to fighting poverty through its impacts on productivity.

While this renewed push for access to electricity is significant, the sentiment is not new. Since the early 20th century, electrification has been viewed as a means of driving economic development and enabling human flourishing. However, while there is general evidence of positive impacts from electrification, there are also a numerous cases in which impacts have either been difficult to achieve or reviewed as disappointing by their proponents (Bernard 2010),[3] resulting in challenges for the sustainability of electrification efforts. It is vital that current electrification efforts learn from these past experiences.

Among proponents of electrification, few would argue that providing access to electricity in isolation will result in productive use and economic growth, and it is important that this account not be seen as a straw man. That said, there remains a pervasive sentiment that electrification’s impact on productive use is catalytic

2. This is not because progress was non-existent, but rather due to generally slow progress and population growth.

3. Bernard (2010) invokes the notion of “disappointing” results without quantifying the term. He makes this assessment, based on evaluations of electrification efforts, citing Rambaud-Measson (1990) and De Gromard (1992).

and that as long as one wraps electrification in complementary services, productive uses will arise. Furthermore, in cases where the sustainability of financing for electrification is in doubt (owing to the cost of electrification infrastructure, low incomes [Grimm et al. 2016, 2017],[4] and low demand among very poor populations), there is a view that this problem will be solved when productive uses emerge and increase both demand and incomes (Cook 2013).

As will be shown, while complementary services appear important, the challenge of achieving productive use remains significant, especially among populations experiencing the most chronic conditions of energy poverty. Understanding why and when productive use arises is therefore central to contemporary electrification efforts, as is the question of what to do when productive impacts are difficult to realize.

This report explores the questions of whether and to what extent electrification drives productive use, and what can be done to try and increase the productive impacts of electrification. The reasons for focusing on productive uses are myriad, ranging from their impacts on poverty to the fact that they are central to the sustainability of energy investments. Still, *it is important to note that productive gains are not the only benefit to arise from electrification, which is also thought to drive significant welfare gains.* Consequently, this report is not intended as a referendum on investments in electricity access based solely on an assessment of their economic impacts. Rather it is an effort to learn from previous endeavors aimed at increasing productivity so that policy (and policy advocacy) can be oriented toward maximizing the impact of electrification efforts.

This report proceeds by first making the case for a specific focus on productive use, as well as presenting the methodology underpinning this review. The report then considers historic efforts at electrification, identifies the lessons learned from them, and makes the case for incorporating these lessons in contemporary efforts at electrification. The report then turns to the main substance of this work: *what have been the impacts of electrification on productive use, and what complementary services might increase the likelihood of realizing productive use*? Penultimately the report discusses findings from the literature on the rural nonfarm economy (RNFE) and considers the factors that drive off-farm economic growth in rural areas. This work is considered a means of triangulating the results of the review conducted here. Finally, the report presents conclusions.

A final note on the focus of the report: This report looks at *electricity access.* It is not about understanding the broader notions of energy access or energy poverty. Such a focus may seem narrow, but, for reasons that will be made clear below, it

4. Grimm et al. (2016) assess the ability of households to pay for a $30 system capable of delivering the most basic amounts of energy. They find that the resultant savings come to $0.95 (PPP) per month (or around 2 percent of household monthly expenditure). Based on this calculation, the system, which has a lifespan of two to three years, would be paid off in 18 months. However the interplay of cash and credit constraints, the lack of information, and high discount rates mean that most households forgo this investment.

is thought worthwhile. Readers interested in broader assessments of the energy issue should see Oxfam's other publications on the energy challenge and energy distribution.

THE SPECIAL CASE FOR PRODUCTIVE USE

Before discussing the special case for productive use, it is worth briefly mentioning the extent to which there is a general consensus that electrification is expected to drive welfare gains.[5] It has even been argued that the notion of "productive use" should be redefined to include a broader set of effects such as those on health, education, and gender equality (Cabraal, Barnes, and Agarwal 2005). Despite these arguments, this report maintains a focus on productive use, narrowly defined.

Productive use, in this report, refers to activities that increase people's incomes from existing activities or that create new opportunities for people to generate incomes or savings. Electrification can lead to productive use by increasing energy inputs (for example, making irrigation possible with electric pumps), increasing the efficiency of energy services (for example, using electric motors rather than diesel engines), or by making new energy services available (for example, showing movies or playing music). Productive use is distinct from welfare gains, which pertain to the non-monetary elements of people's well-being, such as the improved quality of life experienced by people residing in well-lit dwellings.

Regarding the specific focus on productive uses, there are two principal justifications. First, increased productivity has the potential to have the most direct impact on material poverty, thereby significantly improving people's well-being. Second, realizing productive uses of electricity has the potential to address energy poverty more generally by reducing the cost of electricity. This happens both because productive use increases the overall demand on the energy system (thereby taking advantage of the economies of scale that tend to characterize energy infrastructure) and because productive use tends not to correlate with peak demand, thereby smoothing out peak demand and increasing the overall capital utilization of a system—an advantage that is especially relevant for distributed systems (Morrissey 2017; Bhattacharyya 2015). Notably,

5. It should also be noted, however, that while general agreement exists on the positive welfare impacts of electrification there are also contradictory findings. On limited education impacts, see Bensch, Kluve and Peters (2011), Lenz et al. (2017), Furukawa (2014) and Burlig and Preonas (2016); on limited health impacts, see Lenz et al. (2017). Also, on health, note that numerous authors caution that electrification has little impact on the use of solid fuels and therefore little impact on indoor air pollution (Bailis, Ezzati, and Kammen 2005; Broto, Stevens, and Bartlett 2015; Gebreegziabher et al. 2012; Malla and Timilsina 2014; World Bank 2008; Prasad and Visagie 2006; Rewald 2017). Further, while electrification reduces the use of candles and kerosene, it tends not to eliminate them (and their associated risks) (Madubansi and Shackleton 2006; Masera, Saatkamp, and Kammen 2000; Morrissey 2017).

increased income and price reductions together constitute virtuous cycles, further increasing demand (both for productive use and for domestic consumption) and lowering prices. Third, by increasing demand on the system, productive use aids in cost recovery. This is especially important for capital-intensive grid rollout[6] (Jimenez 2017) and vital in cases where the private sector is expected to provide electricity, whether grid-based or decentralized (Cook 2011; Mulder and Tembe 2008). Finally, it is widely understood that the poorest members of society need their electricity to be subsidized (Grimm et al. 2016, 2017; Bhattacharyya 2015), so the price reductions and income increases that productive uses can provide are important in making these subsidies sustainable (Cook 2013; Fluitman 1983). This is important because although electricity generates a host of welfare gains, if the gains are not economic they can be difficult to capture (Barnes 2014). Without productive impacts, it can therefore be difficult to ensure that the necessary infrastructure investments get made and the necessary maintenance takes place. Without investments and maintenance, the sustainability of the electrical system becomes extremely challenging.

It is also important to define what is meant by “electrification” in this review. As the World Bank Global Tracking Framework makes clear, the notion of energy access includes access to varying quantities of electricity with variable levels of reliability. Obviously the expected impacts of electrification will vary based on the quantity and quality of the supply. Much of the literature reviewed here specifies whether the electrification process being studied pertains to the grid or to distributed generation sources (see Appendix A for a discussion of the different opportunities and challenges presented by these technologies), and thereby sheds light on variability in the quantity of electricity. In contrast, the issue of reliability is rarely addressed and thus cannot be commented upon systematically in the review. That said, section 4 of the report discusses the issue of reliability as a condition shaping variability in the outcomes of electrification on productivity.

METHODOLOGY

The purpose of this report is to understand the concomitant policy and contextual factors necessary to realize economic impacts from electrification. The motivation for this analysis comes from a cursory engagement with the empirical literature on productive use that showed mixed results (Cook 2011; Schillebeeck et al. 2012; Terrapon-Pfaff et al. 2014; Khandker et al. 2009; Burlig and Preonas 2016;

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6. It is useful to keep in mind the scale of the challenge involved when it comes to cost recovery and grid rollout, based on the high cost of grid extension. Estimates of grid extension costs range widely. Moner-Girona et al. (2017) use an average cost of €40,000/km. Fuso Nerini et al. (2016) and Mentis et al. (2017) suggest a cost of $5,000 for low-voltage lines, $9,000 for medium-voltage lines, and $28,000–$54,000/km for high-voltage lines. Deichman et al. (2011) suggest higher prices of $20,000/km for medium-voltage lines and $192,000/km for high-voltage lines. Regardless of these ranges, it should be clear that grid extension is extremely expensive and that productive use is thus extremely important for cost recovery.

Cowan and Mohlakoana 2005; Clancy 2006; Dinkelman 2011), which contrast with Oxfam's own project assessments (Walsh and Mombeshora 2017) and a perceived sentiment among advocates that electrification will drive positive impacts on productivity. The assumption, based on this reading, was that contextual factors determined whether electrification projects resulted in increased productive activity. As such the work intended to review the literature in order to determine which contextual features mattered in driving productive use, and whether such contexts could be encouraged by pursuing specific policies as a complement to electrification efforts.

This report thus entailed a literature review of the research exploring the economic, or productive, impacts of electrification. Works were sought out that deal explicitly with how to achieve such impacts. Expecting that studies of this sort would be limited in number, however, the literature review also sought out individual studies aimed at assessing the impacts of electrification under the assumption that such studies would detail some of the contexts in which the results were or were not realized. An assessment of commonalities among these contextual factors would point to concomitant factors for realizing economic impacts. Finally, to gain a greater understanding of the conditions under which productive uses might arise from off-farm economic activity, the work sought to consult the rich literature on the determinants of livelihood diversification. The intention here was to assess the extent to which this literature identified electricity and/or other factors in driving productive activity in rural areas.

The literature review entailed a search of relevant articles using Google Scholar and further searches for gray literature not confined to academic sources. Not all of this work could easily be consulted owing to proprietary academic publishing. Based on work that could be accessed, relevant references were snowballed. Seminal studies (heavily cited) were sought out specifically, as were studies showing particularly confounding results. Finally, as part of contacting authors to request specific studies (largely through ResearchGate), the researcher was exposed to other studies that these leading authors thought relevant. The review was not systematic, but rather sought out an approach approximating saturation—a method drawn from qualitative research that involves continuing the research until the results start to repeat. The review focused on literature considering electrification in developing countries but did not include impact assessments of small demonstration projects as these were thought to be susceptible to self-selection bias (see Appendix B). Such projects are often implemented in populations where other investments predispose positive impacts and are very distinct from the large-scale efforts at electrification that are required to reach SDG7. As such, the work focused on reviews of the impacts of large-scale electrification efforts. With such concerns in mind, the research sought to include works based on methods that controlled for endogeneity (see Appendix B). In total 19 separate publications were reviewed for their findings on the impacts of electrification on productive use. Papers were assessed based on the conclusions drawn by the researchers. Thus if a paper concluded that “very few households used electricity for productive use,” impacts were considered to be small or limited. Similarly, if a paper concluded that impacts on productivity were large or significant, impacts were considered as such. In cases of mixed impacts with different impacts across pathways, the report expressly represents those with the pathways derived from the research. This is not a quantitative account, because different authors have different interpretations of what constitutes “small” or “limited” impacts, but it is thought to reflect the view of different authors in the literature.

This approach is obviously limited; it may miss important studies or misrepresent the impacts of those studies based on subjective accounts. To address this potential shortcoming, the conclusions drawn from the saturation approach were validated using triangulation, based on consultation with other literature reviews that considered the impact of electrification on productive use, which were identified through online searches. The report considered four literature reviews, one of which was only tangentially focused on productive use; its primary focus was the gendered impacts of electrification (of which productive use was but one impact).

In addition, the work sought further validation by consulting the literature on the drivers of rural livelihood diversification. This area of research has significant thematic overlap with research on the impacts of electrification on productive use but little overlap in terms of the academics working on them—a situation that mitigates the effects of systemic publishing bias. This consultation was largely limited to reviews of the literature on rural livelihood diversification and included 10 publications.

Finally, it should be noted that while this report is principally a review of the literature on electrification, the research came across literature showing that electrification efforts are not new and that they have achieved mixed and sometime disappointing results in the past. This seemed an important discussion, which has been included in the historical section.

NOTES ON NEW TECHNOLOGIES AND EVALUATIVE METHODS

The fundamental aim of this review is to enable learning from past efforts at electrification. Much of the literature reviewed in this work focuses on the impacts of grid electrification rather than electrification through distributed renewable sources. It is legitimate to ask whether past efforts at electrification actually hold lessons for current efforts, given the potentially different technologies involved. This paper contends that there are lessons that can be learned. The short justification for this (a longer account is offered in Appendix A) is that while distributed systems change the investment challenges and risks (they are less capital intensive overall and less costly for populations with low demand and far from the grid), they are unlikely to change the likelihood of using electricity for productive purposes. In fact, if anything, it is possible that distributed systems might undermine productive use compared with the instances of grid delivery that form the focus of reviews consulted here, because the electricity generated by distributed systems (when unsubsidized) tends to be more expensive than the grid tariffs explored in this review.[7]

A second point when considering evaluations of the impact of electrification on productive use is how such evaluations have been conducted. This is an especially relevant question when it comes to electrification, owing to the problem of controlling for endogeneity. In short (again a longer account of the issue appears in Appendix B), endogeneity is a statistical term that refers to cases where the relationship you seek to explore (in this case electrification's impact on productivity) is characterized by interactions between other factors that are difficult to observe. In the case of electrification's impact on productivity, both productivity and electrification can be driven by other factors. Electrification does not occur randomly in a country but is instead driven by other forces, such as the political salience of an area or the fact that an area might be expected to experience economic growth in the near future owing to evolution in its local economic base. In this context, exploring the impact of electrification on productivity requires disentangling the impacts of electrification on productivity from the other factors that might be driving increases in productivity. This process is known as controlling for endogeneity. To understand the different methods used to address this challenge, please see Appendix B of this report. Readers should also consult Appendix B when making sense of the footnotes contained in section 3.

