Intermediaries and Electrification: Dimensions of Trust and Consumer Education in Kenya’s Off-Grid Solar Market

by

Elise Schley Harrington

B.A., University of Pennsylvania (2011)

Submitted to the Department of Urban Studies and Planning in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Environmental Policy and Planning at the MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Abstract

Countries still working towards universal energy access are beginning to utilize a range of renewable energy technologies and services to meet rural electrification goals. Stemming from mobile money innovations in Kenya, “pay-as-you-go” off-grid solar increases the short-term affordability of small-scale solar solutions for rural households. Consumer experiences with off-grid solar vary across distribution models based on the local actors responsible for engaging with end-users. I call these on-the-ground actors frontline solar intermediaries and they link consumers and providers through in person interactions and have the ability to perform different acts of intermediation in designed solar distribution models. Frontline solar intermediaries are not only important for making off-grid solar sales, but for implementing consumer safeguards (e.g. quality assurance and consumer protections).

Based on fieldwork in Kenya, I identify four types of frontline solar intermediaries: community influencers, networking solar agents, embedded entrepreneurs, and group leaders. I use a conjoint survey experiment to test the influence of social capital and reputation on an intermediary’s trustworthiness. I find that trust stems from more than just initial social capital and may be enhanced by strategic partnerships or collaborations between NGOs, government, and private solar providers. Using a second original survey, I examine the effect of intermediary type on consumer knowledge. I find that relying on solar agents for help with solar issues is associated with an 11% higher expected knowledge count and a 23% increase in seeking help to solve problems. Solar agents are the most common frontline solar intermediary in Kenya and remain a key source of information and assistance for after-sales services. The incentives, interpersonal relationships, and training programs that influence frontline solar intermediary behavior suggest that these local actors are critical to building off-grid solar as a lasting complement (or in some cases, alternative) to the centralized grid.

Thesis Supervisor: David Hsu
Title: Associate Professor of Urban and Environmental Planning
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Concluding this journey was marked by a change of pace globally as the COVID-19 pandemic affected communities globally, I am deeply thankful to so many at MIT and beyond who worked tirelessly over the past few months to ensure we are safe and healthy.

***

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***

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Chapter 1

Introduction: Local Connections in Off-Grid Solar Services

1.1 Introduction

We sat in a semi-circle of blue plastic chairs under the shade of a large tree to provide relief from the intense midday sun. With my field partners, I traveled to different areas in Trans-Nzoia county, located in Western Kenya in the former Rift Valley Province, to understand how rural communities experience off-grid solar services. On this dry July day, members of a local farming group in rural Kiminini shared stories of inconsistent experiences with off-grid solar.

In this group, one person was still using the same solar system with no problems for over six years. When solar works well, it can meet household needs for basic electricity. However, others were confronted with problems early on in their use of solar. If needed, receiving adequate help with off-grid solar is often challenging. In-person connections – the individuals selling solar and others people go to for help with after-sales needs – play important roles in linking end-users to off-grid solar service providers. For example, local company representatives may be the sole point of contact for end-users and, if these representatives fail to provide that needed link to the company, solar end-users may not know where to turn or what to do.

When the solar light stopped working, the company representative in charge of this area took it for replacement. But then, she lost her job at the company, so she gave me the solar back and told me to take it to a local technician (fundí). When I got there, the technician said nothing was broken. But the representative was gone. Now, I use kerosene or sit in darkness.\(^1\)

To close this gap between solar providers and consumers, companies encourage people to call a customer care number if they experience a problem with their solar system. Neverthe-

\(^1\)Quotations were translated from Kiswahili to English.
less, many people continue to rely on existing and in-person relationships. Prior interactions are imbued with a belief that this person knows the end-user, knows the product they have, and where they are located – at times far from the town center or nearest solar shop. Some solar users call a local company-affiliated solar agent for help, some ask their neighbors or friends, a group leader, or a local electrician. Or some try to fix broken solar systems themselves or they hide the broken lantern or home system under a bed or in a cabinet, and resort back to kerosene.

Local points of contact for off-grid solar are not only responsible for sales, rather they are also key channels for repairs, appliances, and understanding service terms. However, actually receiving services beyond the point-of-sale and holding on-the-ground representatives accountable for those services can feel like an opaque and uncertain process for solar users.

The radio that comes with a solar home system stopped working. So, I called the solar agent representing the company and he took it to exchange for a new radio. Later, I called the agent again to see where the radio was, and the agent asked if the company had called with information about a replacement radio. The company had not called. But three months passed, and now the warranty is expired. I do not know if the agent actually took the radio back to the company, or if he only said he did. The radio was already paid for but I do not have a replacement.

Five of the twelve farmers this group had solar home systems. Others, typically earning about 100 shillings per day, could not afford the down payment, which can amount to 2000 shillings (or about $20) and competes with money used for food, school fees, and transportation. Among the five with solar, one purchased his solar system “kando kando” – part by part – as a component-based system, the other four had “plug-and-play” systems, which are packaged systems from a single company. Component-based systems and plug-and-play systems represent the two common configurations of off-grid solar home systems in rural Kenya. Solar users, in just one village, purchased off-grid solar products from a range of distribution channels: their child’s school, from a solar agent walking door-to-door, and from a farming focused non-governmental organization.

I call these on-the-ground individuals frontline solar intermediaries, they are the individual actors that link consumers, or end-users, and providers in person and perform different acts of intermediation in designed solar distribution models. Broadly, intermediation involves acting as a link, or a go-between, for end-users and off-grid solar providers. Frontline solar

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2Some company customer care lines are toll free, others require airtime and that cost is on the customer.
3The challenges of not getting enough help from the company, uncertainty about payments, and confusion about receiving appliances have also been documented by industry research (@Sunrise_Kat, 2019d,c,e).
4Plug-and-play solar home systems are “all-in-one packaged SHS kits of 11+ Wp” that can power multiple lights and energy efficient appliances (Dalberg Advisors et al., 2018, XIV). Typically considered “Tier 1” access for a household.
5Shop owners reported selling solar home systems with car batteries or without charge controllers as customers asked for those options that were cheapest, and shop owners did not want to miss a sale just to ensure a complete system.
intermediaries both have the potential to help solve problems to strengthen the provider-user relationship, and to sever or weaken the connection between the off-grid solar provider and end-user. In this research, I focus on the ways that intermediaries can build trust and consumer knowledge as key dimensions of the provider-consumer relationship and foundational to a robust consumer safeguard regime. The evolving strategies used by off-grid solar companies to establish communication channels with their customers influence the role and potential impact of frontline solar intermediaries. The consumer-intermediary relationship relies on the existing interpersonal relationships that underpin building trusted services, and on the incentives and distribution models developed by service providers.

Off-grid solar technologies and services have the potential to disrupt traditional electricity services in areas with no or poor-quality electricity access. While still somewhat experimental – and certainly still evolving – adoption of off-grid solar in regions like East Africa indicates the potential for small-scale, distributed solar to contribute to renewable energy and energy access goals. International organizations like the World Bank have been promoting private sector development of off-grid solar for decades and the influx of climate finance is providing additional streams of resources for off-grid providers. Despite this funding, the viability of off-grid solar services is not without debate. Concerns from investors regarding business models and regulation are encouraging the private sector to self-regulate in areas of consumer protections and enforcement of quality assurance measures. The implementation of these safeguard programs (consumer protections and quality assurance) often relies on the behaviors and interactions frontline solar intermediaries have with solar users.

Rural Kenya has been the site of experimentation with solar technologies and services sparking innovation in this growing sector. The distribution and service models developed in Kenya, in particular the recent innovations pairing solar with mobile money and financing (pay-as-you-go solar), are being deployed in neighboring countries and in locations as far as South America and Southeast Asia. Consumer protections or safeguards have grown in tandem with solar adoption in an effort to build the solar market in Kenya based on quality assured products. Issues with solar quality identified in Kenya have influenced the trajectory of quality assurance efforts globally. Even as the market for off-grid solar in Kenya continues to evolve, when asked about solar consumers still recall their early experiences with solar products – both good and poor quality. Frontline solar intermediaries influence these experiences with solar products and services, sometimes for the better and sometimes for the worse.

In this dissertation, I examine the diversity of these frontline solar intermediaries, the opportunities and challenges faced by consumers reliant on these intermediaries, the dimensions of intermediaries influencing trust, and their effect on consumer knowledge about off-grid solar. My focus on frontline solar intermediaries highlights critical challenges and continued opportunities for off-grid solar distribution models and emerging consumer safeguard regimes. I ask three questions to understand the forms and functions of frontline intermediaries in off-grid solar. First, what types of frontline solar intermediaries are active in off-grid solar services? Second, what attributes influence trust in intermediaries? Third, does knowledge about off-grid solar services vary by intermediary type? Each of these questions addresses a
different aspect of frontline solar intermediaries and together these questions provide a more complete picture of what these intermediaries do and how they do it. I argue that the work intermediaries do to build trust is critical to off-grid solar distribution models into last-mile regions and work to build consumer knowledge is foundational to implementing consumer safeguard regimes; together trust in service providers and consumer knowledge about solar services contribute to if and how off-grid solar can become a lasting or more durable service.

Off-grid solar includes lanterns or home systems that provide light, mobile phone charging, and, at times, power appliances such as a radio or television. Often, off-grid solar providers argue that small-scale solar can help shift households away from kerosene and up the “energy ladder” to more modern energy sources. Increasingly off-grid solar providers are using “pay-as-you-go” financing options, which allow customers to pay back their solar in high-frequency and variable increments. Such financing innovations reinforce the importance of the provider-user relationship during the repayment period and beyond, given the potential for upgrading a customer to a new system with more capacity.

Companies leading in off-grid solar services are moving beyond adoption of basic lighting toward products and services that that require more complex and lasting consumer-provider relationships. These long-lasting relationships are critical to the ability of solar providers to have an impact on energy access goals by offering services that can approximate basic service from the grid. Off-grid solar providers are strategically providing more services to up-sell or cross-sell existing customers to larger systems or other appliances, such as smartphones. While the proliferation of pay-as-you-go (PAYGo) solar has reduced upfront costs for solar users, the use of financing extends the relationship between the provider and end-user requiring more repeated interactions between frontline solar intermediaries and solar users. Experts from the World Bank and the solar industry describe that,

“...while PAYGo technology has enabled the rapid deployment of new units (over 700,000 in just 5 years), it has also forced agents to develop an additional set of skills. Agents can no longer focus on one big sale. Instead, they now have to engage in a longer, more sophisticated sales process that includes non-traditional direct sales tasks such as tracking repayments and reminding customers with outstanding payments (some of whom may be their neighbors) to repay every month...Unfortunately, it seems that companies have not yet figured out how to best manage their agent networks, and the high turnover among agents is becoming a big risk to growth and sustainability of the sector” (Chang, 2017).

The role of frontline solar intermediaries increasingly extends beyond point-of-sale to repeated interactions in after-sales services. The reliability and expectations established over the course of repeated interactions can influence how solar users perceive intermediaries and providers: positive repeated interactions may enhance or build trust, while negative interactions may break or diminish trust. Companies and industry groups for off-grid solar have not quite figured out how to effectively manage the networks of intermediaries that engage in ongoing interactions with consumers.

The challenge of repeated interactions between frontline solar intermediaries and solar users is illustrated in the two earlier quotations from focus group participants. In each case,
the end-user relied on the on-the-ground representative for assistance suggesting that, at least initially, solar users believed this person would be able to help solve their problem with their solar system. Each of these illustrations also shows how this relationship can erode if frontline solar intermediaries fail to respond effectively or solve the problem. These examples of the variable experiences of help with solar highlight the importance of these longer, more sophisticated consumer-intermediary interactions for the overall viability of off-grid solar services.

Frontline solar intermediaries are often the first person to explain the terms and conditions associated with off-grid solar services. For some households, solar may be their largest loan or their first financed asset. Frontline solar intermediaries have discretion in how they work to educate and empower consumers, or to deceive them by suggesting different repayment terms or delivering an incomplete package of appliances. What end-users of off-grid solar learn through frontline solar intermediaries can establish the expectations for purchase and repayment terms, use or system capabilities, and after-sales services.

Off-grid solar users rely on the frontline intermediaries for both sales and after-sales needs. Maintaining a positive, ongoing relationship with existing customers is increasingly important for the evolving model of off-grid solar that involves up-selling customers to larger solar systems or cross-selling them to new services. While providing basic lighting and charging options, smaller solar products increasingly serve as a credit-building mechanism or litmus test for reliable repayment for future products. In tandem, defaulting may also damage credit, if reported by off-grid solar companies. The opportunity for frontline solar intermediaries to initiate and support a long-term relationship with customers represents future growth opportunities for companies.

Off-grid solar services have evolved in Kenya from lanterns provided at no, or low, cost by aid organizations to an active private sector services offering larger, financed solar products. The trend towards more flexible financing options – pay-as-you-go – for off-grid solar reinforces the need for strong after-sales services to enhance repayment.

Pay-as-you-go solar companies provide far more than just solar products or appliances, but increasingly participate in financing activities that require frontline solar intermediaries to educate consumers about financing terms and conditions in addition to solar options and uses. With the growth in distribution of off-grid solar and the increasing system size, solar home systems are increasingly viewed as viable electrification options. For providers to understand how they can be lasting electrification options requires assessments beyond sales and adoption measures to implementing services. Financed and larger solar home systems require more robust after-sales services to address additional technical complexity,

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6Muench et al. (2016, 25) emphasize that “citizens engaging in their first financial transactions by financing energy services through an OEC [off-gird energy company] or depositing their savings via mobile money would be the most vulnerable to fraud by unscrupulous companies. As businesses move with financed products toward the BoP, the risks of overindebtedness for customers grow accordingly. While the financing makes the product affordable to the customer, the payments under such a financing arrangement may be unaffordable.”

7Attia and Maze-Rothstein (2019, 10) describe that “sector leaders are testing the depths of customer value through value-adding adjacent services across their existing value chains like internet, cookstoves, insurance, and credit measurement.”
larger loans, and longer repayment periods. Looking only at measures of solar purchases or adoption rates masks these increasingly critical dimensions of transparent provision of solar services.

1.1.1 Framing of Frontline Solar Intermediaries

Contributing to the scholarship on how to meet universal electricity access goals with distributed generation solutions, I examine a subset of distributed generation: off-grid solar. While the category of off-grid is often used in different ways, I use off-grid to describe solar lanterns and household serving solar home systems. While these solutions are on the smaller side of distributed generation options, solar home systems, in particular, are attracting substantial investment attention and undergoing innovations in payment methods and end-uses with increasingly efficient appliances. Given the growth and popularity of solar home systems, this research focuses on the effective service and distribution models and will suggest strengths and potential improvements to existing approaches.

Intermediaries work between different actors, such as service providers, consumers or end-users, and policymakers, and can open markets and new distribution channels. There is no dominant definition of an intermediary, but most descriptions emphasize their role as a mediator or facilitator working between two other entities in a wide range of contexts. Scholars have examined the function of intermediaries in policy processes, in providing access to services, and in innovation. I constrain my empirical analysis to frontline solar intermediaries, those on-the-ground actors that link consumers and service providers. In off-grid solar, these intermediaries function to connect providers and consumers to improve ongoing access to solar services and enhance consumer education. Frontline intermediaries also have the potential to translate end-user experiences into actionable information for service providers that will enable them to improve their model based on the consumer experience. In this case I find a weak flow of information back to the provider regarding on-the-ground experiences with off-grid solar.

Intermediaries rely on the relationships they establish with both parties. These relationships are associated with their trustworthiness and expertise. Similar to energy behaviors in other contexts, local connections and experiences with solar are influential in both adoption and continued use of off-grid solar in the Global South. Scholarship tends to focus more on measures of adoption rather than consumer education or the social interactions that underpin long-term relationships with solar providers.