7. It should be noted, of course, that the higher cost of electricity from distributed systems, compared with typical grid tariffs, could be accounted for through a system of cross-subsidization.

2. HISTORICAL LESSONS ON THE IMPACTS OF RURAL ELECTRIFICATION

Although rural electrification has recently gained prominence as a policy objective, efforts to promote rural electrification have a much longer history. A brief appraisal of these efforts provides further justification for this report and provides some relevant lessons for contemporary efforts to supply poor rural populations with access to electricity.

The notion that electrification is central to development is long-standing. For example, both Lenin in the 1920s and Roosevelt in the 1930s identified rural electrification as central to their country's respective economic transformations (Fluitman 1983). Roosevelt's introduction of low-interest loans to support the construction of power lines into rural areas has been identified as crucial in taking U.S. electrification rates from 13 percent in 1935 to 95 percent in 1955 (Lewis and Severnini 2014). This achievement is thought to have driven significant improvements in rural productivity through access to electric milking, refrigeration, electric lights and heating (for poultry production), and access to pumped irrigation (especially valuable in the dry U.S. western states) (Lewis and Severnini 2014). Such results caused the United Nations, as far back as 1954, to describe "the provision of electricity as a means of 'development first,' to improve the economic status of the population residing in the rural areas by increasing the productivity of human capital and secondly to promote rural welfare by providing an environment equal in comfort and convenience to that enjoyed in urban areas" (United Nations 1954, 33).

The success of such measures has been identified as the inspiration for the wave of electrification efforts that then took place in developing countries in the 1970s (Fluitman 1983; Barnes 2014). During this period it was hypothesized that electrification would increase the efficiency of existing productive activities (in cases where other fuels were being used), alleviate poverty by increasing productivity, address rural-urban inequality in terms of investments and outcomes, improve the quality of life in rural areas, vest human capital through improved access to health and education, and reduce environmental pressures created by the consumption of fuelwood (Fluitman 1983; Bernard 2010). Such imperatives were supported by donors who viewed electrification (through the process of grid rollout) as an area worthy of special attention owing to its character as a natural monopoly[8] with low returns (due to low demand) and thus a need for subsidies (Cook 2013; Bernard 2010). The result was a general belief that development could not happen without electricity and that the provision of electricity would transform rural economies (Barnes 2014; Barnes and Binswanger 1986). Because of electricity's symbolic value as a sign of modernity, it was also an effective source of political capital, and electrification projects tended to be pursued regardless of any assessment of their actual socioeconomic benefits (Bernard 2010).

This period produced widespread and ambitious electrification projects in countries such as Bangladesh, Bolivia, Chile, China, Colombia, Costa Rica, Ecuador, India, Indonesia, Malaysia, and Peru.[9] By the end of the 1970s, however, the mood of the development community had begun to change. With developing-country budgets buckling under the stress of impending structural adjustment, critics became increasingly vocal, pointing to the lack of impacts from expensive electrification projects. Across countries like Bangladesh and Malaysia, where electrification had been pursued, the Independent Evaluation Group of the World Bank, supported by a host of other studies, found disappointing results in terms of low connection rates (Barnes and Binswanger 1986), low economic returns, a lack of cost recovery, and little evidence of impacts on industrial development or the creation of local industries (Cook 2011, 2013; Barnes and Binswanger 1986; Barnes 2014; Bernard 2010; Cabraal, Barnes, and Agarwal 2005; Bastakoti 2006). Fluitman (1983), lamenting the process by which electrification efforts had been pursued, sums up the mood among development practitioners at the time:

> It would be unrealistic to believe that cost-benefit analysis is widely understood and applied; it is not at least in the case of rural electrification. What happens in practice is probably more like this; based on the conventional wisdom that rural electrification is a good thing, a political decision is taken to the effect that a significant amount of money should be mobilised and used to extend the electricity grid to a certain area hitherto without service; the decision, handed down to an organization responsible for implementing rural electrification programmes, is translated into nuts and bolts; sometimes, particularly if external funds are to be used, an attempt is made at cost-benefit analysis; but as it happens, conceptual and measurement problems cause costs to be

8. The electric grid is often described as a natural monopoly because it is characterized by high capital costs and low marginal costs—essentially, it costs a lot to build power stations and power lines, but once they are built it costs almost nothing to add one more person to the grid. Such conditions are not conducive to the operation of the free market. Barriers to entry are high, and established actors can easily undercut new actors, making competition in the market highly inefficient and leading to monopoly behavior. In addition, competition among monopolies can be highly inefficient, resulting in wasted infrastructure (imagine multiple electricity grids in the same geography) and inefficient pricing. For this reason, natural monopolies are thought to be best managed as regulated utilities, either public or private.

9. The current report was initially intended to undertake a detailed review of the impacts of electrification efforts in China as a potential best case. Because of challenges with the work, however, the scope of such a study was beyond the timeline for this paper.

> underestimated while demand for the service, and hence the benefits, tend to be overestimated; if the resulting rate of return is nonetheless too low, immeasurable benefits, usually including the political returns on which the decision was based in the first place, are invoked, and the project is approved; its success is measured in numbers of electrified villages; the project is finally completed and the utility company starts to suffer heavy losses; after some time, particularly if external funds have been used, an impact study of one sort or another is undertaken to discover how successful one has been in realising at least the developmental benefits; unfortunately, the Study suffers from the well known measurement problems and is therefore inconclusive; the rural electrification programme is expanded to cover more remote areas where fewer and poorer people live; additional subsidies take care of the ever increasing losses (pp. 27–28).

As concerning as the lack of economic impacts was the fact that where impacts did occur, they tended to be captured by the relatively wealthy, making public financial support for electrification highly regressive (Barnes 2014). Finally, it was found that people continued to cook using solid biomass (even if they did gain a connection), and thus the impacts of electrification on health and the environment were also called into question (Bernard 2010).

This first wave of electrification was not without bright spots. Some studies showed that electrification in India was correlated with increased land under irrigation and the acquisition of grain mills (Barnes and Binswanger 1986; Fluitman 1983). In Costa Rica, studies indicated that electrification had positive impacts on dairy, pig, and poultry farming as a result of access to milking machines, electric fencing, refrigeration, and incubators. In both China and Costa Rica new industries appeared in electrified areas, with the greatest gains occurring in industries where energy costs were a small proportion of the value output (e.g., milling, furniture making, textiles), although gains were few where energy costs represented a high proportion of outputs (blacksmithing, tile making, cooking) (Fluitman 1983). Overall, however, concerns about the relatively small size of impacts (and the extent to which they were captured by relatively wealthy groups), as well as financial troubles among many utilities, turned the mood against electrification.

Fluitman (1983), again, summarizes the concerns of the time: “There is not much evidence to suggest that electricity which is used for productive purposes has so far had any major impact on the employment/income situation of the rural poor. On the contrary, there is some evidence of net job losses and of a worsening income distribution as a result of rural electrification” (p. iv). By the end of the 1980s, with developing countries operating under conditions of austerity, critics of electrification won out (Barnes 2014). The donor focus shifted to other investments, such as health and education, with the logic generally being that such investments should be prioritized until local incomes had risen sufficiently to warrant investments in electrification (Bernard 2010; Barnes 2014; Cook 2011).

Since the mid-2000s, a renewed push for electrification has emerged, for a number of reasons. The first is growing dissatisfaction with austerity and the logic of structural adjustment[10] (Bernard 2010; Cook 2011). Second, and relatedly, is a sense that the development successes of the Asian economies stemmed from their investments in infrastructure, and thus the case for public investments in infrastructure in other contexts gained credibility (Cook 2011, 2013). Third, development practice and theory during the 1990s expanded beyond its traditional narrow focus on driving economic growth to address issues of poverty more broadly, including health, education, food, and gender equality. As a result, there has been an increased emphasis on the positive impacts of electrification on these outcomes, regardless of its direct productive impacts (Bernard 2010; Cook 2011). This final point has been bolstered, in particular, by numerous evaluations of the impacts of electrification showing that despite challenges to financial sustainability, willingness to pay for energy services is high in the majority of cases (much higher than the investment costs). As such it is thought that there must be some way to ensure that electrification efforts can be made fiscally sustainable (Cook 2013; Barnes 2014).

A notable feature of the above trends has been a general failure to learn from past experience. It is striking that the literature describing the electrification experience of the United States identifies problems identical to those experienced by developing countries in the 1970s. For example Barnes (2014) reports that the U.S. electrification program suffered from low initial loads, users' lack of understanding of the potential advantages of electricity, conservative use, and a lack of capital among rural households to invest in relevant infrastructure (i.e., connections and appliances). The following is from Frederick Muller's (1944) assessment of the challenges around rural electrification in the United States (quoted in Barnes 2014, 3–4):

> Generally speaking, three factors influence the rural use of energy. There is little of the high industrial load and none of the dense residential load, which have made utility operations profitable in urban areas. Second farmers and other rural residents are new, naturally conservative consumers. The purchase of electric energy becomes for most of them a considered alternative to other possible uses of their income. Rural consumers generally are still in the stage of exploring the economy and convenience of electric light and power, and they still hesitate to use these facilities in large

10. Structural adjustment generally refers to policies aimed at addressing fiscal imbalances and adjusting the economy toward achieving long-term growth. This goal is thought to be achieved by increasing the market orientation of any given country. The logic of structural adjustment is that such conditions are necessary for social flourishing; however, such an approach has been criticized for its negative effects on the poorest members of society.

> quantities. Rural communities have not come to the realization of the advantages of electrification with respect to local industries. The third factor is the economic status of most rural residents. They have not found it easy to pay for wiring, equipment, or energy.… Finally, of course, a fairly high percentage of farms are submarginal and not profitable, even if electrified. These factors have worked together to keep rural loads and consumption per consumer low.

Such an analysis could have come out of an assessment of a project in the 1970s or even an assessment of an electrification project being implemented in Africa today.

The emergent lesson from historical experiences is that to fully realize the benefits of electricity requires a set of preexisting conditions or the provision of complementary services, or both. In the case of the U.S. program, for example, to address some of the above problems, the government subsequently introduced programs to raise awareness of the benefits of electricity, to demonstrate the appliances that could be used, and to support the purchase of such appliances (Peters, Harsdorff, and Ziegler 2009).

The rush to electrify households in the 1970s displayed a failure to learn from the experience of the 1930s. The current push for electrification, while noble, likewise appears oblivious to the voluminous experience of the 1970s and 1930s. Among some authors writing on this topic, there is genuine concern that the current unbridled optimism over the potential impacts of electrification will be followed by another period of pessimism when impacts are not realized and invested resources go to waste (Barnes 2014).

3. EVIDENCE OF THE IMPACTS OF ELECTRIFICATION ON PRODUCTIVE USE

To consolidate the empirical literature on the impacts of electrification on productive use, the report breaks down the reviewed work according to the pathways through which productive use is expected to manifest. Based on the literature consulted, the following pathways were identified: (i) increased on-farm productivity, (ii) increased nonfarm household productivity, (iii) firm creation (including agricultural processing), (iv) increased productivity of existing firms, (v) improved productivity due to lighting, (vi) increased employment, and (vii) increased income. Each of these is discussed below, and the findings are summarized in Tables 1 and 2 at the end of the chapter.

INCREASED ON-FARM PRODUCTIVITY

The most obvious pathway by which electrification might affect productivity among rural households is through the uptake of electricity to drive increased agricultural production. This rise in production could take place directly through increased access to inputs (such as labor and irrigation) or indirectly through the availability of new services (such as refrigeration to prevent spoilage or ICTs to increase access to farm extension). In general, the literature considered here supports the claim that electricity increases on-farm productivity. That said, the literature showed variable impacts on income, which are discussed in the section on increased income below.

Several studies show positive impacts. Khandker, Barnes, and Samad (2009),[11] who consider the impact of electrification among 20,000 households in Bangladesh, observe an increase in farm productivity that results in positive impacts on household income. Similarly, Khandker et al. (2009) find that electrification had positive impacts on agricultural productivity in Vietnam.[12] Barnes and Binswanger (1986)[13] add detail to the picture of how electrification drives increases in farm productivity in their study of the impact of electrification on productive agricultural investments in 108 villages across three states in India

11. Using a propensity score matching approach; see Appendix B.

12. Using a difference-in-differences approach; see Appendix B.

13. Using a before-and-after approach that acknowledges place-based bias (by looking across three states over time) but not self-selection bias; see Appendix B.

between 1966 and 1980. They found that electrified households replaced diesel pumps with electric pumps (which could operate deep underground) and that electrification drove irrigation. Finally, in a study of an electrification project in Cuba, Cherni and Hill (2009)[14] also observe that electrification drove increased access to irrigation.

Contrasting with these findings, however, is work by Bastakoti (2006),[15] who finds the impact of electrification in Nepal to be limited, with few farmers using electricity to support irrigation.

INCREASED NONFARM HOUSEHOLD PRODUCTIVITY

Numerous studies of the effects of access to electricity on income-generating activities use the household as the unit of analysis. Such an approach potentially includes both on- and off-farm impacts, through the creation of cottage industries or small-scale processing. Although household impacts could be dealt with in other sections, they are separated out here for evaluation because household productivity was a prominent focus of the literature. Overall the empirical literature reviewed suggests that impacts on household productivity are small.

Across the studies considered, only Khandker, Barnes, and Samad (2009),[16] find substantial positive impacts on household productivity, with other studies indicating only small impacts. Bensch, Kluve, and Peters (2011),[17] for example, found that four years after the provision of electricity in Rwanda, households hardly used electricity to support productive tasks. Corroborating these results, Lenz et al. (2017)[18] find that 3.5 years after being electrified, households in Rwanda show no change in their income-generating pursuits. They further note that households generally do not invest in appliances that would be necessary to support productive use. Households do use appliances productively, including mills and sewing machines, but these are usually human powered, regardless of the availability of electricity. The only cottage enterprises that see any gains as a

14. Using a qualitative approach built around the sustainable livelihoods framework; see Appendix B.

15. Using an after-the-fact participatory qualitative survey approach; see Appendix B.

16. Using propensity score matching; see Appendix B.

17. Bensch, Kluve, and Peters (2011) looked at the impacts of electrification around a set of micro-hydro schemes built in Rwanda. The study avoids placement biases because relevant topography, rather than sociopolitical and economic factors, determined the installation of the micro-hydro generators. To deal with self-selection bias, the study used an approach similar to propensity score matching—it identified counterfactual households that had not been connected and that could be used to compare impacts; see Appendix B.