In Kenya, there are different types of frontline solar intermediaries operating on-the-ground. While solar providers recognize the benefits of working with socially embedded actors, the relationship an off-grid solar intermediary has with a provider or end-user is also related to their expertise established by company training and incentives. In contexts with weaker promulgation and enforcement of quality and service standards, such as off-grid solar, social relationships underpin the extension of services to underserved or last-mile communities. Effective intermediaries utilize their embeddedness and social capital to

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8Post et al. (2017, 954) describe that indirect provision of services may be formally delegated through
establish trust and then use their expertise in off-grid solar to maintain trust over repeated interactions.

Processes outside traditional state channels, led by private sector efforts, help determine what kind of information and education frontline solar intermediaries should provide to consumers. Private sector action in Kenya fills some of the gap left by unenforced standards for quality and consumer protection. Globally, the off-grid solar sector is using Kenya as a model and testbed for issues such as quality assurance, with over a decade of coordination on, and development of, technical standards. The broader set of issues stemming from the blurring between off-grid solar companies and microfinance institutions, requires additional consumer protections in the sector, but such protections are nascent within Kenya and the off-grid solar sector. In Kenya, both state and private sector efforts to build awareness and action on consumer protections is an increasingly important dimension of off-grid solar services.

For off-grid solar, people continue to turn to local intermediaries not only for sales, but ongoing help with solar. The reliance on intermediaries with a link to off-grid solar service providers remains key for rural citizens, as even local officials lack knowledge about solar and the channels for grievances and rectifying poor performance (interview 190709).

To study frontline solar intermediaries in Kenya, I use a mixed methods approach building on field visits, interviews, industry documents and two surveys. Qualitative data provides context from service providers about the design of distribution models and the intended role of intermediaries. While stories and conversations with consumers suggest the opportunities and challenges associated with these existing off-grid solar models. Using a conjoint survey, quantitative analysis provides insights into what aspects of intermediary models build trust between intermediaries and solar users, and where new opportunities may be explored to enhance trust in frontline solar intermediaries, and by extension service providers. Additional survey data is used to test how effectively different intermediaries convey information about solar and educate end-users. This illustrates the roles of different frontline solar intermediaries, especially solar agents, in developing consumer education. While adjustments to the incentives supporting frontline solar intermediary models may increase consumer education, this research also shows that longer-term development goals, such as higher education, are also critical for increasing consumer knowledge.

1.1.2 What Frontline Solar Intermediaries Do and How they Do It

While there are many dimensions of intermediaries relevant to both scholarship and practice, the concept of what an intermediary is or does is used inconsistently. To bring some clarity to analyzing intermediaries, I examine intermediaries active in providing off-grid solar services at the local level to develop a typology of frontline solar intermediaries. This helps identify

contracts or formal agreements, or informally delegated “when states deliberately choose not to provide services and turn a blind eye when non-state providers emerge to cater to citizen needs. Under ‘spontaneous privatization’ of this sort, the non-state providers that emerge may be firms, such as small informal-sector operations.” Off-grid solar in Kenya is considered “independent” provision dominated by non-state actors with little state investment.
key features that may influence what intermediaries do, how they do it, and why. While other scholars highlight particular trends in off-grid solar distribution models or the efficacy of a single model, there has been little systematic comparison of role of intermediaries in different models.\(^9\) Beyond form, I examine dimensions of an effective frontline solar intermediary and what factors may influence an intermediary’s effectiveness over stages of off-grid solar services. I break this down into dimensions of trust and knowledge-building. Off-grid solar distribution varies from temporary vendors to small shops to door-to-door sales. For ease of access to customers, companies also leverage existing social connections, such as chamas (lending groups), churches, and schools.

Solar companies identify on-the-ground actors to extend solar to new customers and often this contact with frontline solar intermediaries lasts beyond point-of-sale. Existing relationships and local knowledge inform sales strategies – when, where, how – and leverage existing social capital. Companies vary in if they restrict frontline solar intermediaries to only their existing social network or if they allow for more flexibility in extending their activities beyond pre-existing ties. Often, this depends on how companies measure and understand success: one-off sales versus repeated sales. Increasingly, repayment periods for financed solar products encourage measures of repeated sales and repayment rates. Company priorities are often reflected, in part, in the incentives that underlie the company-intermediary relationship.

Frontline solar intermediaries are presumed to have stronger interpersonal trust based on pre-existing relationships or other forms of familiarity. How people judge a company or product may be mediated by the trustworthiness of the frontline intermediary. Trust is a frequently used term and can be interpreted differently and, perhaps, even more difficult to measure. Trust is related to dimensions of reliability and truth – broadly dimensions of reputation – that are increasing in importance as off-grid solar providers emphasize repeated sales and longer customer relationships.

The two quotations presented in the beginning illustrate that people engage in repeated efforts to solve issues with solar and seeking help from a frontline intermediary may initially stem from an existing relationship or familiarity. In both examples, solar users initially rely on those they previously interacted with from the provider, these provider-affiliated individuals may enhance trust or break existing trust based on ongoing interactions with consumers. Each example illustrates that solar users often will seek help from intermediaries designed into solar distribution models, but these distribution models may fail in moments of follow-up or responsive service. Trust in an intermediary may change based on an intermediary’s ability to solve a problem and act in a reliable manner. Trust in frontline solar intermediaries is not static and responds to the ongoing interactions solar users experience over the course of a solar product lifecycle or repayment period.

Understanding truthfulness and reliability of a frontline solar intermediary relies on what information they share with the consumer and how it is conveyed. Providing information transparently about solar services and the effort expended teaching customers about how to

\(^9\) See MacLean and Brass (2015) for a discussion of “blurring” trends between NGOs and the private sector in off-grid solar and Heuër (2017) for a specific example of off-grid solar distribution using women-to-women networks, also described further in Chapter 5.
use solar and complete payments may contribute to trust and consumer education, or, if lacking, may contribute to frustration with solar products and services. Beyond just frustration, failures to communicate terms and conditions transparently to solar users diminish effective implementation of emerging consumer safeguards for off-grid solar that provide guidance on product quality and promote consumer rights to fair and transparent services. Incentives for frontline solar intermediaries to engage with customers in a transparent and honest manner range from social to economic to political. Opportunities to build on existing relationships and enhance responsiveness reinforce the value of frontline solar intermediaries to off-grid solar service providers.

1.1.3 Chapter Roadmap

In this chapter, Chapter 1, I introduce frontline solar intermediaries as a frequently overlooked dimension of off-grid solar but instrumental in building trust and consumer knowledge. Dimensions of trust and knowledge are increasing in importance for off-grid solar providers as financing options require repeated interactions with solar end-users. In the next three chapters (Chapters 2-4) I explain what is important to know about off-grid solar, consumer protections in Kenya, and prior scholarship on intermediaries. As I bridge different scholarly disciplines and perspectives on energy access and intermediaries, the discussion in Chapter 2 provides the context for my application of the literature on intermediaries in Chapter 4.

Following the introduction in this chapter, I illustrate that prior scholarship focuses more on adoption and sales of off-grid solar than ongoing services, explain my research questions, fieldwork, and methods in more detail in Chapter 2. I provide an overview of off-grid solar with a focus on the increasing role of the off-grid sector in electrification and the growth of the pay-as-you-go or PAYGo solar model. I position my focus on frontline solar intermediaries in dialogue with research on electricity access to fill a gap in scholarship on the incentives and relationships that underpin the frontline actors providing access via off-grid solar. Off-grid solar providers, offering both solar and financial services, rely on frontline solar intermediaries to convey complex information about the use of solar and the financing terms and conditions. Such on-the-ground experiences and interactions with frontline solar intermediaries have implications for scholarship on more commonly studied themes such as solar adoption, satisfaction with electricity services, and policy for electricity access. Consumer satisfaction with early experiences with off-grid solar may influence the viability of these technologies to shift from a stop-gap to long-term solution for electricity access. I explain how my three primary research questions examine different aspects of the relationships

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10 Comments from off-grid solar agents such as “I have actually fallen in love with the sales bonus because it acts as a motivating factor” (@Sunrise_Kat, 2019b) and “I like when I install light in my community and everybody is happy and appreciates me a lot” (@Sunrise_Kat, 2019a).

11 Despite efforts to link consumers directly to the companies via call centers, the direct contact with solar agents has some appeal, but also room for improvement. One post quoted a customer saying “They should be quick to respond to challenges in time. Agents should be available to address our challenges” (McCloskey, 2020).

12 See Aklin et al. (2018), Aklin et al. (2016), and Jacobson and Kammen (2007)
that intermediaries have with service providers and solar consumers. Building on the introduction to off-grid solar distribution models and the importance of building trust in providers and consumer knowledge about solar, I describe why my methods are appropriate to answer these questions. Additionally, I describe my fieldwork and data collection procedures. While subsequent chapters provide additional information on the analyses present in those chapters, in Chapter 2 I synthesize across the methods used to describe their applicability to intermediaries in off-grid solar and the outcomes of interest.

In Chapter 3 I explore Kenya’s leadership in off-grid solar and the engagement of international organizations in piloting and supporting the off-grid solar sector in Kenya. While Kenya is briefly introduced in Chapter 1 and in the context for fieldwork in Chapter 2, this examines the organizations and institutions involved in off-grid solar services in Kenya. I illustrate the shared authority, though not always equally shared, between the Kenyan government, the private sector, and international organizations. The frameworks being established by international organizations, such as the International Electrotechnical Commission, and organizations supporting the off-grid sector, such as Lighting Global and the Global Off-Grid Lighting Association illustrate what consumers should know about off-grid solar services, with a growing emphasis on industry-developed consumer protection guidelines. In particular, this chapter examines how off-grid solar companies provide both technologies and financing. I discuss the implications for this blurring of services in the standards and protections emerging in the sector. This chapter sets the stage for understanding frontline solar intermediaries in Kenya by describing the interplay between non-state led initiatives in Kenya and activities led by the government that support off-grid solar.

With an understanding of the off-grid solar context in Kenya, in Chapter 4 I examine the dimensions of frontline solar intermediaries within the context of the broader intermediary literature. In this chapter, I identify an analytical framework to help assess the variation in frontline solar intermediaries. I review the literature on intermediaries from different disciplines to characterize intermediaries across their forms, functions, and motivations. Much of the literature on intermediaries recognizes the lack of definition and broad applicability, but does not provide specific dimensions by which to assess variation in intermediaries. To fill this gap, I provide three dimensions associated with the form of intermediaries: formality, scale, and durability. Further, I describe three actions that intermediaries do: facilitate, configure, and broker. Finally, I look at economic, social, and political motivations that underpin acts of intermediation.

In Chapter 5, I apply the intermediary literature to solar distribution models to understand how service providers build relationships with communities using frontline solar intermediaries. Based on field visits, interviews, reports, and prior scholarship, I describe four frontline solar intermediary types: community influencer, networking solar agent, embedded entrepreneur, and group leader. In Chapter 5, I use the term “networking solar agent” to describe this type, but throughout other chapters I more succinctly use “solar agent.” I also describe two additional frontline solar intermediaries that operate slightly differently than the first four: shop managers and field officers. The variation in after-sales service options, illustrates that while these local intermediaries are critical, their effectiveness is influenced
by a range of incentives and interpersonal relationships. I examine these types of frontline solar intermediaries in a set of distribution models to illustrate their implementation dynamics. The discussion of these models provides more evidence and detail for the opportunities, challenges, and complexity of utilizing intermediaries to promote not just off-grid solar sales, but after-sales services and the associated consumer protections.

Building on the literature and typologies of frontline solar intermediaries, Chapter 6 examines what attributes of a solar intermediary underpin trust. In this chapter, I characterize trust as associated with multiple dimensions of an intermediary. I identify how attributes influencing trust align with the typologies identified from cases of solar distribution models. Prior scholarship identifies trust-building as key dimension of an intermediary, and this chapter probes what exactly influences trust across: embeddedness, expertise, external connections, and sector affiliation. Using conjoint survey data and a conditional logistic model, in this chapter I find that solar users trust more in intermediaries from their communities and with connections to service providers, confirming trends in existing distribution models. There is a lack of trust in those with connections to politicians, but trust in government affiliation. Trust in the expertise of an intermediary depends on the sector providing it, with increased trust in non-governmental organizations providing training. Comparing the typologies in Chapter 5 and the dimensions of trust in Chapter 6, I suggest potential avenues for off-grid solar providers to build strategic partnerships to enhance trust in frontline solar intermediaries.

Ultimately, I argue that frontline solar intermediaries play a critical role on how consumers experience off-grid solar and what they understand about the safeguards provided by consumer protections. I propose that intermediaries exist at different stages of solar services, from awareness-building to repairs and maintenance, but existing models of frontline solar intermediaries prioritize awareness and sales over after-sales services.¹³ This focus overlooks that it is often the after-sales efforts that build the trust needed for repeated services to support future growth of pay-as-you-go companies. I argue that intermediaries are an important way to communicate about consumer protections and ensure that such polices respond to consumer experiences. In Chapter 7, I ask if variation in intermediaries affects consumer knowledge of off-grid solar services and protections. Examining survey data on perceptions of off-grid solar and measures of knowledge about off-grid solar – use and broader services such as financing – I test whether knowledge of off-grid solar varies by the intermediary consumers rely on for help with solar. I find that solar agents – or what I call networking solar agents – have a positive effect on knowledge about off-grid solar and taking action to resolve issues. This underpins the importance of solar agents in current off-grid solar distribution models and the growing safeguard regimes for quality and consumer protections.

Overall this research aims to understand how intermediaries facilitate off-grid solar services and their role in how frameworks for quality standards and consumer protections are experienced implemented using frontline intermediaries. Each of the questions I address examines a different aspect of intermediaries and together they provide a more complete picture of what intermediaries do and how they do it. In conclusion, in Chapter 8, I discuss

¹³With almost no existing intermediaries for the later stages of recycling or disposal
the implications of intermediaries in off-grid solar for trust in off-grid solar providers and consumer knowledge. To support efforts to provide electricity with off-grid solar, I identify how intermediary models may be improved to leverage local resources and enhance off-grid solar as a lasting service. Lastly, I connect the role of intermediaries to broader discussions occurring in Kenya about enhancing participation in energy decision-making.

1.1.4 Key Findings and Contributions

Findings from this research illustrate the strengths and weaknesses of existing frontline solar intermediaries and their roles in current off-grid solar distribution models. The emphasis on socially determined elements of services, such as trust and knowledge, suggests ways that these models can be improved by industry actors. With respect to academic scholarship, this research speaks to multiple disciplines from planning and implementation to political science to sociology. My effort to define and specify what frontline solar intermediaries are and what they are not finds both support for and diverges from prior scholarship. I breakdown both trust and knowledge into multiple dimensions to provide actionable improvements for providers and new avenues of exploration for academic scholarship. The attributes included in my conjoint experiment and the survey questions on solar knowledge provide a baseline for future survey research, relevant to off-grid solar, electrification more broadly, and other key services.

I illustrate the variation of intermediaries in off-grid solar, focusing on those that act in-between providers and users: frontline solar intermediaries. As literature on intermediaries spans multiple disciplines, it can appear diffuse or unwieldy. To synthesize across this literature, I identify dimensions of intermediaries that help differentiate between intermediaries and other actors, as well as between different types of intermediaries. There has been little comparison of how different solar models engage end-users and my focus on frontline solar intermediaries better specifies variation in this key dimension of off-grid solar services. My focus on intermediaries examines different stages of solar services, from awareness to after-sales services, while most prior scholarship focuses on the early stages of awareness and adoption.

In practice, intermediaries are integrated into off-grid solar service models in different ways and I describe a range of frontline solar intermediaries. Variation in frontline solar intermediaries suggests strengths and weaknesses in the design of distribution models and the incentives influencing intermediary behavior with implications for implementing consumer safeguard programs. The importance of social capital and personal familiarity with an intermediary is supported by my research, and I find that people continue to rely on in-person interactions. This research also highlights opportunities to build out new capacity to enhance trust in intermediaries, such as cross-sector partnerships or new training options. In many of the discussions about intermediaries, trust is described primarily as social capital, this work illustrates that social capital actually works in tandem with expertise and connections to services providers to build trusted frontline solar intermediaries.

Existing solar distribution models have room for improving incentives for frontline solar intermediaries and enhancing trust in these on-the-ground actors by promoting stronger
partnerships, in particular for the most common frontline solar intermediaries in this research, solar agents (also called networking solar agents in this dissertation). Solar providers rely on solar agents to reach more remote areas and attend larger gatherings, such as market days, to make sales. I show in this research that solar agents play a critical role beyond sales too. Not only do consumers rely on solar agents for help with solar issues more than on other frontline solar intermediaries, but solar agents are building some consumer education – the baseline for holding providers accountable to consumer service standards. I find that solar agents are associated with an increase in knowledge about solar services and safeguards. While not a panacea for solving all issues with off-grid solar after-sales models, this increase in knowledge associated with solar agents indicates that more attention should be paid to enhancing the solar agent role, rather than circumventing with call centers.
Chapter 2

PAYGo Off-Grid Solar Background and Research Design

2.1 Introduction

Solar home systems continue to attract substantial investment dollars and are increasingly viewed as solutions to last-mile electrification goals, as off-grid solar providers now offer more system sizes, appliances, and financing options. Distributed generation technologies, from lanterns to mini-grids, provide new opportunities for electrifying households and businesses. Solar technologies are being incorporated into the stack of available options used to different energy needs. Off-grid solar, here defined as solar lanterns and solar home systems, can provide basic electricity. Historical efforts experimented with and promoted off-grid solar, now resulting in an increasing number of providers active globally, but especially prominent in East Africa. The off-grid solar sector is increasingly diversified, moving from just lighting to a wider range of end uses (such as televisions and refrigeration) and broader services (such as other loan products). Currently, the off-grid solar sector includes providers offering some type of solar-related product or service, but this sector continues to grow and change.

Incorporating larger appliances and broader services often relies on existing customer relationships (for up-selling or cross-selling) and positive customer experiences throughout the repayment period. While off-grid solar companies still remain more akin to a product distributor than a traditional utility, changes in the sector suggest a growing emphasis on repeated services rather than one-off sales. Studying “street level ‘brokers’” (Post et al., 2017, 956) in off-grid solar is an important dimension of how services are distributed. I focus on how these frontline actors in off-grid solar work to build – or not – positive and durable provider-user relationships. I call these actors frontline solar intermediaries and they encompass a range of individuals that act as an on-the-ground go-between for providers and end-users. Frontline solar intermediaries are an important linking actor in off-grid solar service models as they often provide an introduction to solar products and services, including the first information about service dimensions, such as system functionality and service terms and conditions. Frontline solar intermediaries remain a point of contact for customers even
In this chapter, I contextualize frontline solar intermediaries in the broader discussions of distributed generation for electricity access goals. Within this literature I describe the need to focus on intermediaries as socially embedded actors that can help explain outcomes of interest to scholars, such as trust in off-grid solar. I highlight the dimensions of frontline solar intermediaries explored in future chapters: intermediary forms, building trust, and building knowledge. I outline the research design and methods used to study these dimensions of intermediaries in off-grid solar. Finally, I provide a brief introduction to the country context for this research, Kenya. Here, I introduce Kenya’s leadership in off-grid solar and describe its position compared to other countries with active solar markets. In the next chapter, Chapter 3, I provide far more detail on off-grid solar in Kenya and the organizations involved in the development of off-grid solar and emerging consumer safeguards for solar users.

2.2 Using Distributed Generation to Meet Universal Energy Access Goals

Distributed renewable energy technologies – mini-grids, solar home systems, and lanterns – are beginning to have an impact on electricity access. As of 2017, the number of people globally without electricity access finally reached less than 1 billion people, down from 1.7 billion in 2000 (International Energy Agency, 2017a; International Energy Agency et al., 2018). Electricity access with distributed renewable energy increased from 20 million people in 2011 to over 152 million in 2017. With over 95% of the connections coming from lanterns and solar home systems: “off-grid” solar systems. Figure 2-1 illustrates the ways that different forms of distributed solar (as pico, off-grid, and micro-grid) can provide households and small businesses with basic electricity services, here I indicate the focus of this dissertation on a sub-set of distributed generation options: solar lanterns and home systems.

I focus on pico-solar and off-grid forms of distributed generation because these small-scale solutions are attracting substantial investment and innovation. Increasingly, distributed generation solutions are incorporated into electrification strategies. Practitioners recognize that “access to even small quantities of modern electricity – sufficient to power basic modern lighting, cell phone charging, a small radio or television – can trigger a giant step for [those] that are without any access” (World Bank, 2016, xi). Recent trends in this sector suggest a growing demand for solar home systems and increased financing allocated to solar home

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1 Off-grid solar products include pico solar (lanterns or multifunction lanterns that offer both light and mobile charging), “plug-and-play” solar home systems (solar home system kits that include basic or upgraded appliances), and component-based systems (PV modules, batteries, lights, inverters, charge controllers, and wiring that are compiled separately and therefore range in configurations and associated appliances) (Dalberg Advisors et al., 2018). Beyond standalone solar home systems, distributed solar also includes microgrids that provide electricity to multiple households but are not connected to the main electricity grid (100 kW to 5 MW) (Baldwin et al., 2015).

2 This is supported in a recent report that deemed solar lanterns “the most impact bang-for-your-buck” (Harrison et al., 2020, 14).
The diversity of distributed solar services complement more traditional grid extension efforts, especially given limited financial resources to extend centralized electricity infrastructure. Operating with constrained budgets, governments often allocate resources to key public services such as transportation, health, and education, over allocating resources to electrification (Grimm et al., 2018). Nevertheless, electrification remains an important “powerful multiplier” of other development goals (Nathwani and Kammen, 2019, 2), yet universal electricity access remains a lofty goal for many countries. Entrepreneurs, non-governmental organizations, international financial institutions, and governments are supporting off-grid solar services as a way to achieve energy access goals.

Innovations in off-grid energy systems are often designed and marketed to households that either lack electricity completely or experience poor-quality electricity from the grid. Sub-Saharan Africa continues to have the largest unelectrified population globally, at 61%, with developing Asia next at 35% (Ren21, 2019). Many of the households lacking electricity are rural and low-income, and spend a large portion of their income on expensive consumable energy goods, such as kerosene, charcoal, and candles (International Energy Agency, 2017a). Small-scale solar solutions have the potential to offset the need for a connection to the more traditional, centralized electricity grid by providing basic electricity services of higher quality.

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3See Harrington et al. (2020) and Shrivastava (2017)
and at a lower cost than kerosene. The use of distributed solar technologies may reduce upfront connection fees for consumers, the high cost of rural grid extension for utilities, and increase distributed renewable energy penetration in support for global climate goals. But the reality of this opportunity, relies on building sufficient consumer belief that these solutions are a lasting or durable alternative, not just a complement or backup, to the grid.

Rural electricity access is often provided by a range of energy sources, households typically piece together different technologies and fuels to meet their energy needs. The range of technologies and services in rural electrification illustrates both the challenge of reliable services and promise of entrepreneurship and innovation in this sector. The failures of utilities “unable to meet demand and solar home system programs that install systems that no longer work after a couple of years” are juxtaposed by continued efforts to provide electricity using these solutions supported by “a whole host of actors ranging from international donors and national ministries to entrepreneurs, NGOs, cooperatives and local governments” (Zerriffi, 2011, 179). The landscape of electricity access is changing and varied as a wider range of organizations strive to provide energy access and, in doing so, are also redefining what it means to have access to electricity.

### 2.2.1 Refocusing on End-Use: Beyond A Binary Measure of Access

As governments and utilities look to solutions beyond grid access – and cope with grid-connected households facing unreliable service – international financial institutions and aid organizations are refocusing the discussion from grid access to the ability to use electricity when needed. What it means to have electricity access is evolving alongside the growth of off-grid solar. In 2015, the Energy Sector Management Assistance Program released “Beyond Connections Energy Access Redefined” which recognized the difficulty of defining and measuring energy access. This effort, in partnership with other international organizations, redefined access in the Multi-Tier Framework as a set of indices spanning supply, service, and consumption (ESMAP and Sustainable Energy for All, 2015). For households, this framework provides “technology neutral multi-tiered standards” that move beyond a binary measure of access. Moving beyond the notion of electricity access as connection to the centralized grid is creating space for technologies such as off-grid solar by emphasizing the use of electricity over just having a connection. This shifts far more attention to issues of quality and affordability than just the presence of a meter.⁵

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⁴Zerriffi (2011) targets the goals of universal services and low prices, he intentionally does not include decarbonization as a goal of these distributed options and argues that while linked and equally important climate change and distributed generation should be de-linked so that the full range of options is considered for rural electrification. Despite this proposed de-linking, in practice many distributed generation options are currently developed and financed using climate-related mechanisms (see, for example, US-India Clean Energy Finance (USICEF) (NDC Partnership, 2019).

⁵Recent evidence from grid extension in Kenya reinforces the importance of examining the use and affordability of electricity, not just a connection. In 2017, an internal audit at Kenya Power (KPLC) found that of 3.6 million new connections, up to 1 million may have been falsified. Such “connections” may have not actually been installed or not even delivered to the customer (Wafula, 2017). Further, despite the increase in grid connections, more than half of Kenya Power customers spend less than 305 KES per month, or about
Countries are beginning to integrate these technology-neutral tiers of electricity access into electrification planning. Tier 1 of this framework, for households, specifies a minimum of 3 W and 4 hours of electricity during the day and 1 hour in the evening, with task lighting and phone charging. The “plug-and-play” solar home systems, which provide a bundle of components and appliances from one company, typically meet this Tier 1 threshold, with some systems easily able to provide higher tiers of access with larger system sizes, number of hours, and more end-uses that include appliances such as televisions and fans (Dalberg Advisors et al., 2018). In Kenya, the 2018 National Electrification Strategy defines the minimum level of service for standalone solar as “Tier 1 service as defined by the Multi-Tier Framework” (Ministry of Energy et al., 2018, 29). Thus, Kenya’s planning efforts are now directly referencing this new measure of access. The technology-agnostic definition of electricity access allows for electrification from different companies and different generation sources as long as they meet this common tier-based standard. This standard does not capture the sustainability or durability of electrification from different companies or service models; this aspect of after-sales service remains unspecified. Ensuring that after-sales services are available in rural communities and, further, that consumers are aware of these services are central to a more multifaceted measure of lasting electricity access.

Academic scholars generally focus on understanding the impact of off-grid solar on energy use and development outcomes, rather than the development of associated safeguards that support ongoing use of off-grid solar and fair business practices. Research on the impact of smaller solar systems indicates mixed results, with limited linkages between solar home systems and income-generating activities (Stojanovski et al., 2017). Compared to households connected to the centralized grid, households with only solar home systems are more like those using kerosene, despite desire across all groups to own appliances (Lee et al., 2016). Baldwin et al. (2015) describe that even small-scale solar systems improve the quality of life for end-users, although economic and social development outcomes require more than just electricity access. Different forms of distributed generation may be able to achieve the well-being outcomes of basic electricity, with standalone solar home systems and the use of other distributed generation (mini-grids) to meet productive use needs (Boamah, 2020). With the growth of off-grid solar, there is a need to better understand the different types of value that stem from solar products, which may include a broader set of indicators associated with quality of life and well-being not only measures of consumption (fuels, electricity, additional appliance purchases).

Increasingly researchers working for industry think-tanks argue that the metrics of income generation and cost savings do not reflect the true value that some households receive from solar. More attention should be paid to “the forms of value that bring comfort and well-being today” not just economic goals for tomorrow (Zollmann, 2017). Think-tank based research efforts are grappling with issues of exactly what the value of off-grid solar is and how households may experience a range of benefits (often difficult to quantify) from off-grid solar.

Measures of off-grid solar services focus primarily on sales and adoption, rather than the $3 USD suggesting the use electricity for not much more than lights and phone charging (Otuki, 2018).
full consumer experience with off-grid solar technologies and providers. Addressing challenges post-sale, including faulty systems, mismatched expectations, and misuse, is increasingly recognized as an important area of improvement for the off-grid solar sector (Harrison et al., 2020). The focus on adoption and modes of introducing new solar products, while often missing dimensions of addressing ongoing services, highlights opportunities for partnerships and how solar providers leverage the “social network of family, friends and neighbours” (Heuër, 2017, 122) to enhance trust and understand local needs. Starting with early stages of awareness-building, social and local networks are often viewed by providers as key to on-the-ground solar service models.

Social ties and peer-to-peer recommendations are influential in the adoption of off-grid solar, given uncertainty about characteristics that are difficult to immediately ascertain, such as quality. While word-of-mouth is increasingly influential in adoption of systems (see Bisaga (2019)), seeing one’s neighbor with solar may be more influential than solely word-of-mouth (Opiyo, 2019). Efforts from word-of-mouth to neighbor influence or targeted demonstrations and door-to-door campaigns, aim to build awareness and sales in hard-to-reach areas and to provide opportunities for education about solar products (Scott, 2017). Scholarship on the adoption of off-grid solar recognizes the importance of formal and informal connections, ranging from established partnerships to friends and neighbors.

The efficacy of local connections to support services beyond awareness and sales is uncertain, calling into question the long-term sustainability of “access” using off-grid solar services. While temporary or targeted efforts to build adoption in one town or region may be effective for short-term sales, if they are not sustained over time, they can diminish future market development (Goyal and Jacobson, 2019). Time and again, scholars highlight the importance of partnerships to help sustain off-grid solar models. With community engagement to help “establish legitimacy and gain knowledge of community norms and informal institutions” (Scott, 2017, 54), partnerships can provide both managerial and financial support to reach more remote communities. Scholars also recognize that even more formal, institutionalized partnerships must be paired with local capacity to “overcome barriers related to trust and knowledge of the product, fill institutional voids in the supply chain, and provide needed education, installation service, and after-market support” (Scott, 2017, 54). There is increasing support from both scholars and industry actors that “short-term diffusion does not guarantee long-term operation” (Brass et al., 2012, 127), but how to implement policies and programs to address the issues influencing this long-term sustainability is less clear.

Local services and connections are key for efforts to promote lasting, more sustainable off-grid solar models that extend beyond awareness and sales. In India, Joshi et al. (2019) find that training local women for repairs and maintenance can enhance access in more remote communities and reduce issues of technical failures since community members can repair them on-site. This model built “a ‘local solar ecosystem’ anchored by a manufacturing facility with a deeply involved SHG [self-help group] network” (Joshi et al., 2019, 280). Based

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6In previous work in India, Harrington et al. (2020) distinguish between adoption and retention of energy options and seek to differentiate across stages of the consumer experience with off-grid solar.

7See Harrison et al. (2020) and Global Off-Grid Lighting Association (2019a) for examples of industry recognition of needed improvements in consumer relations and after-sales efforts.
on fieldwork in Kenya, Cross and Murray (2018) argue that there is insufficient attention on repairs, waste, and recycling. The uncertainty of how the off-grid sector is addressing these post-sales activities suggests that current adoption of off-grid solar “does not just presage a low-carbon energy transition” (Cross and Murray, 2018, 107); but it does indicate a growth of waste from electronic equipment. With evidence suggesting growth in adoption of off-grid solar products, industry and government attention is now shifting to the services, programs, and policies required to support long-term off-grid solar use.