18. Using census-produced panel data for 974 households, along with qualitative surveys from 83 microenterprises and 50 schools. They complement this work with interviews with local leadership and deploy a difference-in-differences approach; see Appendix B.

result of electrification are those based on lending out cell phones, charging people's cell phones, or charging people to watch television (Lenz et al. 2017). Peters and Sievert (2016) ground the Rwandan case in a broader set of data drawn from household surveys conducted across Burkina Faso (two surveys), Indonesia, Rwanda, Senegal, and Uganda. Based on these data, they conclude that, within seven years of having been connected, households hardly use electricity productively and almost no households use appliances productively. In the few cases in which electricity is used productively, it is oriented toward the local population (e.g., mobile phone charging, showing television) with little export to urban markets and therefore little impact on the larger economy (Peters and Sievert 2016). Elsewhere in Africa, Wamukonya and Davis (2001)[19] consider the case of Namibia, where they use of survey of 371 households to compare the impacts of grid connections and solar home systems. They find no significant impact of electrification on income-generating activities. Finally, findings from sub-Saharan Africa are supported by a study of 1,262 households in Vietnam, where Khandker et al. (2009)[20] observed almost no impacts on household productivity, noting that "households … even those … that have home-based businesses or enterprises, use electricity predominantly for lighting and seldom for production or other business operations" (p. 10).

FIRM CREATION (INCLUDING AGRICULTURAL PROCESSING)

One of the most significant hopes for electrification programs is that they will create opportunities for myriad new services that were not previously available. It has been hypothesized that these services can, in turn, support the creation of new firms that either offer electronic services or deliver services that are only available when electricity is available as an input. The greatest hope for electrification has been that it will drive industrialization in newly connected areas, thereby transforming the agricultural economy, increasing incomes, and smoothing vulnerability to variable or worsening agricultural conditions. In general, the literature reviewed suggests that electrification can lead to firm creation but that the results are often more modest than anticipated. Impacts on rural industrialization are thought to be non-existent.

In terms of positive impacts, Bastakoti (2006)[21] finds that electrification in Nepal was accompanied by the development of numerous industries. Likewise, Barnes

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19. Not accounting for endogeneity and instead using a qualitative approach built around semi-structured interviews; see Appendix B.

20. Using a difference-in-differences approach; see Appendix B.

21. Using a simple before-and-after comparison; see Appendix B.

and Binswager (1986),[22] looking at the impacts of electrification in India, observe strong correlations between the acquisition of grain mills and the length of time an area has had access to electricity. Barnes (2014) further finds that electrification drove growth in the number of firms in India and Indonesia. Such positive effects notwithstanding, Barnes (2014) notes that the overall number of firms in electrified areas remains low and that any impacts were not as large as planners anticipated. Lenz et al. (2017, 102)[23] offer similarly cautious findings, noting that in Rwanda[24] electrification led to only "a slight increase in business activities in connected communities," with the impacts being greatest in areas that already contained thriving business centers. Barnes (2014) points out that nowhere in Colombia, India, or Indonesia did electrification lead to a significant increase in industry and commerce. Dinkelman (2011)[25] corroborates this claim, noting that rural electrification in South Africa has no impact on any sort of rural industrialization. Finally, Lenz et al. (2017)[26] point out that large energy consumers, such as welding enterprises or copy shops, established themselves in Rwanda only in response to electrification in areas with large and vibrant business sectors that existed before electrification.

INCREASING PRODUCTIVITY OF EXISTING FIRMS

Electrification has been anticipated to raise productivity by helping existing firms either increase their efficiency (as electricity and electric tools are more efficient) or as a result of increased energy inputs. The evidence here is, again, mixed, with some results suggesting effective uptake by firms and other research showing limited impacts.

Cowan and Mohlakoana (2005)[27] find that few households in an informal settlement in South Africa described using electricity to support their local business, but such findings seem to be something of an exception. Barnes (2014), for example, finds that in Colombia, India, and Indonesia, the productivity of firms that had connected to the grid had increased through the use of lighting, refrigeration, and a few driveshaft applications (though in Indonesia driveshaft applications continued to use diesel owing to the subsidies available). In addition, firms using electricity had lower fuel costs, higher labor productivity, and a

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22. Using a simple before-and-after comparison; see Appendix B.

23. Using census-produced panel data for 974 households, along with qualitative surveys from 83 microenterprises and 50 schools. They complement this work with interviews with local leadership and deploy a difference-in-differences approach; see Appendix B.

24. Using a propensity score matching approach; see Appendix B.

25. Using an instrumental variable approach; see Appendix B.

26. See footnote 19.

27. Based on qualitative interviews; see Appendix B.

greater diversity of processed or manufactured products. They were also larger and more efficient, had larger capital stocks, and were more productive. Likewise, Lenz et al. (2017, 102)[28] note that in Rwanda "existing enterprises partly extend either their hours of operation or their range of products and services. Some enterprises increase net community income by attracting demand from outside the community or offering products locally that were previously imported from urban areas." Specifically, they find that milling businesses benefit most as their switch from diesel to electricity results in access to a cheaper energy source running in an appliance that is more efficient. Hair salons also benefit as they switch from using car batteries to drawing power from the grid. Finally, some small kiosks benefit from increased access to lighting, media (via the radio), and refrigeration (though this is rare). As with the development of new firms, the impact of electrification on firms is generally greatest in areas that already have a thriving business center.

Nonetheless, the positive impacts of electrification on existing firms are not unmitigated. A study of 20,000 connectable structures across 150 rural communities in Kenya found that five years after the electricity grid had arrived, only 22 percent of businesses close enough to connect to the grid had actually done so (for comparison, only 5 percent of households had connected) (Lee et al. 2014). The firms most likely to connect were barbershops and salons. Energy-intensive enterprises such as mills (13 percent connected) and welders and carpenters (39 percent connected) also had relatively low connection rates—a surprising finding that suggests that firms continue to use expensive diesel even when the grid is available.[29] Food stands did not connect to the grid to any degree (Lee et al. 2014). Lenz et al. (2017)[30] echoes these findings, noting that in Rwanda tailors and woodworkers tend not to use electricity because their tools can currently be powered by human effort, and electronic appliances would be expensive to buy and susceptible to breakdown. Corroborating such accounts, Peters, Harsdorff, and Ziegler's (2009)[31] research in Benin observes that few firms use electricity to run appliances. There is also relatively little demand for these industries. These findings suggest that although electrification can have positive impacts on existing firms, as with households, simply making electric services available to an area is no guarantee that firms will use it.

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28. Using census-produced panel data for 974 households, along with qualitative surveys from 83 microenterprises and 50 schools. They complement this work with interviews with local leadership and deploy a difference-in-differences approach; see Appendix B.

29. As discussed in the following section, Lee et al. (2014) ascribe problems with the uptake of electricity to the government's failure to support last-mile connections.

30. See footnote 24.

31. Using a simple cross-sectional approach; see Appendix B.

IMPROVED PRODUCTIVITY DUE TO LIGHTING

Work on the impacts of electrification commonly points to the clear impacts of improved access to lighting, which are almost universally recognized. One particular focus of lighting has been the possibility that it will drive increases in productivity by increasing the efficiency of tasks carried out under better lighting and increase the number of hours any business can operate (Attigah and Mayer-Tasch 2013; Cabraal, Barnes, and Agarwal 2005). Further, numerous authors argue that the savings that accrue from the increased efficiency of electric lighting should drive increased incomes (Cabraal, Barnes, and Agarwal 2005; Aklin et al. 2017; Grimm et al. 2016; Aguirre 2017). In this regard, lighting could be considered an input to increasing the productivity of existing firms, but because of the extent to which this impact is discussed in the literature, it is here treated separately as a special case.

While it is true that improved lighting improves people’s productivity in performing tasks that would otherwise be carried out under low-light conditions, we should be wary of overstating the exact impact of such gains. First, as Attigah and Mayer-Tasch (2013) point out in their review of energy for productive uses, any benefits are likely to be business dependent. While firms that operate after dark (e.g., retail) or in poorly lit structures (e.g., cottage enterprises operating out of people’s homes) are expected to see greater benefits, industries that operate during the day, outdoors, or in structures with good natural light will likely see little improvement. Further, even among industries for which lighting might extend hours of operation, we should be cautious about overstating the impacts. In this respect, Azimoh et al. (2015),[32] in their study of the impact of solar home systems in South Africa, confirm that a major benefit of solar home systems was the ability to extend business hours. However, they further point out that the only benefit of this (as described by retailers who benefited from the scheme) was that retailers were more likely to give the correct change when working after dark. Aklin et al. (2017) confirm this in their randomized control trial looking at the impact of micro-grids on 1,491 Indian households that were provided with energy for basic lighting and mobile phone charging. They find no impacts on a variety of productivity indicators: no consistent effect on savings, household expenditure, household business creation, time spent in productive work by women, use of lighting for studying, or other indicators of development. While Peters, Harsdorff, and Ziegler (2009)[33] note that in Benin light is the most common way that firms take up electricity to support productive use, they also note that the impacts of lighting on income are almost non-existent. Finally, regarding the impacts of access to more efficient lighting on saving, Bensch, Kluve, and Peters (2011)[34]

32. Using a qualitative interview approach; see Appendix B.

33. Using a simple cross-sectional approach, not accounting for endogeneity; see Appendix B.

34. See footnote 13.

point out that one should be careful of overstating their value as households tend to consume efficiency gains in the form of more light rather than converting efficiency gains into savings.

INCREASED EMPLOYMENT

Under conditions of increasing land pressure and worsening agricultural returns, there has historically been a great deal of hope that electrification will drive productivity gains enough to increase employment in rural areas. In effect, efforts to explore impacts on employment use a single metric to consider impacts on household productivity, firm creation, and firm growth. Within the literature there is some debate over whether the introduction of electricity drives job contraction or job expansion. One thesis is that electricity replaces labor-intensive tasks. Another thesis contends that electricity contributes to the formation of new industries, thereby creating new jobs (Peters and Sievert 2016; Fluitman 1983). Empirical work on this front suggests that positive impacts are possible and are most likely to be realized by women. Again, however, variable findings across studies suggest caution in drawing conclusions.

A high-profile study of electrification efforts in the South African province of KwaZulu-Natal finds that within five years of electrification, both men and women work more hours per week (13 and 8.9 hours more, respectively) with women's employment increasing significantly by between 9 and 9.5 percent (Dinkelman 2011).[35] Male employment also rises, but it does so insignificantly and to a lesser degree than for women. Dinkelman explains these findings in terms of electrification's effect in the home, where it frees up women's time and allows them to take up work, largely in home-based microenterprises (the study finds, however, that women's income does not increase; see the following section, "Increased Income").

Similarly, a study of 7,018 rural households in Bangladesh finds that electrification "has brought substantial benefits to rural households … evidenced by increased labor force participation" (Samad and Zhang 2017, 3).[36] Like Dinkelman (2011), the authors find that electrification disproportionately benefits women, whose labor force participation increases 2.3 percentage points a year, whereas men see no impact on labor force participation. In a study of the mass rollout of electrification in Peru, Dasso and Fernandez (2015)[37] observe "modest effects": Women see an increase in their likelihood of being employed, whereas men see the hours they work in their main job increase by 2.5 hours per week

35. Using an instrumental variable approach; see Appendix B.

36. Using an instrumental variable approach; see Appendix B.

37. Using a difference-in-differences approach; see Appendix B.

and become less likely to hold a second job. Men also see an increase in their likelihood of being employed in agriculture, whereas women see a decrease.

Confounding the above findings, Cherni and Hill (2009)[38] find that although electrification in Cuba drives improvements in health and irrigation, its impacts on job creation are minor. Likewise, in a study of households receiving solar home systems in South Africa, only one quarter of the interviewed respondents reported that the electrification program had led to any sort of job creation or increased chance of employment (Azimoh et al. 2015).[39] Burlig and Preonas (2016)[40] find more startlingly negative results in their large study of the impacts of electrification in India. They observe only a small (but statistically precise) impact on male employment, with employment in agriculture declining and employment outside of agriculture rising (by a similar amount). They observe no impact on female employment. Importantly, they note that their findings hold regardless of how long a village has been connected and they account to some extent for the quality of the electricity supply.

INCREASED INCOME

Other positive impacts notwithstanding, the fundamental purpose of promoting productive use is to increase income. In this regard, some studies indicate positive results and others show no impacts. Moreover, some studies that identify positive impacts in terms of firm creation or labor participation suggest that caution should be exercised when using these as proxies for understanding the potentially productive impacts of electrification.

Both Khandker, Barnes, and Samad (2009)[41] in Bangladesh and Khandker et al. (2009)[42] in Vietnam find positive impacts on income as a result of electrification. The impacts in Vietnam stem from increases in on-farm income only, whereas in Bangladesh they stem from productivity improvements in both on- and off-farm endeavors. The impacts in Bangladesh are particularly notable, with household income increasing by 9–30 percent. These returns, however, are found to be diminishing; increases in productivity decline year-on-year, saturating after 8.6 years of connectivity. Samad and Zhang (2017)[43] corroborate these findings for Bangladesh in a study exploring how the length of time someone has been connected and the quality of the electricity supply affect income. Using a large

38. Using a qualitative approach built around the sustainable livelihoods framework; see Appendix B.

39. Using a qualitative interview approach; see Appendix B.

40. Using a regression discontinuity approach; see Appendix B.

41. Using propensity score matching; see Appendix B.

42. Using a difference-in-differences approach; see Appendix B.

43. Use an instrumental variable approach; see Appendix B.

sample, they find that "electrification … has brought substantial benefits to rural households … evidenced by increased income" (p. 3). Based on this finding, they estimate that the potential gains from providing universal access to electricity and improving the reliability of Bangladesh's electricity supply could reach $2.3 billion a year. Finally, in the case of Peru, Dasso and Fernandez (2015)[44] see women's wages go up by 35 percent, along with an increase in employment of 3.5%. Given that women's income increases are greater than men's, Dasso and Fernandez suggest that electrification aids in reducing the wage gap.

Other studies contradict these findings. Burlig and Preonas (2016)[45] assess the impacts of rural electrification in India. Their study of 30,000 villages rules out almost any impact on household assets or housing stock, which they take to indicate a lack of impact on income. Likewise, Cowen and Mohlakoana (2005), in a qualitative study of the impacts of electrification in informal settlements in urban South Africa, find that access to electricity does not contribute in a meaningful way to local income generation through productive use.

In addition, the positive impacts of electrification on productivity may not always translate into improved incomes. Although Dinkelman (2011)[46] finds increased female employment and hours worked per week in South Africa, for example, she also finds that women's wages fall by about 20 percent, so that women's earnings remain about the same as in the pre-electrification period. The reason for the fall in women's wages is unclear, but it is thought to be due to the electricity-induced decline in the cost of producing new home-based services. Still, Dinkelman (2011) finds that incomes increase by 16 percent for men, who work more hours while earning wages similar to what they earned before electrification (see the earlier section "Increased Employment").

Similarly, although Bastakoti's (2006) findings indicate an increase in the number of firms operating in Nepal after electrification,[47] that same study shows that the increase in the number of mills has been found to simply increase competition among millers. While this competition has reduced the distance consumers must walk to reach a mill, it also means that mill owners now struggle financially.

Lenz et al. (2017)[48] points out that while small enterprises that benefit from electricity do increase the income of the business owner, given the nature of the businesses they tend to do little to increase the economic base of the community as a whole except in cases where the community is located on a large road that

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44. Using a difference-in-differences approach; see Appendix B.

45. Measured by satellite images showing nighttime brightness that can identify the use of electric lights; see Appendix B.

46. Using an instrumental variable approach; see Appendix B.

47. Based on a simple before-and-after approach that does not account for endogeneity; see Appendix B.

48. Using census-produced panel data for 974 households, along with qualitative surveys from 83 microenterprises and 50 schools. They complement this work with interviews with local leadership and deploy a difference-in-differences approach; see Appendix B.

brings in people from outside to purchase goods and services. This situation limits the genuine growth effects possible as a result of electrification. Finally, even within the literature citing positive impacts of electrification on income (e.g., Khandker, Barnes, and Samad 2009; Khandker et al. 2009), studies point out that these positive impacts on household income accrue only to wealthy households, with poor households seeing no impact at all.

Table 1: Summary of authors' findings on the impact of electricity, by impact pathway

Impact	Farm productivity	Household productivity	Firm creation	Existing firms	Lighting	Employment	Income
Positive	Khandker, Barnes, and Samad 2009; Khandker et al. 2009; Barnes and Binswanger 1986; Cherni and Hill 2009	Khandker, Barnes, and Samad 2009	Bastakoti 2006; Barnes 2014	Lenz et al. 2017; Barnes 2014	Hypoth-esized based on positive lighting effects	Dinkelman 2011; Samad and Zhang 2017; Dasso and Fernandez 2015	Khandker, Barnes, and Samad 2009; Khandker et al. 2009; Samad and Zhang 2017; Dinkelman 2011
None/ limited	Bastakoti 2006	Bensch, Kluve, and Peters 2011; Peters and Sievert 2016; Wamukonya and Davis 2001; Khandker et al. 2009	Barnes 2014; Lenz et al. 2017; Dinkelman 2011	Lee et al. 2014; Cowan and Mohlakoana 2005	Azimoh et al. 2015; Aklin et al. 2017; Peters, Harsdorff, and Ziegler 2009	Cherni and Hill 2009; Burlig and Preonas 2016; Azimoh et al. 2015	Dinkelman 2011; Burlig and Preonas 2016; Bastakoti 2006; Lenz et al. 2017

Note: Note the variance and conflicting findings among authors.

Table 2: Summary of country findings on the impacts of electricity, by impact pathway

Impact	Farm productivity	Household productivity	Firm creation	Existing firms	Lighting	Employment	Income
Positive	Bangladesh, Cuba, India, Vietnam	Bangladesh	Colombia, India, Indonesia, Nepal	Colombia, India, Indonesia, Rwanda	Hypoth-esized based on positive lighting effects	Bangladesh, Peru, South Africa	Bangladesh, South Africa, Vietnam
None/ limited	Nepal	Burkina Faso, Indonesia, Namibia, Rwanda, Senegal, Uganda, Vietnam	Colombia, India, Indonesia, Rwanda, South Africa	Kenya, South Africa	Benin, India, South Africa	Cuba, India, South Africa	India, Nepal, Rwanda, South Africa

Note: Note the general lack of positive impacts in Africa, outside of South Africa.

UNDERSTANDING THE IMPACTS OF ELECTRIFICATION ON PRODUCTIVITY

Overall the impacts of rural electrification on productivity appear mixed. Studies showing significant positive findings are countered by other studies showing either a lack of impacts or small impacts. It is difficult to draw clear conclusions from the review, other than to note that while electrification can clearly have positive impacts, there are a host of circumstances in which impacts will be small or negligible. The question thus arises: what determines such outcomes? The following chapter of this report seeks to answer this question.

One notable feature of Table 2 is the extent to which positive impacts fail to appear in Africa outside of South Africa—a point made explicitly by Peters and Sievert (2016). Further, there appears to be some evidence suggesting that where electrification does have positive impacts on employment, these impacts are greatest among women.

Notably the conclusions drawn above resonate strongly with the findings of other reviews of the literature on electrification and productive use. For example, Bernard (2010), in his review of rural electrification programs in sub-Saharan Africa (considering both grid extension and distributed generation), confirms limited impacts in the region, noting that impacts on productive use are limited and, in general, still a rarity. Attigah and Mayer-Tasch (2013), in their review that considers both qualitative and quantitative studies of the impacts of electricity access on productive use, highlight the large variability across studies. They note that while studies find positive impacts of electricity on productivity, and this occurs across geographies, insignificant (or even negative effects) are found elsewhere. They likewise point out the general sense that impacts are positive but not as large as electrification proponents might have anticipated. Jimenez (2017) obtains similar results in a systematic review that prioritizes robust impact assessments that have attempted to get around the methodological challenges laid out in Appendix B. Jimenez's review comes to a clearer conclusion regarding the positive impacts overall. Based on 50 impact assessments, Jimenez finds that electricity drives labor market participation up by 25 percent on average, with a median increase of 20 percent. That said, large levels of variability are again apparent. For example, of the 24 studies that consider household income, 8 find no significant impact. Further the scale of impact varies widely from an 18 percent reduction in income (although this number is not statistically significant) to a 100 percent increase in income. Finally, in a review of the impacts of energy access among women, Rewald (2017) points to evidence suggesting that electricity has specific impacts on women's economic opportunities, but she also points to work that contests this general finding, suggesting that positive findings might be context specific. Overall she argues that the exact impact of electrification on women's microenterprises and income-earning capacity is not sufficiently well researched or understood.

Beyond the general understanding that impacts can be positive (possibly in the aggregate), yet highly variable and often less than had been anticipated by proponents, some authors draw more pointed conclusions. For example, Attigah and Mayer-Tasch (2013) note that impacts on on-farm income are rare. They further point out that the literature on business income is thin and conclusions cannot be drawn. Jimenez (2017) corroborates this, noting that while studies are more likely to find positive impacts on the productivity of firms, the findings are even more heterogeneous than they are regarding household income. Finally, both Jimenez (2017) and Attigah and Mayer-Tasch (2013) appear to confirm the idea that impacts on women are most likely to be positive, especially for labor market participation.

Based on the above, two questions become apparent. First, what factors drive such variability in outcomes, and can these be manipulated to increase the likelihood that electrification will result in economic gains? Second, in cases where impacts are limited, can other investments be made that might have greater impacts on productive use or that might be more appropriate? The remainder of the report is concerned with these two questions.

4. ELECTRIFICATION AND PRODUCTIVITY: EXPLAINING VARIABILITY

In many ways, this section of the report is the most important. The varied results of the studies on the productive impacts of electrification stem partly from the context in which electrification took place. This situation creates the possibility of pursuing complementary policies to maximize the likelihood that electricity is used for productive purposes. Of course, it is possible that a substantial share of the variance in results from the different studies stems from variations in methods and data quality (Attigah and Mayer-Tasch 2013). That said, the dominance of more sophisticated methods used in the studies reviewed here suggests that methodological deficiencies do not account for all of this variance, and thus an exploration of the impact of context is relevant.

COMPLEMENTARY SERVICES AND THEIR GROWING RECOGNITION

Frustration with disappointing results from electrification efforts in the 1970s has led to a general sense that electrification alone will not drive economic development (Bernard 2010). With the renewed focus on energy access, there has been a greater focus on the need for electricity to be delivered with complementary services in order to make sure that the people and firms capable of connecting do so and that they reap the benefits of access to electricity (Peters and Sievert 2016; Cook 2011; Barnes 2014; Rogerson 1997; Attigah and Mayer-Tasch 2013). For the most part this notion of complementary services has stemmed from efforts to resolve the puzzle of why people express high willingness to pay for electricity yet tend not to connect when electricity is available. The most obvious explanation is that people either lack an understanding of the benefits electricity provides, or they understand the gains but lack the means to connect. As such the vast majority of complementary services have focused on providing additional finance as well as raising awareness about the benefits of electrification. Beyond these two prominent recommendations, the literature identifies a host of other conditions and services as able to support the uptake of electricity for productive use. Below we discuss each of these: awareness raising and education, finance, transport, ICTs/telecoms, quality of supply, time connected, income, and policy coordination.

What follows is somewhat speculative. In some cases, authors have studied contextual factors—for example, income or the impact of reliability or time connected. In other cases, authors have sought to explain variable impacts by speculating on the role of contextual factors or on the policy implications of projects generating disappointing findings. That being said, the validity of the activities identified below is bolstered by other publications, such as a manual for promoting productive use that was developed by GIZ and the World Bank, which identifies concrete possibilities for productive use in the local economy and then focuses on raising awareness of productive electricity, providing technical assistance to enterprises, and facilitating access to finance (Brüderle, Attigah, and Bodenbender 2011). Overall, then, while this section is useful as a starting point for policy formulation, more research is needed on the impact of such complementary services.

Awareness raising and education

A number of authors point to the need for electrification efforts to be accompanied by some form of awareness raising regarding the benefits of electrification (Barnes 2014; Peters and Sievert 2016; Cook 2011; Attigah and Mayer-Tasch 2013). As mentioned, assessments of willingness to pay reveal large benefits, yet electrification projects experience low connection rates and low loads (Cook 2011, 2013). In addition, a number of authors point out that even the iconically successful rural electrification efforts in the United States initially faced resistance (Barnes 2014), being perceived by some recipients as a threat to morality and an interference with God's order (Peters and Sievert 2016). Even these projects thus required support in the form of awareness raising and advocacy around the benefits of electricity in order to be successful (Bastakoti 2006; Barnes 2014).

Similar awareness-raising efforts are needed regarding the benefits of appliances (Fluitman 1983). Peters and Sievert (2016) observe such dynamics in Benin, noting a general lack of knowledge about both the benefits of electricity and the use of electric tools and appliances for productive use. They argue for the need for awareness raising and vocational training in order to realize the full array of benefits from electrification (Peters and Sievert 2016).

Beyond awareness, Barnes (2014) points to the connection between formal education and the positive effects of electrification, noting that electrified areas are correlated with education levels. He also notes that electrification efforts need to be accompanied by educational investments if we are to see the uptake of electricity for farm irrigation and innovation.

An additional frequently mentioned component of education is the need for business development support (Attigah and Mayer-Tasch 2013). Barnes (2014) argues that the limited impacts of electrification in Colombia could have been improved if the electrification project had been wrapped in services delivering training in entrepreneurship. Likewise, Bastakoti (2006) points out that Nepalese firms that formed in response to electrification described having received specialized training that helped them think through the many dimensions of their potential business undertaking. Finally, although only tangentially related to education, efforts to capitalize on the gendered dimensions of productive use as a result of energy access point to the need for electrification to be supported by women's empowerment initiatives (Rewald 2017).

Financial services

Besides education and awareness, the most commonly cited complementary service consists of supportive finance and access to credit (Attigah and Mayer-Tasch 2013; Cook 2011, 2013; Barnes 2014; Rewald 2017), the lack of which is considered a major impediment to the uptake of electricity for productive use (Fluitman 1983; Peters and Sievert 2016; Rogerson 1997). Among poor populations, credit is necessary to allow them to invest in actually connecting to the grid. This point is well established when it comes to domestic uses of electricity, but in a study of the grid rollout in Kenya, Lee et al. (2014) show that it applies to businesses as well; the majority of businesses (outside of hair salons) in newly connected regions of Kenya fail to connect.

Credit also enables households to purchase the appliances they need to benefit from electrification. Peters and Sievert (2016) point to the unwillingness of microfinance institutions to accept purchased equipment as collateral. Fluitman (1983) further notes that the appliances necessary for productive use must have established supply chains so that households are not only able to buy them but also can be taught how to use them and have them repaired and serviced as necessary.

Finally, although not a clear financial service, issues of pricing and availability of competing fuels also affect the uptake of electricity for productive use (Barnes 2014). Barnes argues that India saw a rapid uptake of electricity for irrigation only because of the availability of a subsidy for electricity. It should go without saying that subsidies for fossil fuels that render them cheaper than electricity will slow the uptake of electricity for productive use.

Transport (access to markets)

Many authors point to the need for electrification to be accompanied by investments in complementary infrastructure. The most frequently cited of these is investments in roads (Attigah and Mayer-Tasch 2013; Cook 2011). Barnes (2014) notes that any sort of industry is unlikely to relocate to a rural area until issues of transport and telecommunications (see below), as well as electrification, have been resolved.