Increasingly, this long-term model for off-grid solar includes not only solar lanterns and home systems, but a range of additional appliances and services. For off-grid solar, after-sales services and upgrade opportunities enhance the value of solar services to customers. Even with financing, willingness to pay for electricity may not meet cost-covering prices for off-grid solar (Grimm et al., 2018). One of the biggest innovations in the sector is the use of mobile money networks to allow customers to make payments in small, high-frequency, and variable increments (called “pay-as-you-go” or PAYGo). PAYGo solar increases short term affordability, but also increases the total amount households pay for solar given relatively high interest rates, as high as 20% (Dalberg Advisors et al., 2018). Increasingly, off-grid solar companies are focused on upgrading and cross-selling customers by adding appliances and other services to solar home system packages (Energy Access Practitioner Network and Efficiency for Access Coalition, 2018). This application of the “information-energy nexus” to off-grid solar can reduce transaction costs and better guarantee repayment for providers (Alstone et al., 2015). As solar home system providers increase the size of standalone systems, provide a larger number of efficient and compatible appliances, and offer a wider variety of services, there is also a need for safeguards that ensure high-quality products, consumer protections, and sustainable service models (Dalberg Advisors et al., 2018). Consistent safeguards that promote quality and protections for solar consumers allow for PAYGo solar companies to coordinate their efforts across country contexts.

Frontline solar intermediary models can influence both adoption and subsequent issues related to this PAYGo model, such as of customer defaults or payment issues. Barrie and Cruickshank (2017) find that while using a model of promotional events with solar agents increases adoption rates significantly, during these centralized demonstrations agents may sell products to customers that live far away (or in an unknown location), which may complicate future interactions with these customers. Additionally, if frontline solar intermediaries themselves are not sufficiently familiar with PAYGo, they may not educate the customer leading to future defaults in the repayment process. As off-grid solar services increase in complexity, frontline intermediaries are necessary and an asset for sales, but can increase risks at later stages if information, terms, and system uses are not sufficiently explained to customers.

Discussions with households in rural Kenya suggest that people do not know what to do with electronic waste of all kinds—solar or otherwise. Some store it in the house, some give it to kids to play with, and others throw it in their pit latrines for disposal. Songa and Lubanga (2015) suggest that the growth of e-waste has caught both government and non-governmental actors unprepared to deal with the problem.
2.2.2 The Evolution of Off-Grid Solar Beyond Lighting

Off-grid solar companies are evolving from technology manufacturing companies to companies that offer a broader array of services. Offering a broader set of solar-related services reinforces the importance that frontline solar intermediaries provide customers with reliable and transparent information. High and increasing levels of investment in off-grid solar companies suggest growing confidence in this sector. The off-grid solar sector received just under $1.7 billion in disclosed investments through end-of-year 2018, with over $500 million in 2018 alone. Of the total amount of disclosed investments in solar, 50% has gone to East Africa and 81% toward solar home systems (Attia and Maze-Rothstein, 2019). Figure 2-2 illustrates the increasing number of companies providing off-grid solar and the growth of investment in the sector in recent years. However, there is some debate within investors if all the investment in off-grid solar is “too much, too fast” as the core business model of off-grid solar is still evolving (Neichin et al., 2017). Investor concerns stem from uncertainty about what defines the core services provided by off-grid solar companies, ongoing challenges with after-sales services, and the ability for off-grid providers to serve last-mile households.

**Figure 2-2:** Year founded (count) for off-grid solar companies globally and investment in these companies over time (companies identified by author, while covering a large number of active companies it is not comprehensive). Data from Pitchbook (MIT access), identified by searching off-grid solar companies referenced in reports (Global Off-Grid Lighting Association, 2019b) and key search terms in Pitchbook (N = 49).

The focus within the off-grid solar sector on PAYGo models reflects an increasing number of companies experimenting with financial technologies and services. Companies like PEG Africa explicitly focus on the consumer-facing aspects of the industry, including sales, credit, repayments, and after-sales services. While others specialize in a particular segment of the value chain, such as Angaza’s PAYGo technology platform or Renewit’s emphasis on manufacturing. Further, some companies that historically operated in a vertically integrated manner are starting to offer specific aspects of their business to other companies, such as
Mobisol’s licensing of software that supports up-selling customers to new products (Dalberg Advisors et al., 2018, 101). The breadth of company classifications in this sector illustrates the diversity of companies – and interests – striving to provide solar services.

The growing diversity of activities within the PAYGo off-grid solar sector is allowing for more specialization. Figure 2-2 shows the overall growth of off-grid solar companies, especially from 2009-2012, and the parallel growth in investment. Looking more closely at how off-grid solar companies are classified illustrates the variety of interests held by these companies; the division across industry group classification is in Table 2.1. Some of the dominant players in the sector (BBOXX, d.light, M-Kopa, Mobisol, Zola, and SELCO) all are classified as Energy Equipment providers, while Greenlight Planet (manufacturer of Sun King products) is under Consumer Durables. Others such as Lumos Global and Pawame are under Utilities, while PEG Africa is Other Financial Services and SOLShare in Bangladesh is classified as Software. Figure 2-2 and Table 2.1 are not comprehensive of all companies or providers in the off-grid solar sector, but include some of the largest players globally and some of the companies trying to develop a niche or specialization within this sector. Not all off-grid solar companies provide the same services, some continue to focus on providing introductory (Tier 1) lighting while others are moving into offering more financing options or develop software platforms.

Table 2.1: Off-grid solar companies (counts) classified by Primary Industry Group. Data from Pitchbook (MIT access), identified by searching off-grid solar companies referenced in reports and key search terms.

<table>
<thead>
<tr>
<th>Primary Industry Groups for Off-Grid Solar Companies</th>
<th>(N = 49)</th>
</tr>
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<tbody>
<tr>
<td>Energy Equipment</td>
<td>23</td>
</tr>
<tr>
<td>Consumer Durables</td>
<td>7</td>
</tr>
<tr>
<td>Energy Services</td>
<td>5</td>
</tr>
<tr>
<td>Exploration, Production and Refining</td>
<td>4</td>
</tr>
<tr>
<td>Commercial Products</td>
<td>2</td>
</tr>
<tr>
<td>Services (Non-Financial)</td>
<td>2</td>
</tr>
<tr>
<td>Software</td>
<td>2</td>
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<tr>
<td>Utilities</td>
<td>2</td>
</tr>
<tr>
<td>Other Financial Services</td>
<td>1</td>
</tr>
<tr>
<td>Commercial Services</td>
<td>1</td>
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</tbody>
</table>

The diversity of companies in the off-grid solar sector supports a trend of specialization rather than continued vertical integration. Industry experts and leaders recognize that early, vertically integrated off-grid solar companies “tried to do everything” from hardware and software to manufacturing to distribution and logistics to financing (Parnell, 2019). The ongoing evolution of the off-grid solar sector suggests that specialization may allow for companies to leverage the strategic use of big data to inform decisions, meet untapped demand, and develop partnerships to, for example, mitigate political challenges (Parnell, 2019). The trajectory of the sector appears to be in flux, but with growing focus on financing and services beyond lighting.
Opportunities to specialize are attractive to providers because it is challenging to excel in all of the areas included in vertically integrated models off-grid solar. Increasingly, companies are making decisions about their core functions and position in the off-grid solar value chain (Dalberg Advisors et al., 2018). While some of the larger off-grid solar companies remain vertically integrated, “specialization has been driven by a maturing market that allows for it, in comparison to the early days of the market which necessitated vertical integration (to account for lack of suppliers in various parts of the value chain)” (Dalberg Advisors et al., 2018, 24). As companies continue to grow and enter new markets, they are making key decisions based on their position in the value chain (including the use of strategic partners), development of payment platforms, financing models (lease-to-own, payment period), and the payment process (including mobile money, airtime, and cash payments to solar agents) (Dalberg Advisors et al., 2018). The specialization occurring within off-grid solar suggests that future policies and programs responsible for setting and implementing solar service standards may need to address subsets of the sector differently.

The growing number of services provided by solar companies highlights some of the challenges of financed off-grid solar. As solar providers increasingly offer pay-as-you-go financing for solar technologies and services, key issues identified by industry analysts and end-users include: remote lockouts from solar systems given defaults and grace periods in repayment plans. While lockout technology is viewed as an important element of scalable solar financing, the link between lockouts and repayment defaults is uncertain. Industry experts have voiced concerns about locking out income-generating loans and the potential for lockouts just make it more difficult to eventually repay if households must then spend money on alternative energy sources, such as kerosene (Waldron and Swinderen, 2018). Companies are still experimenting with how to integrate off-grid solar with additional services, but having effective links to end-users remains ever important.

2.2.3 Blurring of Financial and Solar Services Requires New Consumer Protections

The blurring of expertise and innovation allows for off-grid solar providers to address more than just access to lighting, but it also raises questions about what kind of company off-grid solar providers are and therefore what rules and regulations they must follow. Regulatory issues associated with PAYGo solar mirror those of mobile money lending in Kenya, including high interest rates, questionable lending practices, and the growth of over-indebtedness.

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\(^9\) de Bresser (2017) describes off-grid solar companies as distributed energy service companies or “DESCOs” which may be more akin to the products and services offered than a utility, thus while not a direct “utility of the future” just as utilities must engage with ESCOs providing services such as demand management, so too do existing electricity utilities must account for distributed solar companies in their strategic planning.

\(^{10}\) Partnerships and joint ventures are increasing in the off-grid solar sector, with early partnerships like Awango between Total and d.light in 2012 to over 9 big partnerships in 2018, such as the launch of joint solar and cell phone bundles between Orange and Niwa, d.light, and BBOXX in Burkina Faso, Democratic Republic of Congo, and Madagascar or M-Kopa and Mastercard’s payment processing partnership (Attia and Maze-Rothstein, 2019, 28).
The PAYGo solar model is an innovation that enhances short-term affordability, but also instills some uncertainty about what services comprise off-grid solar and, therefore, what regulations should guide their actions.

Cash payments remain the most common payment method for off-grid solar globally, but PAYGo solar adoption is increasing in prevalence and in investment dollars. The capital provided by financial institutions has been associated with enhancing the role of women in the use of solar and solar entrepreneurship activities (Lighting Africa - Women Initiative, 2013). While solar pico-solar lantern sales are expected to remain dominated by cash sales, larger solar home systems are more likely to provide financing options, with 91% of investment going to PAYGo companies as of end-of-year 2018 (Attia and Maze-Rothstein, 2019). Of the 4.1 million off-grid solar lighting products sold across the globe, 3.1 million were completed in cash sales and 1 million using PAYGo, but the value of the PAYGo sales exceeds that of cash sales with a PAYGo value of $216.85 million compared to a cash sales value of $85.34 million (Global Off-Grid Lighting Association, 2019b, 15). Despite the murkiness of regulations guiding PAYGo solar, the trends in the sector suggest a strong emphasis on PAYGo solar.

Academic scholarship on off-grid solar is just beginning to recognize the implications of PAYGo solar for consumer protections. Recently, academic literature has started to contend with the ethical and business implications of data collection in off-grid solar. The implications of data collection and use are often overlooked with the hope of identifying financially and technically viable electrification options (Lee et al., 2019, 2). A range of stakeholders collect data on solar users and electricity access more broadly, including solar providers, traditional utilities, government (e.g., demographics), development or aid organizations, funders (e.g., Acumen’s spin out 60 Decibels), and researchers. Lee et al. (2019) argue that there is value and risk for each stakeholder group across data types (including technical, financial, and demographic data). For example, as of April 2015, M-Kopa shares information on loan defaulters with credit bureaus to try to curb non-payment, with those defaulters hypothetically blacklisted by lenders. This aligns M-Kopa with traditional electricity and water utilities which report defaults to credit bureaus (Herbling, 2015). Steps to remedy information asymmetries will result in winners and losers in the industry, but new rules may benefit from co-designing data sharing practices, standardization, and more concrete privacy and anonymity mechanisms (Lee et al., 2019). To implement efforts to co-design new practices for off-grid solar sector experts need to effectively engage consumers to incorporate salient, on-the-ground experiences with solar.

The range of experiences with off-grid solar – as illustrated in Chapter 1 – is becoming more prevalent in academic research. For example, Cross and Murray (2018) chart out three models of solar repairs with varying amounts of waste and ability to provide lasting repairs: a home repair, a town fundi (skilled worker), and a company technician. Academic scholarship is now incorporating off-grid solar discussions with energy justice as an opportunity to enhance energy access (Boamah, 2020). But this access requires after-sales options, from repairs to waste disposal (Cross and Murray, 2018). The convergence of PAYGo financing and the recognized weakness of after-sales services for off-grid solar is bringing consumer protections to the fore of recent off-grid solar sector efforts.
While academic research does not engage with PAYGo solar as much as industry gray literature, the growth of PAYGo off-grid solar engages with prior academic scholarship on mobile money. PAYGo solar companies entering into mobile money and financing services are stepping into uncertain territory. While some scholars find increased financial resilience and savings associated with access to mobile money agents (Suri and Jack, 2016), others find less favorable associations for financial inclusion (Van Hove and Dubus, 2019). In addition to an uncertain effect on financial inclusion, when participating in mobile money transactions consumers often do not know the terms associated with these services, especially when provided with loan options. For example, in Kenya, users of loan products may not sufficiently understand the fee structure with mobile money loans that often charge higher rates than typical microfinance (Malala, 2018, 364). For many solar providers offering access to more flexible financing via PAYGo has encouraged continued – albeit variable – growth in solar sales.

Research from think-tank and industry gray literature is contending with the issue of how to classify PAYGo solar providers. With an increasing emphasis on the financing capacity of off-grid solar companies, industry researchers are drawing stronger links between off-grid companies and microfinance institutions. Industry think-tanks remain uncertain about whether off-grid solar companies are “energy service companies, durable goods retailers or microfinance institutions” (Sotiriou, 2017). The growth of PAYGo solar is important for understanding the responsibilities of frontline solar intermediaries because it illustrates that they must do much more than just sell a solar product. As described in Chapter 1, frontline solar intermediaries such as solar agents, must be familiar with both financing terms and solar functionality and participate in a wider set of activities that ensure consistent repayment of financed solar.

The information shared with consumers about terms and conditions matters for adoption and use of off-grid solar services. The complexities of PAYGo solar requires explanation about what pay-as-you-go is, how to make payments, and the payment period terms. Based on a survey of over 1,300 people in Uganda, 45% had heard of pay-as-you-go but only 19% were confident about what it was. Upon explaining that PAYGo solar systems allowed people to pay in small increments over time, but that given non-payment households would be locked out of the system, interest went from 63% of respondents to 40% (Waldron and Swinderen, 2018). Issues of indebtedness, transparency, and use of off-grid solar are related to who and how accurately these concepts are explained to end-users, with implications for achieving development goals.

In some cases, such as Kenya, off-grid solar providers are operating in areas where digital credit markets are already active. PAYGo companies in Kenya and Tanzania are in markets where “transparency and responsible lending issues are contributing to high late-payment and default rates in digital credit” (Izaguirre et al., 2018). With 50% of digital loan borrowers in Kenya and 56% in Tanzania reporting late repayment on a digital loan, digital credit models are still nascent. Experts suggest that more consumer protections are needed to prevent a credit bubble (Izaguirre et al., 2018). PAYGo solar companies entering into new financial services are providing both electricity and financial services, each service with a set of data,
transparency, and equity considerations.

Off-grid solar companies are not hiding the activities beyond solar products, but nevertheless it is uncertain if regulators can keep up with this quickly changing sector. M-Kopa, one of the largest PAYGo solar companies and responsible for much of the PAYGo mobile money innovation in the sector, “...is a finance company [and they] give the customers some collateral and a line of credit” (Faris, 2015). Increasingly, it is clear that using the repayment data from solar products as a credit mechanism is an influential asset for solar providers in this growing sector. Beyond providing solar, M-Kopa provides, those who are able to pay off their first loan with the company, access to other products and services (stoves, bicycles, water tanks, school fees loans, or smartphones) (Faris, 2015). Operating ahead of regulators, but with a need to maintain good customer relationships, companies rely on intermediaries to explain the complexities of financing or additional services.