For productive use, the principal value of roads is to provide *access to markets* (Peters and Sievert 2016). It is widely appreciated that, in addition to awareness and credit, access to markets is the greatest determinant of whether electrification will result in economic growth. Fluitman (1983) points out that where electrification did not drive the desired economic impacts in India, it was because villages were so dispersed that would-be entrepreneurs could not access markets. Barnes (2014) reiterates this point, noting that proximity to markets was essential for electricity to be taken up for irrigation in India, as well as for firm development to take place alongside electrification.

Rogerson (1997) also identifies access to markets as one of the most powerful factors determining whether electrification drives productive use. Similarly, Peters and Sievert (2016) note that the single resounding finding from their assessments of the impact of electrification on productive use in five countries is that access to markets is the major determinant of whether people use energy for productive purposes. They note that while complementary services might help increase the uptake of electricity for productive use, without a customer base to which people can sell their goods, it is unlikely that businesses will form. Only in the most vibrant market centers, therefore, does electrification have any impact on firm development (Peters and Sievert 2016).

Information and communication technologies (ICTs)

Besides roads, the most commonly mentioned type of infrastructure necessary to support productive use consists of ICTs or telecommunications (Cook 2011; Attigah and Mayer-Tasch 2013). ICTs are thought to be important for providing information on market conditions and linking consumers with producers (Peters and Sievert 2016). Further, as mentioned, Barnes (2014) argues that without access to roads and ICTs in addition to electrification, firms will not relocate to rural areas—and there will thus be no major impacts on labor markets.

Quality and reliability of electricity supply

An additional consideration related to infrastructure is the quality of the electricity actually supplied. Attigah and Mayer-Tasch (2013) argue that impact studies' failure to control for the quality of supply explains some of the variance across studies considering productive use. Fluitman (1983) lends credence to this claim when he notes that low-quality electricity supplies undermined the capacity of electrified populations in India to effectively use electricity for productive use. Samad and Zhang (2017) quantify these impacts when they analyze the impact of the quality of electrical supply in Bangladesh; they find that for every one-hour increase in daily outages, households experience a 5.9 percent increase in paraffin use and a 0.3 percent reduction in annual household income. In cases where outages occur for more than 21 hours a day, the differences between connected and unconnected households disappear.

Considering those findings, and given the numerous brownouts experienced by households in the developing world, one might be tempted to throw out the literature on complementary services and simply argue that so long as high-quality electricity supply can be made available, then we should see the expected development impacts of electrification.[49] In contrast, other findings that control for quality (certainly at the levels of sensitivity captured in Samad and Zhang's 2017 work) generate findings showing that electricity has few, or no, impacts on productive use. For example, Burlig and Preonas (2016) account for the quality of supply using measures of nighttime illumination, which would be sensitive to brownouts, and still find the impact of electrification on productive use to be insignificant. Similar findings from Peters, Harsdorff, and Ziegler (2009) note that even though blackouts are rare in northern Benin, the uptake of electricity to support productive use is extremely limited. Likewise, Lenz et al. (2017) find that although outages on the Rwandan grid are frequent (3.8 per month), they do not last long. Nonetheless, they find that access to electricity does not result in large changes to the income-generating pursuits of connected households. The only changes pertain to very small enterprises built around services such as charging cell phones or watching television. Overall, it appears that although the quality of electricity supply matters, cases in which impacts on productive use were limited cannot be entirely accounted for by unreliable service alone.

Time connected

Another argument holds that the limited impacts of electrification are a result of the limited amount of time that an area has been electrified (Attigah and Mayer-Tasch 2013). Samad and Zhang (2017) lend credibility to this argument when they find that for each additional year a household is connected to the grid, that household sees a 1 percent increase in annual income. Again, however, a number of studies find few impacts on productive use despite covering periods that would be long enough to see the impacts identified in Samad and Zhang's (2017) analysis. This includes Peters and Sievert's (2016) evaluation of five African countries, as well as Burlig and Preonas's (2016) evaluation of the impacts of electrification in India. Notably, if the time an area is connected matters for driving impacts from electrification, the impacts expected to take longest to manifest are from electrification's impact on education (Mulder and Tembe 2008).[50] Essentially, as with the quality of electricity supply, it appears that the length of time any area and household are connected affects the likelihood of seeing productive uses, but simply connecting areas does not mean that the productive promise of electrification will eventually arise.

49. Samad and Zhang (2017) argue against this, noting that their findings are context specific and that caution should be exercised before they are extrapolated to other contexts.

50. Mulder and Tembe's (2008) findings are based on a theoretical model of the impacts of electrification and not on empirical data.

Income

Wealthy individuals have been found to benefit disproportionately from electrification, while low-income households see few to no effects (Fluitman 1983). Attigah and Mayer-Tasch (2013) explain the variance in the findings of impact studies as the result of their failure to control for income. Fluitman (1983) notes that these differential effects are thought to result from the fact that wealthy people use electricity when they can afford it—not that electricity makes people wealthier. Poor individuals are less likely to be able to afford the connection fees and less likely to be able to support the range of investments required to drive effective firm development (Fluitman 1983; Cook 2011). The fact that the poor tend to have less access to education may also contribute to differential impacts; educated groups are thought to have a greater sense of the benefits of electrification (Cook 2011).

Several studies add complexity to these findings. Samad and Zhang (2017) and Khandker et al. (2009) note that while the benefits of electrification accrue to wealthy individuals and have few effects on the poor, the rate of growth in these benefits decreases over time,[51] thereby potentially allowing the poor to catch up (Barnes 2014). This is essentially the argument that electrification drives inequality in a fashion that resembles a Kuznets curve, with inequality initially increasing and then decreasing. Although there might be some evidence of this in certain instances, Samad and Zhang (2017) go on to note that returns to electrification in Bangladesh (in terms of both income growth and expenditure growth) increase monotonically (i.e., growth is always getting larger). As a consequence, the poor will not catch up to the wealthy, and the impacts of electrification will increase inequality.

Furthermore, it may be that the benefits to the wealthy drive spillover effects that benefit the poor. An evaluation of electrification in Ecuador by the U.S. Agency for International Development (USAID) found that the positive impact of electrification on regional or market towns had positive impacts for surrounding areas that were not electrified (Fluitman 1983). However, such positive spillovers did not manifest everywhere. Fluitman makes the point that electrification itself does not meet a basic human need and that the productive impacts depend on the larger structures of the economy that electrification serves. If electrification drives local growth that is inclusive, then spillover effects can be realized—this is not a product of electrification but rather of the structure of the economy in which electrification takes place.

Differential impacts on rich and poor households are mirrored by findings of differential impacts among large and small businesses. Large firms have been identified as benefiting most from electrification, ostensibly because they are

51. The hypothesis is that when households first connect, they see a large increase in their incomes as they take advantage of productive opportunities, but subsequent productivity increases are smaller.

capable of investing in machinery and selling goods to areas beyond their own markets (Attigah and Mayer-Tasch 2013; Peters, Harsdorff, and Ziegler 2009). The process by which wealthy individuals and large firms benefit most from electricity mirrors the fact that benefits tend to accrue most to areas that are well-off and economically dynamic, while poor, economically stagnant areas see few impacts. Almost all authors agree that without a healthy economic base, one should not expect to see electrification lead to development of firms or substantial productive use (Barnes 2014; Rogerson 1997).

The idea that electrification has differential impacts based on income is prominent and well established in the literature. In many respects, the fact that there is a general appreciation of the need for complementary services reinforces this finding, because such services are essentially intended to overcome barriers to the uptake of electricity presented by low incomes. For example, access to credit is intended to overcome a lack of income to invest in connections and appliances, investments in roads are intended to provide access to markets, and access to education is intended to overcome the fact that educated populations are more likely to use electricity productively.

Policy coordination

Overall, the variety of services and infrastructure that needs to accompany electrification in order to generate productive activities has led to calls for electrification to be integrated into broader rural development planning (Rogerson 1997; Cabraal, Barnes, and Agarwal 2005; Bastakoti 2006; Attigah and Mayer-Tasch 2013; Aklin et al. 2017; Rewald 2017)—although there appears to have been almost no empirical testing of this idea. In a review of works on the success of electrification efforts in China, Bhattacharyya and Ohiare (2012) point to the importance of incorporating electrification efforts into broader development policy focused on agricultural intensification and poverty alleviation. Barnes (2014) makes a similar argument comparing the experiences of India and the Philippines. He points out that in the Philippines electrification was rolled out to meet domestic energy access needs, whereas in India it was rolled out to support agriculture. These design imperatives led to supportive complementary policies in India (such as energy subsidies for electricity consumed by water pumps), which in turn drove much greater productive use than in the Philippines. Barnes therefore argues that it is possible to intentionally and effectively take steps to increase the likelihood that people will make productive use of electricity.

It might argued that this conclusion is “fairly obvious … [and] that rural electrification cannot be effective in a vacuum. Local attitudes and skills, the state of infrastructure, levels of income, patterns of land use and land ownership, access to credit, demand for whatever is produced, and other such complementary factors, may each and all turn out to be bottlenecks in making the most out of rural electrification” (Fluitman 1983, 55). Nonetheless, it should be acknowledged that achieving integrated planning and service and infrastructure delivery has not been the norm. As Cook (2013, 33) points out, “These aspects [complementary infrastructure and services] are not normally part of rural electrification programmes provided by private or state-owned utilities. Even enterprise development programmes have not, as a rule, been designed to promote end-uses of electricity.”

Such coordination is not only uncommon but also difficult to achieve (Cook 2011; Bastakoti 2006). Awareness and education are not the normal purview of utilities, and orchestrating the complementary delivery of the broad array of infrastructure and services described above would require effective coordination across different ministries and departments, including roads, finance, rural development, trade and industry, land, and education. Not only is this coordination a challenge, but it is a challenge that weak bureaucracies in developing countries are likely least able to attend to. These bureaucracies not only lack technical capacity, but also suffer from perverse incentives and capture in many countries (Mulder and Tembe 2008). In a study of an electrification effort around a hydroelectric scheme in Nepal, Bastakoti (2006) points out the extent to which the Nepal Electricity Authority lacked the internal institutional mechanisms for providing complementary services, as did the private utilities that are retailing the electricity. Further, even though the initial plan was to provide services to support enterprise promotion, this program was scrapped after it ran out of funding. Bastalokti makes a point that is widespread in the development literature: having institutions in place is one thing, but having both the institutions in place and the political will to ensure they can execute their tasks is another matter entirely.

Finally, while the literature makes a strong case for supporting electrification efforts with integrated development planning and policy coordination, this review covered one case that, despite appearing to implement such integrated planning, achieved only limited impacts. In Cuba electrification efforts failed to drive significant off-farm productive activity even though the electrification effort took place in a context of effective coordination across ministries and delivery of other infrastructure, such as roads, as part of the project (Cherni and Hill 2009).

INSIGHTS FROM THE RURAL NONFARM ECONOMY (RNFE)

The literature on the rural nonfarm economy (RNFE) is focused on understanding the drivers of nonfarm economic activity. The work has been stimulated both by a realization of the importance of the nonfarm economy to rural households and by increasing concern about the declining productivity per capita of the agricultural sector. This work has sought to identify which public investments best support the development of the RNFE, econometrically modeling the relationship between available infrastructure and RNFE activity. While this literature does not account for all the pathways by which productivity might be increased (most obviously ignoring increases in agricultural productivity), it is useful as a means to interrogate the findings from the review of literature described above. This is especially the case because the authors publishing on the RNFE show little overlap with authors exploring the impacts of electrification, thereby limiting systematic bias.

Overall, the RNFE literature largely corroborates the findings described above, with four prominent features emerging. First, there is consonance between the literature on RNFE and the literature on electrification on the necessity of complementary or contextual factors for achieving economic growth in rural areas. Second, the RNFE literature has a relatively minor focus on the role of electricity in driving off-farm economic activity. Third, efforts to drive development of the rural nonfarm economy are paradoxical: the poorest and most marginal areas, which most need nonfarm economic growth, are least likely to see the benefits of investments. Fourth, the impacts of particular forms of infrastructure might be time variant—i.e., they may depend on the stage of development an area is experiencing.

Confirming the need for complementary investments

Just as the literature on electrification finds that it is small retailers who tend to take up electricity (usually in the form of light or electronic services), so the literature on the RNFE points out that firm development in the rural economy initially strongly favors trade and services over industry (Reardon et al. 2007; Haggblade, Hazell, and Reardon 2010). Rural manufacturing occurs only once the agricultural share of the labor force begins to decline, causing an increase in real wages and an increase in the opportunity cost of labor. At that point nonfarm activities such as mechanical milling, transport and commerce, and personal health and education services start to emerge (Haggblade, Hazell, and Reardon 2010). It is therefore unsurprising that impact evaluations find that only small traders tend to take up electricity when it is available, that electricity is generally not used to support large turning power, and that the number of firms using such power is extremely limited. Likewise, it makes sense that it is women—through their engagement in cottage industries—who have been observed to see the greatest gains in labor force participation in the wake of electrification, as it is these small, retail-focused, cottage industries that benefit most.

Second, access to markets is enormously important: a strong and generalizable finding from the RNFE literature is that the nonfarm rural economy requires an economic base (such as mining, agriculture, or tourism) to support its development. Otherwise, it is proximity to towns, or roads carrying people in and out of towns, that matters for the development of the RNFE (Haggblade, Hazell, and Reardon 2010; Reardon et al. 2007).

The issue of access to markets and a thriving economic base dovetails with the issue that it is the relatively well-off who benefit most from electrification, a finding that the RNFE literature confirms. For example, a 15-year study of 1,240 households in Ethiopia finds that it is consumption per capita and livestock holdings (i.e., income and wealth) that determine engagement in nonfarm income-generating activities (Weldegebriel, Folloni, and Prowse 2015). The RNFE literature adds nuance, however, to the general idea that it is the wealthy who benefit by distinguishing between accumulation and survivalist enterprises, which are thought to manifest in response to “pull” or “push” factors respectively. Pull factors are those that drive the accumulation of wealth in the nonfarm sector, while push factors refer to constraints on livelihoods that force people to diversify their rural livelihoods in order to survive (Haggblade, Hazell, and Reardon 2010; Reardon et al. 1998).