Studying frontline solar intermediaries bridges academic scholarship and industry research, addressing the opportunities for electricity access, the complex realities of PAYGo solar services, and the implications of this mode of electricity production for consumer protections. The viability of PAYGo solar as a durable solution to electricity access is tied to the effectiveness of on-the-ground communication channels, the frontline solar intermediaries. Like the concept of “solar prosumers” who both produce and consume energy, the pay-as-you-go off-grid model requires more active end-user participation in the management of household energy generation and consumption. In tandem, more data is collected and used by the provider to understand consumer behavior and offer future services. User empowerment in the renewable energy sector remains an important input into energy service provider and end-user interactions (Moss, 2009). Frontline solar intermediaries have the potential to influence how this user empowerment is built and used by consumers.

2.2.4 Solar Sales Agents: An Example of Frontline Intermediaries

Academic research addressing concerns of off-grid solar challenges often focuses more on technical considerations rather than the ways that service models influence the diffusion of knowledge about solar. In response to poor-quality solar photovoltaics, scholars suggested – and worked to implement – efforts to rectify information asymmetries via labeling and quality standards (Duke et al., 2002). Labeling requirements for off-grid solar go beyond just technical specifications, but include warranty and use information; although, little has been done to assess if and how people use this information. Frontline solar intermediaries provide insight into how this kind of information is explained at point-of-sale and in ongoing interactions.

Intensified by the prevalence of PAYGo financed solar, off-grid solar providers now realize that the incentives provided to frontline intermediaries do not always promote building long-term, trusted relationships that are key to future repeat sales and adoption of new services.

11 Applied to Kenya this link between solar and financing will be explored further in Chapter 3.
12 Prosumers suggest a shift from “passive consumers to active prosumers of energy – most often not yet self-sufficient, but simultaneously producers and consumers of energy” (Szulecki, 2018, 22). This type of engaged consumer is one dimension of the discussions in academic literature of energy democracy.
Stories of exploitative experiences with off-grid solar agents – one type of frontline solar intermediary – include: helping customers avoid payments by taking personal payments to “loop” or circumvent the remote payment system, agents that fail to provide all of the appliances included with a solar package, lie about appliances included, do not return appliances returned for repair, or take the follow-up company calls on behalf of the customer (interview 190712, focus group 190711; solar agent challenges are cited across country contexts see Global Off-Grid Lighting Association (2019a, 11-12)). These stories mirror and expand upon those described in Chapter 1, which highlight a disconnect in after-sales services. Undoubtedly, consumers have positive experiences with solar agents too, but the discretion agents have as a local communication channel is a challenge and opportunity for promoting transparency in sales and after-sales services.

Solar agents are one type of frontline solar intermediary, and while companies are working to limit agents’ post-sales interactions with customers by shifting after-sales contact to a call center, in practice, this shift from agent to call center is difficult. Figure 2-3 illustrates a solar agent installing a solar home system, in this case the agent both transported the system from town to a more remote area in the region, installed the system, and instructed the customer on system use and maintenance. These solar agents are an important distribution link as they can reach more remote areas on motorbikes with solar systems strapped to the back, allowing for solar services to reach more dispersed populations. In the “plug-and-play” model, solar agents commonly act as the agent in Figure 2-3, they deliver, install, and educate the consumer on how to use the system.

Figure 2-3: Solar agent installing a solar home system, with motorbike transport in front of the home, near Arusha, TZ

Solar agents are recognized by industry actors in the off-grid solar sector as a key link to ongoing services and enacting consumer protections. In a recent report, Global Off-Grid Lighting Association (2019a, 11) highlights that “[t]he performance, behaviour, communication, and incentives of sales agents is arguably the single biggest factor in consumer protec-
A sales agent is the main point of contact for a customer and guides them through the sales process." The report calls this “the agent challenge” and while solar agents are integral to off-grid solar sales, many later issues associated with payments or understanding how to use the solar system can be associated with the initial information shared by solar agents. The importance of how agents communicate transparently and effectively with solar users is accentuated by the growth in PAYGo solar and the importance of sufficiently explaining PAYGo terms and conditions in the beginning of the contract.

These solar agents, just like a local leader or school teacher, are not company employees. Rather they receive sales-based, and sometimes repayment-based, commissions, which incentivizes agents to extend the network of a solar provider into rural or more difficult to reach communities. Issues related to solar agents include high turnover rates (as high as 50% per annum), dishonesty, and the use of “sub-agents” or networks that agents construct locally to make more sales – but are often unknown to, and not affiliated with, the service provider (Global Off-Grid Lighting Association, 2019a). These difficulties will be discussed in greater detail in Chapter 5. Solar agents and other frontline solar intermediaries are designed into existing off-grid solar distribution models, as key links to rural communities.

Beyond sales, solar agents represent an ongoing link for companies to their customers. But solar agents present risks as well. As solar companies face challenges of increased competition and the need to cross or up-sell customers to other solar packages, services, or appliances, solar agents are a key mode of establishing a long-term customer relationship (Dalberg Advisors et al., 2018, 11). PAYGo solar requires that agents have additional skills, engaging in longer and more complex sales processes – managing these networks remains a challenge given the need for initial and ongoing training, regular contact with the company, and incentives that encourage loyalty and higher performance (Chang, 2017). More broadly, reports suggest that for digital money, “the customer experience and level of compliance with company policies vary greatly by agent outlet” (McCaffrey and Linares Villuendas, 2018, 3). Agents in PAYGo solar are responsible for reaching last-mile communities and the use of sub-agents or other local actors may challenge provider or policymaker goals of consistent quality of service.

Local relationships that underpin customer-provider communication channels are critical modes of receiving access to, information about, and recourse regarding services. Responsibilities for the most basic participation in infrastructure decisions, informing citizens, has diffuse or multiple responsible parties including “sector-specific intermediaries (for example, NGOs in water, rural community leaders in energy)” (Muzzini, 2005, 35) (also see Arnstein (1969)). Krishna (2011, 98) emphasizes that “[a] great deal of political communication is mediated and indirect,” especially for access to key services. Frontline solar intermediaries, including solar agents, help establish the viability of solar services, from awareness-building to after-sales activities, and how frontline solar intermediaries educate consumers may influence if consumers hold providers accountable to the standards that guide off-grid solar.

For off-grid solar, the incentives and performance metrics for solar agents focus primarily on sales and then on transparency with customers. First and foremost, the performance of agents is measured by the number of sales and then quality of sales for PAYGo solar. For
many providers, a good agent is a good salesperson. Second to sales is customer education and “telling the customer the truth” (interview 190619), which is verified by follow-up calls from the company call center. On-the-ground experiences suggest an uncertain link between consumers and the call center or customer care line. Reports suggest that sometimes solar agents even interfere with follow-up calls, either impersonating the customer or telling the customer what to say in response to questions (Global Off-Grid Lighting Association, 2019a, 11). For most off-grid solar agents, incentives stem from commissions associated with sales, and this encourages behavior that emphasizes sales over other activities.

Frontline solar intermediaries can expend their effort to achieve different goals. Pritchett et al. (2013, 10) characterize these goals and actions to range “from malfeasance to mere compliance with rules to working within the spirit of the rules to customise responses to the particular needs of clients.” Ultimately, whether frontline solar intermediaries – from agents to local leaders – are operating to achieve performance measures or to satisfy self-interest relies on the incentives associated with distribution and service models. If or how frontline solar intermediaries operate to achieve broader goals is “less a function of their individual talents and proclivities than the incentives they face and normative expectations that characterise their work environment” (Pritchett et al., 2013, 10). In Chapter 5, I study frontline solar intermediaries rooted in the services models they work in to better understand the incentives influencing their behavior.\textsuperscript{13}

2.3 Studying Dimensions of Intermediaries: Trust and Knowledge

While the PAYGo model for off-grid solar has opened up new opportunities for access to solar products, appliances, and other financing, the sector is still experiencing implementation challenges. While on paper many companies provide warranties and after-sales support, there is a gap in actually using these assurances and services. Reported challenges with using solar products are not being sufficiently resolved – potentially over two-thirds of such challenges go unresolved (Harrison et al., 2020). Unmet expectations or inaccurate information – or, alternatively, responsive and attentive service – go beyond purely technical dimensions but to the frontline intermediaries linking end-users to providers to make sales and follow-up if there is a problem.

Motivated by challenges with solar agents articulated by industry experts, and from field experiences, I focus on measures that include awareness, adoption, and the stages beyond to better understand the function of frontline solar intermediaries. Local partnerships and social networks are used by solar providers for entry into communities because local actors bring with them local knowledge that helps align distribution efforts to local norms and to provide insights into where, when, and how to effectively sell off-grid solar. Companies expect that individuals embedded in their communities can leverage existing trust in their networks of family and friends (Heuër, 2017). Scholars suggest that as “a new technology, trust and

\textsuperscript{13}In Chapter 4, I outline social, economic, and political incentives from literature on intermediaries.
information sharing are essential in gaining approval and adoption” (Scott, 2017, 51) for off-grid solar. As easily as trust may be initially associated with a friend or family member, trust can also be lost or broken given poor-quality goods and services or unmet expectations. A lack of trust in a provider or product may influence repayments or future referrals to others, therefore having implications for future growth and long-term sustainability of off-grid solar. Variation in frontline solar intermediaries may influence both consumer trust in and knowledge about off-grid solar services.

Increasingly, off-grid solar – both due to PAYGo models and additional services – requires an ongoing relationship with end-users. The fact that end-users can stop paying if the product does not meet their needs or is poor quality, suggests that companies believe PAYGo products to be of good quality and performance (Alstone et al., 2015). Trust matters for this sector because of these repeated interactions central to future growth in the sector. The status quo for building consumer trust in off-grid solar is through existing social networks. For intermediaries, prior experiences with a community may provide trust that is transferable to new endeavors, such as solar (Baruah, 2010). These networks also have other socially embedded attributes, such as accountability and solidarity, that may extend benefits to both end-users and providers.\footnote{Trust and accountability may also be associated with specific sectors, such as non-profits that may support private sector activity (Child, 2016). Accountability may enhance repayment for the provider, while solidarity may encourage members of the community to only suggest products they believe to be of sufficient quality or reliability.}

Frontline solar intermediaries not only build trust based on their existing social connections, they potentially leverage this position to exchange information and knowledge between the provider and end-users, which in turn may enhance trust in off-grid solar services and establish baseline customer expectations. While frontline solar intermediaries are expected to truthfully provide information about solar products and services, scholars suggest that intermediaries are more trusted if they go beyond just information but provide additional advice (Grantham and Baruah, 2017). Further, models that actually incorporate some amount of local training may respond most effectively to after-sales needs (Joshi et al., 2019). The expertise of intermediaries to repackage or reframe information in a manner that enhances use or learning is an effective act of intermediation (Lee, 2011). In theory, the exchange can go both ways, with intermediaries also providing value back to the provider by gathering and synthesizing customer feedback (Heuër, 2017). Frontline intermediaries can play a unique role in enhancing the consumer experience by acting transparently and honestly, while also providing feedback from customer experiences with products and services back to providers.

The intermediary link for building trust and developing consumer knowledge is important for off-grid solar as considerations for quality and consumer protections more frequently rely on providers, rather a government agency or local officials. While other scholars focus on the impact of non-state services on the state (Camnett and MacLean, 2014; Brass, 2016), I focus here on the non-state led efforts to support the off-grid solar sector, where the state may be taking limited action and certainly, limited enforcement.\footnote{I discuss this in more detail applied to Kenya in Chapter 3.} Frontline intermediaries in off-grid solar operate in contexts where the local officials, such as chiefs or county assembly
members, may not have a better source of information than anyone else regarding the terms, conditions, and operations of solar systems. The checks and balances on the information and activities provided by frontline solar intermediaries relies more on the incentives established by providers and end-users.

2.4 Research Design: Studying Both Sides of the Intermediary Relationship

Throughout the following chapters, I examine the forms, functions, and effects of frontline solar intermediaries in off-grid settings. Figure 2-4 provides a diagram of the intermediary as a link between providers and end-user and indicates my associated research questions. My work utilizes data from different points of view to characterize the benefits and challenges of off-grid solar distribution models reliant on frontline solar intermediaries. I argue that models incentivize intermediaries in different ways to communicate with and educate consumers transparently about the use and terms of off-grid solar. The differences in how intermediaries behave are particularly relevant as off-grid solar companies increasingly provide services beyond solar access that rely on repeated interactions and future transactions with existing customers.

Figure 2-4: Representation of provider, intermediary, and end-user with associated research questions

In Question 1 (what types of frontline solar intermediaries are active in off-grid solar services?) I explore the relationship between the service provider and the frontline solar intermediary, illustrated on the left-hand side of Figure 2-4. While scholars identify attributes and forms of intermediaries in other sectors and operating at other scales (Kivimaa et al., 2019) or describe a single frontline intermediary in a different context (Krishna, 2011), I use data from qualitative interviews with service providers, field visits with providers and households, and reports to characterize the variation within frontline solar intermediaries (see Appendix A.0.3 - A.0.5 for specifics on data collection locations and interviewee affiliations).
The typologies I explore in Chapter 5 speak to service providers and illustrate the strengths and weaknesses of different frontline solar intermediary models. Identifying different types of frontline solar intermediaries provides a baseline for discussion of trust and knowledge in later chapters and proposes relationships to test in future research.

The relationship between the intermediary and end-user is explored in Questions 2 and 3. In Question 2 (what attributes influence trust in intermediaries?), I test, from the perspective of solar users, what aspects of an intermediary influence trust in seeking help with a solar issue. As described in Section 2.3, trust is an important reason for why providers rely on frontline solar intermediaries and trust also underpins continued, repeated off-grid solar services. Trust is a multidimensional concept, often simplified down to social capital, but literature on intermediaries suggests that trust and trustworthiness stem from multiple sources, including expertise and sector affiliation. Given the complexity of trust, I use data from an original conjoint survey experiment to examine how variation in attributes of intermediaries influence trust.

Given variation in intermediary types and their use in off-grid solar distribution models, Question 3 (does knowledge about off-grid solar services vary by intermediary type?) uses individual-level responses about off-grid solar services to test if intermediary type has an effect on solar knowledge. While the previous question about trust provides insight into the consumer’s perceptions of an intermediary, this final question, examines if intermediaries provide information in a manner that creates knowledge about off-grid solar use, service terms, and consumer safeguards.

2.4.1 Mixed Methods to Study Multiple Aspects of Intermediaries

Kenya is an opportunity to examine substantial within case analysis using both qualitative and quantitative methods. With a long history of off-grid solar entrepreneurship and use, Kenya represents an exploratory, extreme case where I expect the variation in intermediaries to be greater than other countries. With this variation, insights I derive from this research may be at least partially applicable to places with less a developed – but developing – solar market. Additionally, the findings and variables studied may be applicable to similar (or the same) distribution models used by solar providers in other countries. Yin (2009) emphasizes that a single case study can involve multiple sub-units of analysis comprising an embedded case study design. For this research, my focus on Kenya allowed me to examine multiple dimensions of intermediaries: form, trust, and knowledge. I examine each of these dimensions in Chapters 5, 6, and 7, respectively.

In Table 2.2, I map the data collected and how I use it across my research questions. Additionally, in the following chapter, Chapter 3, I describe Kenya in the context of broader trends in off-grid solar to better understand what to expect with respect to how companies engage with consumers and consumer safeguard policies. I use data from my fieldwork, sector reports, and policy documents in addition to prior academic literature to develop this characterization of Kenya within the landscape of international efforts to promote off-grid solar. To support quantitative findings for Questions 2 and 3, I use qualitative data to both corroborate (provide supporting results) and elaborate (illustrate results) (Brannen, 2005).
**Table 2.2: Research Questions and Associated Methods**

<table>
<thead>
<tr>
<th>Question</th>
<th>Interviews</th>
<th>Field Visits&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Conjoint Survey</th>
<th>Survey</th>
<th>Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: Typologies</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Q2: Trust Attributes</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Q3: End-User Knowledge</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Kenyan Context</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<sup>a</sup>Including focus groups, household visits and focus groups are differentiated in Table 2.3

Off-grid solar in Kenya, compared to other services, has relatively limited involvement from the government. This falls into the category of “independent provision” which is characterized by a low-level of state penetration and indirect involvement of the state. Given the lack of data collected by the Kenyan government on off-grid solar, “scholars may need to collect original data to measure service quality or reach” (Post et al., 2017, 957). I do just that in Chapters 6 and 7, which provide analysis of original survey data, collected in July-August 2019, on how people perceive those they rely on for off-grid solar services.