Accumulation strategies generally occur in stable, productive areas with a strong economic base and access to other infrastructure and markets. Survivalist strategies tend to dominate in areas with low or variable productivity where impoverishing processes dominate (such as when land fractionalization is taking place in response to population growth). Survivalist strategies also tend to be characterized by very small amounts of capital and large labor inputs (Haggblade, Hazell, and Reardon 2010; Reardon et al. 2007; Alobo 2012). Notably, for both the accumulation and survivalist strategies, the RNFE literature has made extensive use of the livelihood model to understand investment decisions. In general households with access to large amounts of capital (human, physical, natural, social, or financial, as defined by the sustainable livelihoods approach) are more likely to engage in nonfarm economic activity. As Reardon et al. (2007) point out, all nonfarm activity requires some form of capital input, and rare capital tends to generate the largest incomes; because the wealthy have access to the most capital, they tend to benefit the most from nonfarm economic activity (even if poor households might be more reliant on that activity as a share of their total income). Despite this general rule, the RNFE literature seems to suggest that there is no clear trend regarding whether RNFE activity increases or decreases inequality.

Such findings mirror those from the electrification studies pointing out that it is areas with access to other infrastructure, markets, and dynamic economies that tend to generate the largest nonfarm incomes. Essentially electrification is likely to drive accumulation strategies in well-off areas, whereas it is likely to support survivalist strategies, at best, in poor, marginal areas. Likewise, it is wealthy groups within these areas that tend to benefit most.

Electrification's modest impact on growth

Within the RNFE literature, electrification is identified as playing a relatively minor role in supporting growth and poverty alleviation. Although electricity is often hypothesized to be an important generic input for supporting RNFE, in statistical efforts to understand which investments have yielded the greatest impacts on poverty, it is rare that electrification comes out as particularly salient. Rogerson (1997) speaks to this explicitly in her assessment of the role of electricity in supporting small, micro, and medium enterprises (SMME) in South Africa. She points out that the literature on support for rural SMME development focuses more on services, such as skills development and access to finance, than it does on the provision of infrastructure. Thus, she concludes, we should not be surprised to find that electrification does not drive SMME development.

A host of studies corroborate the idea that electricity is not the most salient investment for driving nonfarm activity and poverty alleviation. Kinda and Loening (2010), for example, find that the predominant determinants of enterprise growth in rural Tanzania are access to finance, availability of transport infrastructure, and access to cell-phone communication, with education crucial in determining who starts a firm. In that study, firm owners identified lack of access to electricity as one of the most important barriers to their business development, but when the determinants of enterprise growth were modeled, access to electricity did not feature prominently—other than among firms that already used electricity, where it was found that reliability was crucial. Kinda and Loening (2010) explain the difference between what people say they want and what econometric models indicate by suggesting that what firm owners really want is electricity in their homes. Again, the greatest determinant of firm development in Tanzania is access to markets (Kinda and Loening 2010).

A study of public investment and growth in India from 1960 to 1990 finds that while electricity is statistically significant in improving nonfarm incomes, the three most effective public investments for promoting agricultural growth and poverty alleviation are agricultural research, education, and roads (Fan, Gulati, and Thorat 2008). Finally, Alobo (2012) finds that education, agricultural potential, and market access are the most important determinants of livelihood diversification in Kenya and Senegal.[52]

In some cases, authors reviewing the literature on the economic impacts of electrification acknowledge the sorts of findings mentioned above. Attigah and Mayer-Tasch (2013) point out that electricity is thought to have relatively limited impacts on poverty compared with roads, agricultural research, and agricultural

52. Specifically, Alobo (2012) finds the following to be of greatest relevance: completing secondary or university education, access to farm capital and access to transport, access to mutual or unpaid labor, access to migration opportunities, farm size, access to farm capital (plow), and access to irrigation.

extension. Cook (2011) points out that while a number of studies show that electrification contributes to economic growth, lack of electricity generally constrains firm development less than capital and labor shortages, and that transport costs are generally larger than energy costs for rural firms.

Essentially then, the RNFE literature confirms the findings of the electrification literature noting that access to markets (and thereby roads), education, and investments in agriculture tend to be the most important investments for driving productive use and addressing rural poverty. Electricity matters, but it is not generally found to be the most important factor.

Paradoxes

An insight from the RNFE literature is that efforts to drive nonfarm economic growth are characterized by an unfortunate paradox: those who would benefit most from increased RNFE activity are the least able to access it (Haggblade, Hazell, and Reardon 2010). This paradox is thought to exist across two scales. At the individual scale, the poor, who have the greatest incentive to diversify their incomes and who would benefit most from doing so, have the least capacity to do so. At the scale of the community, it is those areas with marginal agricultural systems that need RNFE the most and that are least able to capitalize on it (Reardon et al. 1998).

Considering these findings, along with the findings of the literature on the impacts of electrification, it seems clear that efforts to extend electrification, and ambitions for its impacts, face the same paradox. The dispersed, marginal, and isolated areas in which we would most like to see electrification's transformative power emerge are those least likely to gain from its benefits. Likewise, in electrified areas, the poorest who stand to gain most from electricity's capacity to support productive use are the least likely to benefit from efforts at electrification. As discussed in more detail in the conclusion to this paper, this paradox presents significant challenges for actors who are pursuing electrification as a vehicle for addressing inequality and overcoming urban biases in infrastructure investments (Barnes 2014). That said, for reasons of sustainability and effective policy-making, it is crucial to address these challenges.

Time variance

A final observation from the RNFE literature is that areas may have to reach a certain point in their development before electrification can have a catalytic impact. Reardon et al. (1998) offers a general description of the stages of development of the rural nonfarm economy as the economy moves from (1) being dominated by agricultural products with the non-agricultural economy focused on petty trade and services, to (2) having a mix of activity, with strong rural-urban linkages and a focus on producing light durables, to (3) producing heavy durables with formal, complex linkages between rural and urban areas and large agro-industrial enterprises. Reardon notes that different investments may be needed to drive economic growth at different stages: where roads might be an important first investment to support market access, at some point investments in infrastructure (such as electricity) become central in allowing production processes to become more sophisticated.

Fan, Gulati, and Thorat (2008) point to this phenomenon when they consider the impacts of agricultural investments on agricultural growth in rural India. They show how the types of investment that produced the greatest results varied over time. For the period 1960–1970, subsidies for credit and electricity produced good returns (albeit less than returns on roads and education), but in the following decade returns on these subsidies dropped dramatically, and by the 1990s they were found to provide low returns. The authors explain this result as follows: "Initial subsidies … helped farmers, especially the smallholders, to adopt new technologies. Small farms are often losers in the initial adoption stage of a new technology because the increased supply of agricultural products from large farms that have benefited from new technologies pushes prices down. These subsidies help them to avoid this disadvantage" (Fan, Gulati, and Thorat 2008, 169).

Based on similar logic, Fan, Hazell, and Haque (2000) point out that whereas investments made in high-potential agricultural areas had previously yielded the greatest returns on public spending in India, those returns subsequently shrank. It is now the case that public investments in lower-productivity areas generate the greatest returns for poverty alleviation and economic growth—although in their assessment, among public investments in those areas, roads again generated the greatest returns.

Work on the impacts of electricity contains echoes of these findings. Recall that Khandker et al. (2009) observed diminishing returns on electrification in Bangladesh, suggesting that moving electrification efforts into increasingly marginal areas might generate the greatest cumulative returns. More troublingly, Lenz et al. (2017) suggest that the iconic positive findings of the impacts of electrification on development observed in Bangladesh (from Khandker et al. 2009) and South Africa (from Dinkelman 2011) might not be replicable in the rest of sub-Saharan Africa because they were driven by the relatively large economic bases in these countries, which are not currently apparent in the rest of sub-Saharan Africa. Taking a more positive approach, Barnes (2014) calls for advocates of electrification to be explicitly cognizant of the time-variant and place-specific impacts of electrification in order to identify areas where the impacts on growth might be particularly large—for example, in unirrigated areas with a single rainy season, where electrification might create the opportunity for dry-season cropping.

5. CONCLUSIONS AND CHALLENGES

In the literature on the impacts of electrification on productivity, a prominent finding appears to be that the impacts can be positive—and sometimes large. Further, there is evidence to suggest that positive impacts on productive use are more likely to be experienced by women. This is good news for advocates of electrification. It shows that electrification is a valuable investment that can drive economic development, and it suggests that electrification's large up-front investment costs can be covered, and rendered sustainable, by subsequent growth, with additional potentially positive impacts on reduced unit prices for electricity. Moreover, it suggests that electrification can be an important tool for women's economic empowerment.

Nonetheless, the literature also makes clear that the impacts of electrification are highly variable; sometimes electrification has no impacts on productive use and even negative impacts on incomes. This creates challenges for efforts to achieve 100 percent electrification, as realizing productive use is often necessary for ensuring the long-term sustainability of energy investments.

Regarding the variable impacts, however, there is more good news: there is strong speculation in the literature that the likelihood of realizing productive impacts can be increased by ensuring that the electricity service provided is sufficiently reliable and of suitable quantity to support productive uses, and by the provision of complementary wraparound services. Such services include (1) awareness raising about both the benefits of electricity for productive use and about the value of appliances; (2) access to affordable credit, to support both connections and subsequent enterprise investments, (3) business development training; (4) robust agricultural extension; and (5) integrated development planning and investments in education, health, and transport.

Still, the literature on electrification and productive use also suggests some more challenging implications. The most striking of these is the repeated finding that the largest determinant of productive use is the existence of a large and dynamic economic base in the area being electrified. Simply put, enterprise development and productivity require the existence of a market in which increased productivity can be translated into increased incomes. This finding suggests that the push for 100 percent energy access will run into sustainability challenges when trying to connect the most remote and isolated populations, especially when one considers that, for the poorest populations, capacity to pay for services may be insufficient to cover the cost of electrification, even from distributed systems (Grimm et al. 2016, 2017). This result gives particular pause to proponents of distributed generation systems, who see the capacity to connect the most remote and isolated households first (as opposed to last when rolling out the grid) as the principal benefit of this technology. Such a challenge is particularly acute when one considers the high levelized costs of energy from distributed technologies, which are likely to serve as a further break on productive use (Bhattacharyya 2015).

Moreover, while wraparound services seem capable of increasing the likelihood of productive use, the actual delivery of these services is not a simple matter. Utilities have struggled to provide such integrated services in the past, and limited bureaucratic capacity in less industrialized economies means that coordination of this sort is likely to be challenging. Of further concern is the history of mismanagement among many utilities in sub-Saharan Africa. Finally, while it would be ideal to see electrification fully integrated into sophisticated development planning and accompanied by a host of complementary investments, many developing-country budgets are under significant strain, and thus some triage in these investments will likely be necessary. Overall, these findings create further concerns for actors focused on driving energy access in sub-Saharan Africa, which the literature suggests has, in general, seen limited impacts on productive use, in part because of the smaller economic base of populations in this region.

All of the above factors create a significant challenge for efforts to achieve 100 percent electrification. The challenge of energy poverty is most acute in areas where households are poor, isolated, and lacking access to other services. These populations are least able to afford electricity services and also least likely to adopt electricity for productive uses; as a consequence there is little scope for electrification to drive increases in income so as to make electricity affordable. This nexus of challenges creates significant problems for the sustainability of electrification efforts, which need to be taken seriously in order to avoid wasting capital investments in cases where there is insufficient financial support to ensure effective maintenance.

Based on the above, this review leads to a number of conclusions:

1. **Electrification efforts should be supported with complementary wraparound services to the extent possible**. These services should certainly include awareness raising, access to finance, and training on business development. They would ideally be accompanied by the delivery of other infrastructure and services, such as roads and education, and be part of a coordinated rural development policy. In all cases the electricity services being provided should be of suitable quality and reliability to meet the energy service needs of the population. Further, electrification projects should be constructed in a flexible manner and include scope for evaluation and learning. This is essential to take advantage of the fact that new or additional wraparound services might be necessary to support the realization of productive use.

2. **Issues of sustainability need to be considered carefully**. In contexts where populations cannot afford the cost of electrification infrastructure, careful consideration must be given to whether future productive gains will be able to change this situation. Given the extent to which electrification efforts have generated disappointing results, productive uses should be predicted conservatively, taking into account the contextual factors identified in this work. Finally, in cases where energy access is subsidized, it is crucial to make sure that subsidies can be sustained, accounting for the possibility that productive use will not be realized in the longer term.
3. **Future research should be conducted**. While there has been significant research into the impacts of electrification on productive use, much of this research varies in quality, failing to address issues of endogeneity and to control for a number of contextual factors. Further, there appears to be a lack of focus on explaining the variability of results across studies and on testing the value of different wraparound services on increasing the likelihood that productive use will be realized. Achieving greater consensus on these issues will be of significant value to policy makers and advocates seeking to address the challenge of energy poverty.

APPENDIX A: ACCOUNTING FOR NEW TECHNOLOGIES (DISTRIBUTED RENEWABLES)

While this review aims to enable learning from previous experiences, the current push for electrification does have some contextual differences from the electrification experiences of the 1970s. Most notable is the current push for electrification through distributed energy delivery systems rather than through grid extension. Distributed systems have the advantage of being far less capital intensive than grids. They can match energy resources with their intended use, creating the potential for bespoke, flexible energy systems that mitigate the financial risk of grid extension (Barnes 2014; Fluitman 1983). In addition, owing to the modular nature of cheap renewable systems, it is possible to start off with small systems that are capable of meeting the required load and then expand them as demand increases (Morrissey 2017). It is notable that many actors who have lamented the problems of electrification through grid rollout have pointed to the need for an increased role for distributed systems (e.g., Barnes 2014).