**Using Qualitative Data to Understand Form and Explain**

My process of identifying intermediaries as an important dimension of off-grid solar services was an iterative process of fieldwork and reviewing prior scholarship. Field visits – including both household visits, market visits, and focus groups – were conducted at different stages of research design. Early visits with off-grid solar companies in Tanzania first suggested the importance, but also the challenge, of the agent model.<sup>16</sup> My in-person field visits emphasized the importance and variety of frontline intermediaries in how consumers experience off-grid solar services and provided insights into how these intermediaries build local connections.

The key elements of off-grid solar distribution models and ways different providers differentiate themselves from one another were identified using interviews, reports, and prior literature. When possible, interviews with head office staff in Nairobi were used in conjunction with interviews of their staff on-the-ground in Western Kenya (Kisumu, Kitale, and Kakamega).<sup>17</sup> In addition to the iterative process of field visits and interviews to understand key dimensions of frontline solar intermediaries, my observations from household visits and focus groups are used to provide context and explanations for quantitative findings.

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<sup>16</sup>Earlier fieldwork in India also highlighted the important role of NGOs as intermediaries in garnering support for solar microgrids in rural communities.

<sup>17</sup>The competition in Kenya between off-grid solar providers made some hesitant to speak candidly about their business model, but the range of interviews conducted in indicate in Table A.2 in the Appendix.
Using Quantitative Data for Impacts of Intermediaries

Used in tandem with fieldwork, scholarship on intermediaries in service provision, innovation, and public policy identified key attributes and outcomes important to off-grid solar and intermediation. The quantitative data I use is from two surveys, with different functions and designs. The first, a conjoint survey experiment, was designed to capture multidimensional preferences (Horiuchi et al., 2018). As an experiment, respondents made a choice between two profiles with varying attributes of intermediaries and asked to make their choice based on which profile they trust more. While stated choices, rather than revealed preferences (e.g., choices actually made), the results from this survey allowed me to test attributes described in the literature as influential for trust in intermediaries. The second, a more typical survey instrument, captured responses about respondent awareness of solar, use of solar, and knowledge about measures of solar functionality, quality, and financing.

2.4.2 Geographic Focus and Locations

The characterization of the off-grid solar sector in Chapter 3 is rooted in evidence from Kenya and the typologies in Chapter 5 rely on this Kenyan context but, when applicable, both chapters draw on examples from other countries and international trends to reinforce the broader applicability of frontline solar intermediaries. When possible, comparisons are made between evidence from Kenya and other locations to suggest similarities and differences. As indicated in Table 2.3, survey data in Chapter 6 and Chapter 7 were collected in two different counties in Kenya. In Table 2.3, I summarize the data used in this dissertation, including collection information and the type of data; specifics on field visits, interviews, and focus groups are available in the Appendix (A.0.3 - A.0.5). In each location, I visited local markets and shops when possible to view what is available in the marketplace and different modes of solar distribution.

<table>
<thead>
<tr>
<th>Data</th>
<th>When</th>
<th>Where</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>2018-2019</td>
<td>Phone &amp; In-person (Nairobi, Trans-Nzoia,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kakamega)</td>
</tr>
<tr>
<td>Household Visits</td>
<td>March 2018; January &amp; July 2019</td>
<td>Arusha, TZ; Kisumu, Vihiga, and Trans-Nzoia, Kenya</td>
</tr>
<tr>
<td>Focus Groups</td>
<td>July 2019</td>
<td>Trans-Nzoia, Uasin-Gishu, Kakamega, Kenya</td>
</tr>
<tr>
<td>Conjoint Survey</td>
<td>July 2019</td>
<td>Machakos, Kenya</td>
</tr>
<tr>
<td>Survey</td>
<td>July 2019</td>
<td>Trans-Nzoia, Kenya</td>
</tr>
</tbody>
</table>

18Discussed further in Chapter 6, dimensions include: expertise (Lee, 2011), affiliation (Baruah, 2010), embeddedness (Gould and Fernandez, 1989), and bargaining (Krishna, 2011).
Within Kenya, the survey data supporting this research is from Trans-Nzoia and Machakos counties, in the western side of the Rift Valley and Central Kenya, respectively. Both counties are in regions with active solar providers, although Western Kenya is recognized as the region with the most active off-grid solar sales. While information on sampling and survey design is detailed in Chapters 6 and 7, Table 2.4 provides a comparison of the two counties surveyed as well as overall statistics for Kenya. Notably, the electrification statistics in Table 2.4 are much lower than expected today, with the access rate increasing from 20% to 65% from 2012 to 2017 (International Energy Agency, 2017a, 82). Currently, Kenya is reported to have the highest electrification rate in East Africa when including both grid-connected and off-grid electrification: 75% as of December 2018 (World Bank Group, 2018); given the growth of services in rural areas providing small appliances like TVs and radios, those statistics are likely to be higher today as well.

Table 2.4: Survey County Statistics at Household (HH) level, from Kenya National Bureau of Statistics county-level statistical abstracts

<table>
<thead>
<tr>
<th>County</th>
<th>% of HHs using Electricity for Lighting</th>
<th>% of HHs Using paraffin for lighting</th>
<th>% of HHs owning a radio</th>
<th>% of HHs owning a TV</th>
<th>% of HHs owning Mobile Phone</th>
<th>% of HHs using the internet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machakos</td>
<td>17%</td>
<td>79.2%</td>
<td>81.6%</td>
<td>25.8%</td>
<td>67.7%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Trans-Nzoia</td>
<td>8.9%</td>
<td>88.8%</td>
<td>77%</td>
<td>21.7%</td>
<td>–</td>
<td>3.4%</td>
</tr>
<tr>
<td><em>Kenya</em></td>
<td>22.7%</td>
<td>69.5%</td>
<td>74.0%</td>
<td>28.0%</td>
<td>63.2%</td>
<td>5.7%</td>
</tr>
</tbody>
</table>

### 2.4.3 Kenya: Leading in PAYGo Off-Grid Solar

Sub-Saharan Africa is home to the largest and most dynamic off-grid solar market (Harrison et al., 2020), with Kenya setting an example for others in the region. Countries in East Africa, such as Kenya and Tanzania, are hotbeds for innovation related to new solar energy service models stemming from support from the government, international donors, and development organizations beginning in the 1980s (Ondraczek, 2013). At least for the past 6+ years, Kenya has led the region in sales of solar lanterns (Nygaar et al., 2016). Kenya is often the

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19 Kenya Climate Innovation Center identified Kisumu, Homabay, Migori, Kakamega, Bungoma, Nairobi, Kiambu, Mombasa, Kilifi, Kwale, Machakos, and Kajiado as 12 counties in Kenya with high population and solar use (Kenya Climate Innovation Center, 2017).

20 Unfortunately, up-to-date census data with electrification numbers was not available in time to include, so statistics presented are from 2015 county-level statistical abstracts from the Kenya National Bureau of Statistics.

21 Recent articles suggest that Kenya’s numbers may be very different on-the-ground. Kenya’s electrification metrics and the meaning of “access” to electricity must be reviewed more carefully. In 2017, an internal audit suggested that 1 million of the recent 3.6 million new connections were either fake or unconnected but reported as new connections (Wafula, 2017).
site of ongoing experimentation with how to expand off-grid solar to appliances and higher quality products. For example, M-Kopa Solar launched a solar refrigerator (Njanja, 2019) and smartphone (Maina, 2020) in late-2019 and early-2020, respectively.

Kenya has many active off-grid solar companies and is considered to be a relatively mature solar market, classified by experts in sector as at a stage where the market is mature enough to sell the next stage of services from solar providers (Dalberg Advisors et al., 2018, 16). In addition to growth in off-grid solar, Kenya has increased electricity grid connections and added geothermal capacity (International Energy Agency, 2017a, 82). Kenya’s status as the largest market for off-grid solar home systems and lanterns is influenced partially by a historical exemption of VAT (value-added tax) on solar, the presence of quality assurance standards, and new off-grid solar investment efforts (e.g., Kenya Off-Grid Solar Access Project). Efforts to extend the centralized grid and perform reliability enhancements from the nation’s single electric utility, Kenya Power & Lighting Company (KPLC), also have renewed financial and political resources that rely on funding from the World Bank to support targeted efforts in rural areas (Last Mile Connectivity Project) and in urban informal settlements (Global Partnership on Output-Based Aid) with (World Bank Group, 2015, 2019).

While the distribution of small-scale solar technologies, such as lanterns, was originally dominated by non-governmental organizations operating in the Global South the landscape is continually changing. Some companies operating in countries like Kenya and Uganda are hybrids of NGOs and commercial efforts – as NGOs, spin-offs from NGOs, or social enterprises (MacLean and Brass, 2015), suggesting this ongoing change in the off-grid solar sector. One of the most widely cited spin-off social enterprises is SunnyMoney, originating from SolarAid, which has explored a range of distribution options such as “Light Libraries” that received additional support from Lighting Africa (joint IFC/World Bank initiative) (SolarAid, 2019c). The growth in private provision of solar in Kenya is illustrated by SolarAid/SunnyMoney’s exit from Kenya to focus on other markets, because “SolarAid doesn’t aim to have an ongoing presence... [but] to catalyse more solar markets to the point that we are not needed anymore” (Sylvester-Bradley, 2017). Options for off-grid financing have also grown since the mid-2000’s with specialized lenders such as SunFunder and their “Beyond the Grid” Fund. In 2019, Acumen established a $70 million off-grid energy fund (KawiSafi Ventures) to target off-grid energy in East Africa (Acumen, 2019).

While Kenya is likely to meet energy access goals given this renewed push for both grid extension and off-grid connections, many areas in sub-Saharan Africa will likely lag behind Sustainable Development Goal (SDG) 7: ensure access to affordable, reliable, sustainable and modern energy for all (International Energy Agency et al., 2018). As a lower-middle income country, Kenya has a stronger economy than its neighbors in East or Central Africa and the Kenya Vision 2030 aims to achieve middle-income status by 2030 (Africa-EU Renewable Energy Cooperation Programme, 2014). Energy access plays an important role in the Kenyan

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22 To date, KawiSafi has invested about in BBOXX and d.light, along with companies innovating in other aspects of off-grid solar such as panel manufacturing and productive use farming equipment (Bloomberg, 2019).
government’s Vision 2030 which aims to strengthen manufacturing, food security, universal healthcare, and affordable housing (World Bank Group, 2018). Kenya may serve as an example of how to use multiple energy technologies and services to provide universal energy access.  

The Kenya National Electrification Strategy (2018) utilizes a least-cost electrification strategy to plan for universal access by 2022, which includes integrated planning between Kenya Power (PKLC) and the Rural Electrification and Renewable Energy Corporation (REREC, previously Rural Electrification Authority), a geospatial planning platform, increases in the deployment of off-grid solar photovoltaics, and establishes training, technical assistance, and management support to improve program performance (Ministry of Energy et al., 2018). In sub-Saharan Africa, much of the off-grid solar expansion has occurred in Kenya, Tanzania, Rwanda and Uganda, with 86% of sales of Global Off-Grid Lighting Association member companies occurring in East Africa, 12% in West Africa, and 2% in Asia (Dalberg Advisors et al., 2018, 9).

In 2017, with the start of the Kenya Off-Grid Solar Access Project (KOSAP, Ministry of Energy (2018)) and its inclusion in the Kenya National Electrification Strategy, the Kenyan government is targeting electrification in counties with limited electricity access from grid connected or off-grid sources. The number of counties and regions with off-grid solar is likely to continue to grow in Kenya, with solar home systems now being deployed as a part of the government’s coordinated effort to meet universal energy access goals by 2022 (Ministry of Energy et al., 2018).

The Kenya Off-Grid Solar Access Project provides USD $48 million for solar home systems and clean cooking and an additional USD $40 million for solar home systems and water pumps for community facilities. The Ministry of Energy in Kenya is responsible for oversight of KOSAP financing for solar home systems, while Kenya Power (KPLC) and the Rural Electrification and Renewable Energy Corporation (REREC) are responsible for implementing the other components of KOSAP, including mini-grids. KOSAP introduces a new stage of government engagement with direct contracts for serving more remote areas of Kenya with off-grid solar systems with a minimum equivalent to Tier 1 electricity service.

While little information has been released since applications for KOSAP funds were opened, this effort supports Kenya’s universal energy access goals. In July 2019, the Results-based Financing (RBF) and Debt Facilities for KOSAP were opened for applications by

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23In the International Energy Agency’s scenario of universal energy access by 2030, decentralized (off-grid or mini-grid) technologies provide 72% of electricity connections (485 million people) primarily in rural areas, while the traditional grid reaches 185 million people. These least cost estimates emphasize the important role of decentralized energy technologies, primarily solar PV, in reaching rural and unelectrified (or poorly electrified) areas (International Energy Agency, 2017a).

24The Kenya National Electrification Strategy states that, “while the Kenya Off-Grid Solar Access Program (KOSAP) has been designed to provide capital subsidies to support off-grid service provision in the fourteen marginal counties, a similar facility may be needed to stimulate accelerated investment and expansion of service in the more densely populated areas close to the KPLC service area” (13).

25Tier 1 is equivalent to task lighting, phone charging, and a minimum of four hours of lighting during the day and 1 at night, often met by “plug-and-play” solar home systems, see Chapter 2. Under KOSAP off-grid solar services represent what Post et al. (2017) call “regulated provision.”
the Ministry of Energy, SNV, and SunFunder (the latter two as the Facility Managers for KOSAP) (SNV and SunFunder, 2019). In the country’s 2018 electrification strategy, solar home systems are planned to reach at least 1.96 million households in addition to those already with solar (Ministry of Energy et al., 2018). The funds provided by KOSAP are not designed to reach all those in need of solar home systems, rather the RBF and Debt Facility aims to provide financing to support off-grid solar in 250,000 households to jumpstart solar in these regions. The criteria for KOSAP funds support the existing international regimes in place for quality assurance, requiring compliance with Lighting Global quality standards.26

With government coordination of KOSAP, off-grid solar is now integrated into Kenya’s government-led electrification program (Ministry of Energy, 2018) and, in tandem, international decision-makers also recognize the need for stronger standards and consumer protections (Dalberg Advisors et al., 2018; Lighting Global, 2018). The 2018 Kenya National Electrification Strategy was established in close coordination with the World Bank, and existing World Bank programs such as Lighting Global are being integrated into Kenya’s strategy (Ministry of Energy et al., 2018). While standards are needed for both mini-grids and home systems, past international efforts have addressed home systems more than mini-grids.27 Kenya provides a case for exploring both a leading example of off-grid solar adoption and a country working closely with international and private sector actors to develop the regulatory frameworks for distributed solar infrastructure.

Kenya’s leadership in off-grid solar may provide a window into opportunities and challenges other countries may face as off-grid solar adoption grows, but, as I will discuss in Chapter 3, Kenya’s current levels of pay-as-you-go off-grid solar use are built on a history of government and international action to support the sector. Examining a leading case like Kenya allows for exploration of the conditions that support the experimentation and diversity of off-grid solar distribution models, but caution should be exercised when applying these lessons to other countries. Extreme cases are not intended to be representative when studied alone and must be compared to other cases to understand broader generalizability (Seawright and Gerring, 2008). As a first application of the “intermediary” framing to off-grid solar models, this extreme case allows for exploration of the variation of frontline solar intermediaries in a case with many active solar providers developing different distribution models.

Kenya not only has an active and competitive solar market, but the pay-as-you-go model was built on Safaricom’s M-Pesa platform that was actively used by the mid-2010s when PAYGo off-grid solar started. Other countries, such as Bangladesh have strong mobile money

26 The materials provided by SNV indicate compliance with Lighting Global and do not mention the Kenya Bureau of Standards, while materials from the Ministry of Energy indicate both Lighting Global certification and compliance with KEBS standards.

27 Highlighted in Kenya’s strategy is: “a need to establish quality of service standards for off-grid solutions including both mini-grids and stand-alone remote power systems. The World Bank is currently reviewing mini-grid standards. Lighting Global standards have already been adopted for the future KOSAP program; these standards will apply for purposes of the KNES. Mini-grid operators will also require some form of protection against stranded investment value for off-grid private service providers. Compensation provisions should be included in the event that the service area is encroached by grid extension” (14).
adoption, but that does not necessarily translate to high PAYGo solar adoption: Bangladesh actually has far more recorded cash sales than PAYGo (Navis, 2019; Global Off-Grid Lighting Association, 2019b). Places without such strong mobile money penetration may rely more on in-person payments, which may change the intermediary-customer relationship and what information solar providers expect intermediaries to share with customers at point-of-sale. Future comparisons, can examine measures of consumer education across countries with common solar providers, such as BBOXX that operates in Kenya and Rwanda or Mobisol that operates in Kenya, Tanzania, and Rwanda (Dalberg Advisors et al., 2018); although more research will need to be done on how consistent off-grid solar models are across contexts even from the same provider. Consistency in solar distribution models allow for the intermediary types I explore in this dissertation to be held constant across countries in order to test the effect of intermediaries on consumer knowledge, whereas other distribution models may differ such that the intermediaries I explore in Chapters 5 and 7 are not present in those countries.

The dimensions of intermediaries explored in Chapter 4 and Chapter 6 draw from scholarship conducted in multiple contexts. The variation in, and potentially familiarity with, frontline solar intermediaries in Kenya may be extreme, but some of the basic attributes may be applicable to other contexts. Scholarship on electrification in India suggests the importance of government in electricity provision (Aklin et al., 2018) and NGO-utility partnerships have been used to help facilitate new electricity project (Baruah, 2010), my findings (especially in Chapter 6) may provide a common dialogue to contexts where the electrification situation may be different than the situation in Kenya. In Chapter 4, I highlight that across issues of electricity, and even within off-grid solar, there are multiple types of intermediaries involved in decision-making and service provision. For example, the frontline orientation of intermediaries in this research focuses on off-grid solar, but similar attributes of frontline intermediaries may potentially be at play in Tata Power DDL’s abhas model implemented in New Delhi, India, which is focused on repayment and consumer education for grid connected communities. Many of the dynamics that underpin the active PAYGo solar market in Kenya may be unique and extreme, requiring caution when extending these findings to other locations (even other areas within Kenya), but the commonalities across distribution models and frontline intermediaries suggest opportunities for future comparisons to Kenya.

2.5 Summary

In this chapter I introduced the background for my research on frontline solar intermediaries in Kenya. I describe the focus in prior scholarship on measures of development and adoption, rather than continued after-sales services. In off-grid solar, after-sales services are increasingly importance with pay-as-you-go financing and opportunities to up-sell or cross-sell customers. Continued repayment and willingness to sign on for additional services requires not only good quality products, but trusted off-grid solar service providers. Frontline solar intermediaries are key actors in after-sales services as they have discretion in what they tell consumers and how effectively it is communicated, which may influence the trustworthiness of solar providers.
What the off-grid sector recently termed “the agent challenge” identifies that these intermediaries are integral to off-grid solar sales and many later issues with payments or understanding of the solar system can be associated with the initial information shared by solar agents. While solar agents are just one type of frontline solar intermediary, they illustrate the critical but potentially tenuous link agents provide between the end-user and the provider. In addition to motivating the need to understand the types of frontline solar intermediaries active in the off-grid sector, I introduce my focus on the dimensions of trust and knowledge generated by intermediaries. Each of these dimensions will be expanded on in Chapter 6 and Chapter 7.

I provide a broad overview of my three key research questions and the context for this work in Kenya, as a leader in the off-grid solar sector. While the Kenyan market for solar is likely more active and competitive than others, it is also a site of experimentation for both solar technologies, appliances, and distribution models. The strong presence of the private sector in off-grid solar in Kenya is both built on historical efforts by international actors and more recently, collaborations with the Kenyan government. In the next chapter, I describe in more detail how off-grid solar programs and policies in Kenya interface with international counterparts and efforts to promote the off-grid solar sector. The priorities and requirements set by these international programs and standards influence the standards adopted by the Kenyan government and often establish the information that must be explained by frontline solar intermediaries to end-users.
Chapter 3


“This tremendous growth in the uptake of off-grid solar solutions is an integral part of my administration’s strategy towards the realization of universal access to electricity by the year 2020....To achieve our electrification programme through off-grid solutions, we also, as a government, recognize the importance of partnering with you, the private sector. And in this regard, we as a government have provided an enabling environment of private sector investors. Indeed, we have given import duty exemptions on a range of solar products to ensure both profitability for investors, as well as affordability and high-quality products for our consumers. This, I have no doubt, has gone a long way in instilling public confidence in solar products.”

President Uhuru Kenyatta, February 2020

3.1 Introduction

The study of frontline solar intermediaries is a study of how to implement solar services and safeguards in an emerging, and changing, sector. Effective intermediaries are beneficial to consumers because they provide service terms and consumer protections in a digestible manner, and critical for providers by making sales and building trust to facilitate future interactions. Poorly performing intermediaries may also have the opposite effect, a lack of effective communication may result in insufficient understanding of solar services and hinder

trust in the provider, reducing interest in future products and services. Frontline solar intermediaries play a critical role in country contexts, like Kenya, where solar companies provide not only a new technology, but are at the forefront of educating consumers about solar technologies and the associated services.

The quotation above, just recently stated by President Uhuru Kenyatta, suggests a strong reliance on the private sector for off-grid solar activities in Kenya. While off-grid solar plays an instrumental role in reaching the current administration’s ambitious goals for electricity access, the government has ceded responsibility for many of these services to the private sector. The underlying assumption of President Kenyatta’s statement is that policies encouraging the availability of quality assured products will provide a viable private sector profit model, while offering affordable solar products. The link between the availability of quality solar products and instilling public confidence relies on the implementation – the on-the-ground experiences – of off-grid solar services.

Often studies of implementing policy goals focus on government programs and bureaucracy, but for off-grid solar implementation, efforts must include private sector activities and services. In Kenya, the “weakness of the ‘steering’ capabilities on the side of the Kenyan government” has carved out a much larger responsibility for non-state actors in Kenya to provide services (Brass, 2012, 213). Frontline solar intermediaries have responsibilities to share information – hopefully in a manner that educates consumers – beyond just the sale of solar products.²

Despite recognized challenges with off-grid solar services, in general, people view solar in a positive light; especially those with direct experience using off-grid solar. Figure 3-1 illustrates this positive association: 80% of those with solar report that solar meets their needs most of the time or all of the time.³ Those who actually use solar report more positive associations with solar, as illustrated by the comparison of those with and without solar in Figure 3-1. Recent news in Kenya suggests that about half of those in Kenya using grid electricity, consume an amount equivalent to basic lighting and phone changing (Otuki, 2018); an amount similar to what solar home systems can provide.

Even while solar users appear relatively satisfied with their solar, 81% still believe that even if you have solar, they need a connection to the grid.⁴ With off-grid solar playing an “integral part” in the Kenyatta Administration’s strategy for universal electricity access, now is a time to understand and test if consumers in Kenya can imagine off-grid solar as a viable, long-term alternative to a connection to the traditional electricity grid. Frontline solar intermediaries play a role in enacting off-grid solar services, they have discretion over what information is shared at point-of-sale and, often, how solar users experience ongoing after-sales service that contribute to off-grid solar as a potentially lasting service.

Research from both academia and off-grid solar industry reports continues to indicate

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²Despite efforts to circumvent these initial connections with follow up from call centers and customer care lines, in-person contact seems preferred to the phone, this is discussed more in Chapter 5, or at least on par with the call center as indicated in Table 7.3 in Chapter 7.

³most of the time: N = 256, all of the time: N = 146

⁴From original survey data in Trans-Nzoia County, when asked “if someone has solar, do they need KPLC (Kenya Power)?” 80.85% responded yes, while 19.15% responded no.
a gap in after-sales services. While solar may meet household needs, these issues with after-sales service suggest providers may be struggling to offer lasting services. This gap in after-sales service may be unresolved issues with the system, an unclear understanding of repayment terms and the ability to be remotely locked out of the system, or not receiving a replacement part during the warranty period. Experiences with off-grid solar vary across companies, and potentially within companies, based on the local actors responsible for a region or team.  

Figure 3-1: Variation in responses to “How often will solar products meet your household needs?” grouped by respondents without solar (No, N = 389) and those with solar (Yes, N = 504), survey from Trans-Nzoia County, Kenya

If and how these local actors connect to company and sector initiatives may illustrate the strengths and weaknesses of current efforts to implement policies for off-grid solar. Responsibility for implementing initiatives in this sector is shared by international organizations, companies and industry groups, and the government. The on-the-ground presence of off-grid solar providers suggests that, in Kenya, the private sector must do the majority of direct consumer education about off-grid solar. As a more mature off-grid solar market, studying Kenya provides an opportunity to compare multiple distribution models and to study market dynamics that come with time. In Kenya, the concerted effort to promote off-grid solar has resulted in a shared responsibility between non-state actors and the government for developing and implementing safeguards for the solar sector (e.g., quality assurance and consumer protections). Both the private sector and non-governmental organizations have played important roles in the development of off-grid solar, and both sectors continue to grow and change. As off-grid solar providers introduce a wider array of solar and non-solar (financial and other) services, the shared responsibility of non-state and state actors to provide capacity to support policy goals may make reaching electrification goals and implementing safeguards more feasible.

5See Chapter 2: Harrison et al. (2020); Global Off-Grid Lighting Association (2019a); Cross and Murray (2018).
3.2 Shared Responsibility for Supporting Off-Grid Solar Providers and Consumers

Companies and international organizations have been promoting solar in Kenya for decades. This concerted effort has contributed to the within-country and international focus on Kenya as the center of off-grid solar activity. In the 1970s, solar emerged as a possible electrification strategy, and, later, growing support stemmed from the 1992 UN Conference on Environment and Development with subsequent investments from the Global Environment Facility and the World Bank (Jacobson, 2007). The Photovoltaic Market Transformation Initiative approved $30 million in Global Environment Facility funds for solar efforts in Kenya, India, and Morocco in 1996, which lasted through the early 2000s (Duke et al., 2002). Even before this first facility, Kenya had over 150,000 solar home systems sold by small-scale enterprises (International Finance Corporation, 2007). As Jacobson (2007, 146) describes,

"The Kenya solar market...has served as a model in energy and development policy circles, because it developed with a minimal direct government support and only very moderate inputs from international donor aid groups. Solar sales in Kenya have long been (and continue to be) driven largely by unsubsidized over-the-counter cash purchases of household solar systems...This makes Kenya an important example of a growing international trend toward market-based approaches to rural energy service delivery."

The most notable differences between now and the characterization of Kenya from the early 2000s is the proliferation of mobile money and PAYGo solar services. As an early site for investment and pilot programs, many ongoing programs and initiatives for off-grid solar internationally are rooted in the Kenyan experience.

Efforts promoted by international organizations, such as the World Bank, aimed to carve out a private sector niche in off-grid solar services. Such efforts supported multiple goals, including promoting “players other than governments implement the work, mobilizing additional human and financial resources, and reducing pressure on already overextended utilities” (The World Bank and The Energy and Mining Sector Board, 2008, 14). In Kenya, market focused policies and programs continue to advance this goal of active non-state provision off-grid solar services and such efforts continue to be in conjunction with market-focused organizations, such as the World Bank.

The distribution of small-scale solar technologies, such as lanterns, was originally dominated by non-governmental organizations (NGOs), but now the private sector increasingly provides off-grid solar services. NGOs in Kenya, now often act in coordination and to support private sector or market-based solar services. Hybrids of NGOs and commercial efforts – as spin-offs from NGOs, and social enterprises – illustrate the variation in non-state solar service provision (MacLean and Brass, 2015). This growth in private provision of solar in Kenya is illustrated by Sunny Money’s – one of the most widely cited spin-off social enterprises from the NGO SolarAid – exit from Kenya to focus on other markets. The reason for

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6Fieldwork to support this early research was conducted in 2002-03 for Jacobson (2007).
this exit is because, as mentioned in Section 2.4.3, SolarAid intends to catalyze markets and move into other markets once the private sector market is active, like seen in Kenya.\textsuperscript{7} Options for off-grid financing have also grown since the mid-2000’s with specialized lenders such as SunFunder and their “Beyond the Grid” Fund. In 2019, Acumen established a $70 million off-grid energy fund (KawiSafi Ventures) to target off-grid energy in East Africa (Acumen, 2019).\textsuperscript{8} Financing for off-grid solar increasingly stems from both development and climate mitigation funds.\textsuperscript{9}

With prevalent non-state activities and more financing mobilized for off-grid solutions, even the utility in Kenya – Kenya Power (KPLC) – is ceding some potential customers to off-grid solar companies. In the 2018 electrification plan, both off-grid solar and mini-grids are integrated into rural electrification in Kenya, with off-grid solar viewed as a key solution for the more remote and dispersed unelectrified populations (Ministry of Energy et al., 2018). Longtime efforts to provide off-grid solar by the private sector have left their mark on current electrification programs in Kenya: there is now a strong emphasis on private sector provision of off-grid solar as an explicit electrification strategy.

With the inclusion of off-grid solar into coordinated and government sanctioned rural electrification efforts in Kenya, the question shifts to whether this is a lasting solution for electrification. As mentioned in the introduction to this chapter (see 3.1), people like solar and it can meet the needs for many. The implicit assumption of a grid connection is electricity in perpetuity (given payment). Reliability issues even with the grid in the Global South suggests this operates more in theory than in practice in many places.\textsuperscript{10} Nevertheless, if off-grid solar meet or approximate the same kind of lasting or durable service requires understanding the ongoing consumer experience with off-grid solar. The ability for off-grid solar to provide electricity services is not only a company or business model challenge, but an issue of achieving government policy goals.

Early research out of U.C. Berkeley’s Energy & Resources Group identified that while high-quality solar products provided good value for consumers in Kenya, the availability of poor-quality products was having a detrimental effect on the solar market. The prevalence of poor-quality solar products in Kenya was inhibiting the sale of higher quality products due to diminished consumer expectations (Duke et al., 2002).\textsuperscript{11} Efforts to develop market institutions and quality assurance programs to support consumers purchasing solar emerged as viable solutions from this research (Jacobson and Kammen, 2007). Starting in the early 2000s, a range of strategies can be seen in ongoing efforts to develop high-quality solar services in Kenya.\textsuperscript{12} International efforts, with early and ongoing support from the World

\begin{footnotes}
\item[7]SunnyMoney has explored a range of distribution options, including “Light Libraries” with additional support from Lighting Africa (joint IFC/World Bank initiative) (SolarAid, 2019c).
\item[8]To date, KawiSafi has invested about in BBOXX and d.light, along with companies innovating in other aspects of off-grid solar such as panel manufacturing and productive use farming equipment (Bloomberg, 2019).
\item[9]The Green Climate Fund is an early investor in KawiSafi Ventures.
\item[10]See Aklın et al. (2016) for discussion of satisfaction with electricity supply in India.
\item[12]Duke et al. (2002) outline six methods for improving consumer awareness about quality and improving
\end{footnotes}
Bank and IFC, responded to the prevalence of poor quality with a quality assurance program targeted at both standards and consumer awareness.