Although the current focus on distributed renewables is relatively new, distributed energy systems themselves are not. Diesel generators[53] and wind pumps are both long-standing technologies that have long been capable of providing electricity at prices that are comparable with fully renewable systems available today (Murphy, Twaha, and Murphy 2014). In general, there is thought to be a lack of research looking at the value of distributed energy systems in providing energy for productive use (Barnes 2014). This research gap is a result of the fact that distributed energy investments have been dominated by stand-alone installations that are usually too small to support any sort of productive load. As a result, work assessing the impact of these systems has ignored the question of productive use and focused more on welfare impacts (Aklin et al. 2017; Grimm et al. 2016; Peters and Sievert 2016). Arguments regarding mini-grids, which would be capable of providing electricity at the scales needed to supply productive use, are undermined both by a lack of programs rolling out mini-grids (and therefore a lack of cases in which to investigate impact) and by the fact that the cost of energy from all such systems—except for mini-hydro–based systems—is high[54]

53. It is appreciated that these technologies are not fully interchangeable. For example, diesel pumps cannot be used for pumping water from deep wells the way electric pumps can. However, the financing for diesel pumps and generators and the established supply chains for the technology are far less daunting than those for renewable energy.

54. There is some confusion about the costs of electricity from distributed systems versus the grid. The correct way to think about this is in terms of the levelized cost of electricity (LCOE). For distributed systems, LCOE is a function of capital costs, operation and maintenance costs (including salvage), fuel costs, and a discount rate on capital costs. For the grid, LCOE is defined by the average cost of generation on the grid, plus any marginal costs of extending transmission and distribution,

(Morrissey 2017). This is a problem because decisions to invest in income-generating activities have been shown to be determined by potential profitability, so the market price for inputs matters (Reardon et al. 1998). One would therefore expect productive uses to suffer in the case of distributed systems owing to the higher cost of electricity.

One important potential distinction that is often pointed out is that connecting to the grid costs more than connecting to a distributed system. Since people's unwillingness to connect to the grid, even when it is available, is often identified as a major barrier to using energy for productive purposes, it is worth addressing this issue explicitly. First, arguing that experiences from the grid are relevant to understanding the impacts of distributed technologies requires the (reasonable) assumption that making the grid available is akin to providing people with the option of connecting to a distributed system, and that in both cases the household will have to make some additional payment (possibly supported, possibly not) to connect to the electricity infrastructure. Second, while it is true that in many countries connections to the grid have been prohibitively expensive—on the order of $1,800, compared with $200 for connecting to a distributed system—this is not necessarily the case. For example, Lee et al. (2014) point out that connecting to the grid in Kenya currently costs $2,000 per household, but that amount could be reduced to as little as $80 per household if households were bundled effectively. Simply bundling households into groups of six could reduce the cost to $200 per household.[55] Thus it is unlikely that the difference in the cost of connecting to the grid versus connecting distributed technologies invalidates the lessons of grid rollout and its impact on productive use.

This is not to say that distributed systems and grid rollout are identical technologies: distributed systems involve different financial risks around electrification and create new opportunities for electrifying certain households more cheaply than would be possible using the grid (opportunities that will increase as the prices of renewable components come down). Rather, they are simply not distinct in ways that are likely to matter for the uptake of productive use (Barnes 2014).

as well as a discount rate on those marginal costs. What this generally means is that the cost of electrification is driven by population density, demand, and distance from the existing grid. At large distances, at low population densities, and under small loads, distributed systems are cheaper than extending the grid and vice versa. That said, where the grid can connect people most cheaply, it tends to produce much lower unit costs for electricity than distributed systems provide in those more distant, isolated, low-demand communities. Thus even though distributed systems will serve as least-cost option for significant numbers of people, the electricity that these systems provide will be more expensive than the electricity that has been sold to newly connected populations that are being served by the grid and that constitute of the focus of literature from the 1930s through the 1970s. Consequently, the disappointing productive impacts from grid extension should be of concern to actors focused on achieving productive use from distributed systems.

55. For more information on bundling see Morrissey (2017, p. 63, Text Box 7).

APPENDIX B: CONSIDERING METHODS IN ASSESSING IMPACTS OF ELECTRIFICATION

Given this report's focus on the impact of electrification on productive use, it is necessary to briefly reflect on the methodological challenges involved in assessing the impact of electrification. A first general problem is that the process of electrification tends not to be random. Rather it is areas that are growing rapidly or that have political salience that tend to get electrified. Once an area is provided with electricity, it is the relatively well-off households that tend to connect.[56] This means that the impacts of electrification cannot be effectively studied by simply comparing either electrified and unelectrified populations, or populations before and after electrification, because it is impossible to untangle whether any positive effects are the result of electrification or of the fact that the community was growing to begin with. It likewise means that one cannot simply compare electrified and unelectrified households, because it is impossible to untangle whether differences stem from access to electricity or from the initial differences in wealth (or other characteristics) that drove specific households to connect in the first place (Attigah and Mayer-Tasch 2013; Bernard 2010; Burlig and Preonas 2016; Dinkelman 2011). Together these challenges are referred to in the literature as problems of *endogeneity*, and they constitute a problem for work on electrification as they drive false positives. To make clear the scale of this problem, Attigah and Mayer-Tasch (2013) point out how one dubiously designed study resulted in findings that a 1 percent increase in access to electricity could lift 140,000 people out of poverty. A number of statistical methods have been used to try and get around these problems (see text box 1). However, poorly designed studies abound in the literature, and any independent reader should interpret such findings with caution. This is especially so because it is argued that in certain cases such evidence has been deployed as a means to justify either previous or future investments in electrification (Rogerson 1997; Fluitman 1983).

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56. In the empirical literature these problems are referred to respectively as "place-based bias" and "self-selection bias," in the selection of cases for study. It should be noted that while most literature considering the methodological challenges of assessing the impacts of electrification biases results toward positive findings, it is also true that findings could be biased negatively. For example, a new government might come to power on a platform supporting social justice and push electrification into the most marginal populations, where results might be limited. Obviously, for the purposes of this report, such cases do not undermine the overall findings: that the impacts of electrification on productive use are likely to be smaller in economic and politically marginal areas, and thus that caution should be exercised when planning how to sustainably finance these projects.

To address these problems and to account for the problematic manner in which electrification efforts have been assessed in the past, a host of more sophisticated methodologies have been deployed. Within this literature review these have been identified as propensity score matching, instrumental variables, difference in differences, and regression discontinuity. Each of these methods is briefly discussed in text box 1.

Text box 1: Dealing with endogeneity

The methodological innovations aimed at addressing the challenge of endogeneity are discussed below. These descriptions are not intended as a comprehensive guide to the use of these statistical methods but rather as an overview for the reader to facilitate their interrogation of the literature mentioned in this report.

Propensity score matching

Propensity score matching deals with the issue of endogeniety by identifying meaningful counterfactual cases against which electrified households can be compared. The idea is to take cases of households that have been electrified and only compare them with households that have not been electrified but which otherwise have similar characteristics. This approach therefore first requires identifying the factors that drive electrification at the village/community level, as well as the factors that drive the uptake of electricity at the household level. Based on these factors, one can match households so that they are similar in all respects other than their access to electricity. Thus differences between electrified households and their matched, unelectrified counterparts can be attributed to electrification. A challenge with this is approach is that it relies on the model for identifying counterfactuals to be accurate. Also, because the approach discards any cases that cannot be matched, it can end up being reliant on very small sample sizes.

Instrumental variable

The instrumental variable approach gets around the fact that electrification likely varies with other positive indicators of well-being by identifying a variable that correlates closely with electrification but does not vary with other indicators of well-being. One prominent example in studies looking at electrification is the use of topography as an instrumental variable (e.g., Dinkelman 2011). The idea here is that topography and electrification have a close relationship, as areas with forgiving topography are more likely to get electrified, yet more forgiving topography is not likely to have a relationship with household well-being. Thus if forgiving topographies are correlated with improved well-being, it can be inferred that electrification drives improvements in well-being as this is the only pathway by which topography might have such an effect. The obvious challenge with instrumental variables is findings suitable “instruments” that affect the independent variable (electrification) while not affecting the dependent variable (well-being).

Difference in differences

The difference-in-differences approach deals with endogeneity by comparing not only the differences in outcomes for electrified and unelectrified households, but also how those outcomes differ from one another. The idea behind this approach is that two groups do not begin in the same place—for example, one might have higher average incomes or greater average levels of education. To account for this, one looks at the indicators for each group (both the electrified and unelectrified) both before and after electrification. What the method considers is not the difference in where each group ends up, but rather how the difference between the groups after electrification might differ as a result of electrification (hence *difference in differences*). For example, incomes might have increased for both the electrified and unelectrified households (as a result of general changes taking place in society), but if incomes have increased to a greater extent in electrified households than unelectrified households, then such differences are thought to be attributable to electrification. The major weakness of this approach is that if any change affects either the electrified and unelectrified households at same time that electrification takes place, then the impacts of this change cannot be disentangled from the potential impacts of electrification.

Regression discontinuity

A final method for addressing endogeneity is known as regression discontinuity. Regression discontinuity attempts to address endogeneity by limiting the comparison between electrified and unelectrified areas to consider only those areas that are similar to one another, based on some characteristic that qualifies them for electrification. One then compares the regression between electrification and well-being across groups around the cutoff point. The intention is to identify whether the rate of change between the variables in the regression differs (shows a discontinuity) around that cutoff. The idea is that the discontinuity must be driven by the intervention, because around the cutoff the groups are suitably similar. The challenge with applying regression discontinuity is that the application of the treatment (in this case electrification) must be random, other than the cutoff requirement. In this review, only one study using a regression discontinuity approach was identified (Burlig and Preonas 2016). The study took place in India, where only villages with a habitation of more than 300 people could qualify for electrification, and every village that met this threshold was connected. By comparing only villages that had slightly more than 300 people in a single habitation with villages that had slightly fewer than 300 people in a single habitation, the study could identify the specific impacts of electrification—based on the fact that other than a very small difference in size, differences across the villages would be random and therefore any systematic differences would be attributable to electrification.

In addition to problems of endogeneity, however, efforts to understand the impact of electrification have to deal with other factors that drive variability across different cases. The first of these pertains to issues of variable data quality (Cook 2011) and the use of datasets that are not comparable across studies (Fluitman

1983). In addition, authors point out that studies of electrification do not tend to consider a suitably long time horizon (Jimenez 2017) to allow for positive development effects to emerge—this is thought to be especially important when trying to account for the positive economic impacts of electrification (Mulder and Tembe 2008). Other authors, however, lament that the only major innovation in efforts to understand the impacts of electrification on productive use is to extend the time period over which studies take place (Cook 2011). Finally, efforts to evaluate the general impact of electrification suffer from the fact that the causal chains linking electrification and increased incomes are often long and complex (Attigah and Mayer-Tasch 2013). For example, the impacts of electrification on farm productivity in India are often cited as justification for electrification, but these occurred only because electrification took place in areas with higher levels of income and education and were accompanied by effective agricultural extension that made improved seed available. The result is that findings from one case often lack validity in other contexts where similar intervening factors are not apparent (Bernard 2010).

Together, issues of endogeneity, problems with data, and the complex causal processes by which electrification impacts development are significant. Indeed, Attigah and Mayer-Tasch (2013), in their meta-analysis of the impacts of electrification on productive use, argue that the issue is so difficult to study, and the findings are so variable, that the question of whether or not electrification affects economic development is not satisfactorily answered. They thus call for more work, suggesting that rather than trying to simply identify whether electrification impacts economic growth, effort should be focused on understanding what sorts of interventions matter and in which contexts. Still, it is worthwhile to echo the sentiments expressed by Khandker, Barnes, and Samad (2009, 22), who point out that "in the end it must be admitted that all cross-sectional analyses have their shortcomings, and moreover, assessed impacts may be short-term. The patterns observed today may not hold in the future." In this respect, seeking best practices on electrification may be a matter of both undertaking more rigorous research and at the same time operating cautiously and allowing for the sort of flexibility in program design that that allows for ongoing learning and adjustment. Such findings present significant challenges to the global ambition of achieving universal access to electricity as quickly as possible—an ambition that tends not to be amendable to context-specific, flexible programming.

REFERENCES

Aguirre, Julio. 2017. "The Impact of Rural Electrification on Education: A Case Study from Peru." *Lahore Journal of Economics* 22 (1): 91–108.

Aklin, Michaël, Patrick Bayer, S. P. Harish, and Johannes Urpelainen. 2017. "Does Basic Energy Access Generate Socioeconomic Benefits? A Field Experiment with Off-Grid Solar Power in India." *Science Advances* 3 (5): e1602153.

Alobo, Sarah. 2012. "Determinants of Rural Household Income Diversification in Senegal and Kenya." *6èmes Journées de Recherches En Sciences Sociales SFER-INRA-CIRAD.* Paris: Société Française d'Economie Rurale (SFER).

Attigah, B., and L. Mayer-Tasch. 2013. "The Impact of Electricity Access on Economic Development: A Literature Review." *Productive Use of Energy (PRODUSE): Measuring Impacts of Electrification on Micro-Enterprises in Sub-Saharan Africa.* Eschborn, Germany: German Society for International Cooperation (GIZ).

Azimoh, Chukwuma Leonard, Patrik Klintenberg, Fredrik Wallin, and Björn Karlsson. 2015. "Illuminated but Not Electrified: An Assessment of the Impact of Solar Home System on Rural Households in South Africa." *Applied Energy* 155: 354–64.

Bailis, Robert, Majid Ezzati, and Daniel M. Kammen. 2005. "Mortality and Greenhouse Gas Impacts of Biomass and Petroleum Energy Futures in Africa." *Science* 308 (5718): 98–103. https://doi.org/10.1126/science.1106881.

Barnes, Douglas F. 2014. *Electric Power for Rural Growth: How Electricity Affects Life in Developing Countries*. 2nd ed. Washington, DC: Energy for Development.

Barnes, Douglas F., and Hans P. Binswanger. 1986. "Impact of Rural Electrification and Infrastructure on Agricultural Changes, 1966–1980." *Economic and Political Weekly* 21 (1): 26–34.

Bastakoti, Badri Prasad. 2006. "The Electricity-Livelihood Nexus: Some Highlights from the Andhikhola Hydroelectric and Rural Electrification Centre (AHREC)." *Energy for Sustainable Development* 10 (3): 26–35.

Bensch, Gunther, Jochen Kluve, and Jörg Peters. 2011. "Impacts of Rural Electrification in Rwanda." *Journal of Development Effectiveness* 3 (4): 567–88.

Bernard, Tanguy. 2010. "Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa." *World Bank Research Observer* 27 (1): 33–51.

Bhattacharyya, Subhes C. 2015. "Mini-Grid Based Electrification in Bangladesh: Technical Configuration and Business Analysis." *Renewable Energy* 75: 745–61.

Bhattacharyya, Subhes C., and Sanusi Ohiare. 2012. "The Chinese Electricity Access Model for Rural Electrification: Approach, Experience and Lessons for Others." *Energy Policy* 49: 676–87.

Broto, V., L. Stevens, and D. Bartlett. 2015. "Energy Access and Urban Poverty: Energy in Everyday Life in an Informal Settlement in Maputo,

Mozambique.” 4. Poor People’s Energy Briefing. Rugby, UK: Practical Action.
Brüderle, Anna, B. Attigah, and Mirka Bodenbender. 2011. *Productive Use of Electricity–PRODUSE: A Manual for Electrification Practitioners*. Eschborn, Germany: European Union Energy Initiative Partnership Dialogue Facility at German Society for International Cooperation (GIZ).
Burlig, F., and L. Preonas. 2016. “Out of the Darkness and into the Light? Development Effects of Rural Electrification in India.” Working Paper 268. Berkeley, California: Energy Institute at Haas, University of California, Berkeley.
Cabraal, R. Anil, Douglas F. Barnes, and Sachin G. Agarwal. 2005. “Productive Uses of Energy for Rural Development.” *Annual Review of Environment and Resources* 30: 117–44.
Cherni, Judith A., and Yohan Hill. 2009. “Energy and Policy Providing for Sustainable Rural Livelihoods in Remote Locations: The Case of Cuba.” *Geoforum* 40 (4): 645–54.
Clancy, Joy. 2006. “Enabling Poor Livelihoods Policy Making: Understanding the Role of Energy Services.” DFID KaR Project R8348. Synthesis Report. London: UK Department for International Development (DFID).
Cook, Paul. 2011. “Infrastructure, Rural Electrification and Development.” *Energy for Sustainable Development* 15 (3): 304–13.
———. 2013. “Rural Electrification and Rural Development.” In *Rural Electrification through Decentralised Off-Grid Systems in Developing Countries*, edited by Subhes C. Bhattacharyya. London: Springer-Verlag.
Cowan, B., and N. Mohlakoana. 2005. “Barriers to Modern Energy Services in Low-Income Urban Communities: Khayelitsha Energy Survey.” Cape Town, South Africa: Energy Research Centre, University of Cape Town.
Dasso, Rosamaría, and Fernando Fernandez. 2015. “The Effects of Electrification on Employment in Rural Peru.” *IZA Journal of Labor and Development* 4 (1): 6.
De Gromard, C. 1992. “L’électrification Rurale dans les Pays en Voie de Développement: Les Contraintes Financiéres et la Recherche de Solutions Économiques Viables.” Bingerville, Côte d’Ivoire: Institut de l’Énergie et de l’Environnement de la Francophonie.
Deichmann, Uwe, Craig Meisner, Siobhan Murray, and David Wheeler. 2011. “The Economics of Renewable Energy Expansion in Rural Sub-Saharan Africa.” *Energy Policy* 39 (1): 215–27.
Dinkelman, Taryn. 2011. “The Effects of Rural Electrification on Employment: New Evidence from South Africa.” *American Economic Review* 101 (7): 3078–3108.
Fan, Shenggen, Ashok Gulati, and Sukhadeo Thorat. 2008. “Investment, Subsidies, and Pro- poor Growth in Rural India.” *Agricultural Economics* 39 (2): 163–70.
Fan, Shenngen, Peter Hazell, and Tanja Haque. 2000. “Targeting Public Investments by Agro-Ecological Zone to Achieve Growth and Poverty Alleviation Goals in Rural India.” *Food Policy* 25 (4): 411–28.
Fluitman, Fred. 1983. *Socio-Economic Impact of Rural Electrification in Developing Countries: A Review of Evidence*. Geneva: International Labour Organization.

Furukawa, Chishio. 2014. “Do Solar Lamps Help Children Study? Contrary Evidence from a Pilot Study in Uganda.” *Journal of Development Studies* 50 (2): 319–41.

Fuso Nerini, Francesco, Oliver Broad, Dimitrios Mentis, Manuel Welsch, Morgan Bazilian, and Mark Howells. 2016. “A Cost Comparison of Technology Approaches for Improving Access to Electricity Services.” *Energy* 95: 255–65.

Gebreegziabher, Zenebe, Alemu Mekonnen, Menale Kassie, and Gunnar Köhlin. 2012. “Urban Energy Transition and Technology Adoption: The Case of Tigrai, Northern Ethiopia.” *Energy Economics* 34, no. 2: 410–18.

Grimm, Michael, Anicet Munyehirwe, Jörg Peters, and Maximiliane Sievert. 2016. “A First Step up the Energy Ladder? Low Cost Solar Kits and Household’s Welfare in Rural Rwanda.” Policy Research Working Paper 7859. Washington, DC: World Bank.

Grimm, Michael, Luciane Lenz, Jörg Peters, and Maximiliane Sievert. 2017. “Demand for Off-Grid Solar Electricity: Experimental Evidence from Rwanda.” Economic Paper 745. RUHR Economic Papers. Essen, Germany: Leibniz-Institut für Wirtschaftsforschung (RWI).

Haggblade, Steven, Peter Hazell, and Thomas Reardon. 2010. “The Rural Non-Farm Economy: Prospects for Growth and Poverty Reduction.” *World Development* 38 (10): 1429–41.

IEA (International Energy Agency). 2017. *Energy Access Outlook 2017: From Poverty to Prosperity*. World Energy Outlook Special Report. Paris: International Energy Agency.

———. n.d. Energy Access Outlook 2017. http://www.iea.org/access2017/. Accessed December 4, 2017.

Jimenez, Raul. 2017. *Development Effects of Rural Electrification*. Policy Brief No. IDB-PB-261. Washington, DC: Inter-American Development Bank.

Khandker, Shahidur R., Douglas F. Barnes, and Hussain A. Samad. 2009. “Welfare Impacts of Rural Electrification: A Case Study from Bangladesh.” Policy Research Working Paper 4859. Washington, DC: World Bank.

Khandker, Shahidur R., Douglas F. Barnes, Hussain A. Samad, and Nguyen Huu Minh. 2009. “Welfare Impacts of Rural Electrification: Evidence from Vietnam.” Policy Research Working Paper 5057. Washington, DC: World Bank.

Kinda, Tidiane, and Josef L. Loening. 2010. “Small Enterprise Growth and the Rural Investment Climate: Evidence from Tanzania.” *African Development Review* 22 (1): 173–207.

Lee, K., E. Brewer, C. Christiano, F. Meyo, E. Miguel, M. Podolsky, J. Rosa, and C. Wolfram. 2014. “Barriers to Electrification for ‘under Grid’ Households in Rural Kenya.” Working Paper 20327. Cambridge, MA: National Bureau of Economic Research.

Lee, Mitchell, Daniel Soto, and Vijay Modi. 2014. “Cost versus Reliability Sizing Strategy for Isolated Photovoltaic Micro-Grids in the Developing World.” *Renewable Energy* 69: 16–24.

Lenz, Luciane, Anicet Munyehirwe, Jörg Peters, and Maximiliane Sievert. 2017. “Does Large-Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda’s Electricity Access Roll-out Program.” *World Development* 89: 88–110.

Lewis, Joshua, and Edson Severnini. 2014. “The Value of Rural Electricity: Evidence from the Rollout of the U.S. Power Grid.” Paper, University of Montreal and Carnegie Mellon University.

Madubansi, M., and C. M. Shackleton. 2006. “Changing Energy Profiles and Consumption Patterns Following Electrification in Five Rural Villages, South Africa.” *Energy Policy* 34 (18): 4081–92.

Malla, Sunil, and Govinda R. Timilsina. 2014. “Household Cooking Fuel Choice and Adoption of Improved Cookstoves in Developing Countries: A Review.” Policy Research Working Paper 6903. Washington, DC: World Bank.

Masera, Omar R., Barbara D. Saatkamp, and Daniel M. Kammen. 2000. “From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model.” *World Development* 28 (12): 2083–2103.

Mentis, Dimitrios, Mark Howells, Holger Rogner, Alexandros Korkovelos, Christopher Arderne, Eduardo Zepeda, Shahid Siyal, Costantinos Taliotis, Morgan Bazilian, and Ad de Roo. 2017. “Lighting the World: The First Application of an Open Source, Spatial Electrification Tool (OnSSET) on Sub-Saharan Africa.” *Environmental Research Letters* 12 (8): 085003.

Moner-Girona, M., K. Bódis, B. Korgo, T. Huld, I. Kougias, I. Pinedo-Pascua, F. Monforti-Ferrario, and S. Szabó. 2017. *Mapping the Least-Cost Option for Rural Electrification in Burkina Faso*. Luxembourg: Publications Office of the European Union.

Morrissey, James. 2017. “Addressing Energy Poverty.” 2. The Energy Challenge in Sub-Saharan Africa: A Guide for Advocates and Policy Makers. Washington, DC: Oxfam America.

Mulder, Peter, and Jonas Tembe. 2008. “Rural Electrification in an Imperfect World: A Case Study from Mozambique.” *Energy Policy* 36 (8): 2785–94.

Muller, Frederick William. 1944. *Public Rural Electrification*. Washington, DC: American Council on Public Affairs.

Murphy, Patrick Mark, Ssennoga Twaha, and Inês S. Murphy. 2014. “Analysis of the Cost of Reliable Electricity: A New Method for Analyzing Grid Connected Solar, Diesel and Hybrid Distributed Electricity Systems Considering an Unreliable Electric Grid, with Examples in Uganda.” *Energy* 66 (C): 523–34.

Peters, Jörg, Marek Harsdorff, and Florian Ziegler. 2009. “Rural Electrification: Accelerating Impacts with Complementary Services.” *Energy for Sustainable Development* 13 (1): 38–42.

Peters, Jörg, and Maximiliane Sievert. 2016. “Impacts of Rural Electrification Revisited: The African Context.” *Journal of Development Effectiveness* 8 (3): 327–45.

Prasad, Gisela, and Eugene Visagie. 2006. *Impact of Energy Reforms on the Poor in Southern Africa*. Report for the Global Network on Energy and Sustainable Development under Electricity Access Theme III: Explicit Focus on the Poor. Cape Town: Energy Research Centre.

Rambaud-Measson, D. 1990. “L’électrification Rurale en Afrique Sub-Saharienne: Comparaison entre Production Décentralisée d’électricité et Extension du Réseau Interconnecté dans une Situation de Crise Financié Re Aigüe.” Meaux, France: Groupe Energie Développement.

Reardon, Thomas, Julio Berdegué, Christopher B. Barrett, and Kostas Stamoulis. 2007. “Household Income Diversification into Rural Nonfarm Activities.” In

Transforming the Rural Nonfarm Economy: Opportunities and Threats in the Developing World, edited by Steven Haggblade, Peter Hazell, and Thomas Reardon, 115–40. Baltimore, MD: Johns Hopkins University Press.

Reardon, Thomas, Kostas Stamoulis, A. Balisacan, M. E. Cruz, Julio Berdegué, and B. Banks. 1998. "Rural Non-Farm Income in Developing Countries." In *The State of Food and Agriculture 1998*, 283–356. Rome: Food and Agriculture Organization of the United Nations.

Rewald, Rebecca. 2017. *Energy and Women and Girls: Analyzing the Needs, Uses, and Impacts of Energy on Women and Girls in the Developing World*. Oxfam Research Backgrounder Series. Washington, DC: Oxfam America.

Rogerson, Christiaan M. 1997. *Rural Electrification and the SMME Economy in South Africa*. Cape Town, South Africa: University of Cape Town, Energy and Development Research Centre.

Samad, Hussain A., and Fan Zhang. 2017. "Heterogeneous Effects of Rural Electrification: Evidence from Bangladesh." Policy Research Working Paper 8102. Washington, DC: World Bank.

Schillebeeck, Simon J. D., Priti Parikh, Rahul Bansal, and Gerard George. 2012. "An Integrated Framework for Rural Electrification: Adopting a User-Centric Approach to Business Model Development." *Energy Policy* 48: 687–97.

SEforALL (Sustainable Energy for All). n.d. About Us. http://www.se4all.org/about-us. Accessed December 4, 2017.

Terrapon-Pfaff, Julia, Carmen Dienst, Julian König, and Willington Ortiz. 2014. "A Cross-Sectional Review: Impacts and Sustainability of Small-Scale Renewable Energy Projects in Developing Countries." *Renewable and Sustainable Energy Reviews* 40: 1–10.

United Nations. 1954. Rural Electrification. Prepared by the Secretariat of the Economic Commission for Asia and the Far East. Cited in Bastakoti (2006, 26).

Walsh, Martin, and Solomon Mombeshora. 2017. *Turning Water into Wellbeing: How an Irrigation Scheme Changed Lives in a Zimbabwean Dryland*. Research Report. Oxford, UK: Oxfam.

Wamukonya, Njeri, and Mark Davis. 2001. "Socio-Economic Impacts of Rural Electrification in Namibia: Comparisons between Grid, Solar and Unelectrified Households." *Energy for Sustainable Development* 5 (3): 5–13.

Weldegebriel, Zerihun Berhane, Guiseppe Folloni, and Martin Prowse. 2015. "The Determinants of Non-Farm Income Diversification in Rural Ethiopia." *Journal of Poverty Alleviation and International Development* 6 (1): 109–30.

World Bank. 2008. *The Welfare Impacts of Rural Electrification: An IEG Impact Evaluation: A Reassessment of the Costs and Benefits*. Washington, DC: Independent Evaluation Group–World Bank.

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