Just as Kenya was an early site for market investment, it was also a pilot country for off-grid solar quality assurance programs. Lighting Africa started in 2007 with the aim to improve access to clean and affordable lighting, this included sector-driven quality standards for solar components. Later, Lighting Asia was established in 2012 and Lighting Global was formed to administer common and global aspects of the Africa and Asia programs, including quality assurance.\textsuperscript{13} International quality assurance efforts, like that of Lighting Global, responded to these early assessments of poor-quality solar products in the Kenyan solar market. Lighting Global remains a partnership between academic research and international organizations, discussed further in Section 3.3.\textsuperscript{14}

International efforts to promote off-grid solar, such as Lighting Africa, are having a demonstrable impact on the off-grid solar sector. Since the early 2000s there has been substantial growth in Lighting Africa affiliated solar home system sales (Alstone et al., 2015). Countries with a concerted effort from Lighting Global are associated with higher adoption rates of off-grid solar (Dalberg Advisors et al., 2018, 84). Kenya is leading this trend, where more Lighting Global certified products are sold than non-certified products (Dalberg Advisors et al., 2018, 89). But this does not hold globally, the majority of solar products sold globally are not quality verified. Even with growth in the number quality verified products, informal distributors selling products that do not meet quality standards may be able to sell at more affordable rates.\textsuperscript{15} The growth of quality assured products in Kenya may serve as a model for other countries, while also illustrating what aspects of the Kenyan market may not be as easily transferrable across contexts. Lighting Africa has consistently pushed a private sector and market-based focus, and this includes a recognized emphasis on consumer awareness in tandem with technical product standards for off-grid solar.

Starting with these early efforts from Lighting Africa, consumer awareness efforts for off-grid solar focus mostly on measures of technical quality. Governments, donors, investors, tenders, NGOs and projects often require that solar lanterns and solar home systems meet the Lighting Global quality standards for inclusion in programs or to be eligible for funding opportunities (Duke et al., 2002; Global Off-Grid Lighting Association, 2017, 5). The increasing prevalence of quality verified products in Kenya suggests that these international efforts are providing some amount of guidance for off-grid solar providers. But how has this

\textsuperscript{13}Currently, Lighting Global is a joint World Bank and IFC program aimed at supporting global off-grid solar services (Dalberg Advisors et al., 2018).

\textsuperscript{14}The 2009 baseline report for Kenya identified numerous quality issues, in particular for torches/lanterns (Johnstone et al., 2009). Professor Arne Jacobson involved in early studies of solar PV quality in Kenya sits on the IEC and runs Lighting Global through the Schatz Energy Research Center at Humboldt State University in partnership with CLASP (https://clasp.ngo/who-we-are/mission).

\textsuperscript{15}These cheaper, non-verified products can be “attractive to poorer customers” (Global Distributors Collective, 2019, 17). Market visits in Sibanga, Kenya suggest that these informal salespeople mark up non-quality verified and counterfeit products as well. At least in the case of counterfeits, informal salespeople do seem to know that these are not genuine products.
translated to consumers? Focusing only on sales may suggest success with one-off purchases, but does not indicate if quality assurance programs are moving off-grid solar towards lasting electricity service for consumers.

How quality assurance programs impact consumer knowledge remains unknown, but the active role of the private sector in quality assurance has translated down to perceptions of responsibility and capacity. Figure 3-2 illustrates that, in a sample of Kenyans in Trans-Nzoia, respondents are almost equally divided between companies and the government regarding the capacity to ensure product quality. Both government and the private sector are viewed as capable to ensure quality assurance, but more believe that it is the job of the national government to ensure quality. With respect to this responsibility for quality, company executives are second to national government officials with local government in third. These responses illustrate that while the government is expected to act in these areas, so too is the private sector. While more believe that quality assurance is the “job” or responsibility of the government, implementation of quality assurance falls to both the private sector and government.

Figure 3-2: Responses indicating responsibility for quality governance (N = 893), Trans-Nzoia County, Kenya

The configuration of organizations working to promote off-grid solar helps illustrate the evolution of priorities within the sector. Electrification efforts can be understood as not only technical processes, but social processes. Interactions between organizations help define the boundaries of an industry, establish organizational relationships, and coordinate with governments (Granovetter and McGuire, 1998). Reflections on the “lock-in” of historical electricity infrastructure and the interpersonal relationships that underpinned a centralized rather than decentralized electricity system in Western countries, suggests that assessment of off-grid solar must also examine the organizations, capital flows, and social ties that are guiding (and defining) the sector. Like Granovetter and McGuire (1998, 156) find from the late 19th to mid-20th century in the U.S., so too in off-grid solar can “personal and trade organization relationships” be influential in promoting technology configurations and the
priorities of a self-governance regime. For example, the international industry group for off-grid solar does not include mini-grid providers, thus constraining the benefits and advocacy to certain technologies and services.

Social ties are even more influential in services that operate, as off-grid solar does, in more remote areas with limited government oversight or involvement. Compared to modes of service provision with more active oversight from the government, off-grid solar in Kenya is a form of independent provision, which often has more active NGOs stepping in to provide service, community leaders coordinating activities, and informal entrepreneurs (Post et al., 2017). Often when there is limited government oversight, the private sector self-regulates. Self-regulation is when a company or at times through an industry association, “imposes commands and consequences upon itself” (Coglianese and Mendelson, 2010, 5). The ongoing efforts from Lighting Global are an example of this kind of self-regulation in the off-grid sector, as companies are complying voluntarily with Lighting Global standards that are not always required by country governments. This balance between sector self-regulation and more traditional regulatory instruments is constantly evolving and changing as more standards for off-grid solar are adopted by international institutions and government agencies, such as the Kenya Bureau of Standards. Coordination of self-imposed quality standards across providers aims to simplify market entry and compliance with other international requirements. Frontline solar intermediaries act as the on-the-ground actor conveying the necessary components of this self-regulatory regime from the provider to the end-user.

3.2.1 Intermediaries with the Potential to Encourage Participation

In Kenya, with such a strong private sector operating in off-grid solar, it falls also to the companies to educate consumers about solar products and services. While companies try build a direct link to the customer after the initial sale, customers continue to rely on those they know locally for help. As one shop manager described,

“In most cases when we are recruiting agents, we get them where the customers are, so most probably when the customer has an issue, he goes to the agent and the agent will refer him here [to the shop] or the call center” (interview 190719).

While companies hope to reinforce dimensions of transparency and service quality directly, frontline intermediaries remain a go-to for customers.

In this case, frontline solar intermediaries use their discretion not only at point-of-sale when they describe the products, but also in ongoing interactions. With more distributed solutions, user empowerment is increasingly important as it is upon the user to manage and operate their system (Moss, 2009). For frontline solar intermediaries, their connection to the provider is part of the value they offer end-users. Frontline solar intermediaries are, minimally, responsible for introducing consumers to the key protections associated with quality assurance, but, maximally, can help ensure safeguards are acted upon and guarantees to the customer are carried out. While this strongest form suggests an active effort to empower end-users, minimally frontline solar intermediaries can inform and (possibly) educate.
Lighting Global aims to push quality assurance on off-grid solar users by establishing market entry requirements, but effective frontline solar intermediaries have the potential to also create demand for high quality solar products. Efforts to inform and educate hardly achieve true participation in decisions about off-grid solar, as they may be too close to “rubberstamp” efforts rather than encouraging voice (Arnstein, 1969). In particular, participation is limited if education remains one-way, as planning scholars consider this the lowest form of participation (Damgaard and Lewis, 2014). Nevertheless, solar protections led by Lighting Global represent potential modes of strengthening on-the-ground solar experiences in Kenya (Sustainable Energy Initiative Ltd., 2019). When faced with an issue with solar, turning to a solar agent or other frontline actor is natural. They are local and available in-person.

Frontline solar intermediaries are often a consumer’s best bet on having a link to the company when they are uncertain about product performance, use, or payment. Whereas in other services, one might turn to a local official or agency, for off-grid solar the flow of information is directed through non-state organizations. Frontline solar intermediaries have the potential for impact by extending that flow to the end-user.

3.3 Safeguards Promoted Within Off-Grid Solar

With an understanding that non-state actors play a critical role in off-grid solar, both in service provision and the associated protections, the activities promoted by these non-state organizations establish expectations for services and consumer safeguards in Kenya. Given the increasing prevalence of industry-led safeguards for off-grid solar, the forms and priorities of these safeguard programs suggest what end-users are likely to expect and demand from solar providers. For the off-grid solar sector, the Lighting Global Quality Assurance program is the longest effort in place to guide product quality and transparency in the off-grid solar sector. Most of Lighting Global’s effort focuses on technical standards for solar and the information customers should know based on those standards. Lighting Global does not extend to other dimensions of off-grid solar services.

Responding to the increasing complexity of PAYGo off-grid solar, off-grid solar providers are coordinating a set of consumer protection guidelines. While product quality is one dimension of this set of industry consumer protection guidelines, these protections extend to dimensions such as data privacy and fair treatment of customers. As described in Chapter 2, academic scholarship is just beginning to examine this broader set of considerations related to the information and data collected in off-grid solar. This effort is led by the industry group for off-grid solar, the Global Off-Grid Lighting Association (GOGLA). GOGLA is one of the organizations actively defining the sector boundaries and building an international network of relationships to promote off-grid solar. In comparison to efforts addressing solar quality, this broader set of consumer protections is in a much earlier stage of development, let alone implementation.

While off-grid solar may have limited involvement from the Kenyan government, off-grid solar companies are not operating alone. For off-grid solar, international actors – including Lighting Global and GOGLA – play an influential role in establishing priorities for the sec-
tor and in strengthening the role of off-grid solar in national electricity planning.\textsuperscript{16} There is substantial coordination across the private sector, aid organizations and NGOs, and international financial institutions.

The network of organizations emerging at an international-level to coordinate off-grid solar providers influence both state and organizational policies, which may reduce the policy uncertainty of operating in a fast-pace sector. Such networked approaches to regulation may build capacity and serve as checks and balances in situations, such as off-grid solar in Kenya, with weak government action or oversight (Braithwaite, 2006).\textsuperscript{17} The extent to which the state effectively provides services or acts in connection with different actors to steer via networked or polycentric regulatory regimes varies (Goodin et al., 2008).\textsuperscript{18} In Kenya, the strongest examples of coordination between international networks and the government include standards bodies and financing opportunities.

### 3.3.1 Standards to Enhance Quality Assurance

The development of coordinated standards for off-grid solar can provide some amount of certainty for providers, as such standards required for market entry. Constraining market entry for solar products can be via other non-state actors (e.g., an NGO distributing solar) or via government standards. Both more traditional forms of government regulation and non-state requirements are at play in Kenya.\textsuperscript{19} There are efforts are emerging in Kenya rooted in citizen actions and demands for better electricity services (e.g., #SwitchOffKPLC),\textsuperscript{20} but the development of standards for off-grid technologies and services has minimal engagement with citizens throughout the process.\textsuperscript{21} In Kenya, efforts to influence energy decision-making, more broadly, are just emerging.

\textsuperscript{16}As of 2019, GOGLA does include small-scale agriculture (e.g., solar water pump producers) but not mini-grid providers.

\textsuperscript{17}Private authority in global governance regimes can take multiple forms with varying relationships to state authority. Green (2014, 6) defines private authority “as situations in which non-state actors make rules or set standards that other actors in world politics adopt,” which is distinct from lobbying efforts or influencing agenda-setting but rather direct efforts on establishing standards, rules, practices, or guidelines.

\textsuperscript{18}This approach to understanding the role of the state contrasts to the “command-and-control” approach to regulation where the state has the primary authority to establish rules and sanctions (Goodin et al., 2008).

\textsuperscript{19}Enforcement of quality standards by the Kenya Bureau of Standards (KEBS) is limited. This is described in more detail in Section 3.3.3.

\textsuperscript{20}#SwitchOffKPLC is an example of the critical link between consumer protections and electricity services. The Switch Off KPLC movement originated in response to billing from the electric utility in Kenya: Kenya Power/KPLC. Customers of Kenya Power received backdated bills which resulted in a lawsuit against KPLC by the Electricity Consumers Society of Kenya. Otherwise? A podcast by Brenda Wambui provides an overview of the #SwitchOffKPLC movement and why it is important to democracy in Kenya (https://www.otherwisepodcast.com/episodes/episode-57-switchoffkplc/).

\textsuperscript{21}The challenge of consumer participation in energy decision-making in the Global South is also referenced to by Baruah (2010, 1013) who states that, “[c]onsumers typically have no role in electricity delivery other than to expect that they will receive electricity reliably and safely as long as they pay their bills regularly. In India most people are far removed from the policy processes that govern electricity reform and have virtually no ability to influence the process or to articulate their concerns.”
Companies complying with the Lighting Global quality assurance program have historically benefited beyond just a reputation of having (perceived or actual) high quality products. Some of these additional benefits have substantial impact on company finances, including value-added tax (VAT) exemptions (Ben Hagan et al., 2015). Encouraging compliance for reasons other than command-and-control regulation may relieve some of the implementation burden on Kenyan government agencies. Complying with quality assurance policies and programs can serve as a requirement for participating in bulk procurement programs and can mediate access to incentives (such as greenhouse gas reduction certificates), finance, and trade group participation (Lighting Global, 2012). Participation in a regime like Lighting Global may provide access and entry to new markets and additional resources that may strengthen a company’s market position.

Much of the decision-making for off-grid solar is centered internationally, with coordination between Lighting Global and GOGLA and long-standing international standards bodies. The testing framework for off-grid solar products first established by the Lighting Global Quality Assurance program was later adopted by the International Electrotechnical Commission (IEC). As an IEC standard, this provides coordination of standards enabling companies to operate in multiple countries with a common standard. The IEC standard has been adopted by multiple countries through their standards bodies, including Kenya (Ben Hagan et al., 2015). This process aligns with the international standard-setting process behind many of the electrical products used globally, every day, from mobile phones to televisions.

While most current standards, and certainly early academic research, focus on photovoltaic module quality, this may no longer capture the full spectrum of challenges with “plug-and-play” solar home systems. Some of the biggest challenges for households with “plug-and-play” solar are wiring issues and battery failure. To address these additional concerns, the IEC recently adopted standards for pico-solar and plug-and-play kits based on the Lighting Global developed standards. Quality assurance, far more institutionalized now within standards bodies operating at multiple policy levels, continues to evolve with the sector.

Like other electronics, voluntary standards for components of off-grid solar products are developed by the IEC and then adopted by country-level agencies and promulgated by regulatory bodies. For this case, standards are adopted by KEBS and then included in regulation developed by the Energy and Petroleum Regulatory Authority (EPRA). Once adopted by country-level agencies, off-grid solar standards apply to all equipment entering and used in that country independent of other affiliations with Lighting Global or GOGLA.

Voluntary programs for environmental problems can be understood as “club goods” that provide excludable benefits to members (Potoski and Prakash, 2005, 2013), such as signals of superior performance providing a reputational benefit to members.

For a discussion of the influence and history of the IEC see Yates and Murphy (2019).

Technical Specification 62257-9-8 (VeraSol, 2020); also in February 2020 Lighting Global announced a shift to VeraSol a new effort which merges quality assurance for off-grid solar systems with quality assurance of off-grid solar appliances. The role of promoting DC appliances compatible with off-grid solar is an avenue for future research.
Lighting Global or GOGGLA estimate that their members represent 29% of solar lantern sales and 60-80% of solar home system sales (Global Off-Grid Lighting Association, 2019b). While industry group-led efforts are pushing for consumer protections, such efforts do not capture the entire market. Industry groups also lobby for and promote policies that constrain the market to their members or companies that comply with their programs.

IEC members are nation states, but industry groups and international organizations remain influential in the international standard-setting process. GOGGLA, the Global Off-Grid Lighting Association, acts as a “liaison” in an effort to coordinate across groups relevant to rural electrification, primarily off-grid solar and low-voltage direct current efforts. Other liaisons include the International Organization for Standardization (ISO), the European Commission, the International Energy Agency, and the International PV Quality Assurance Task Force (IEC TC 82, 2020). Liaisons can range from regional or international organizations to manufacturing or commercial associations to user groups to professional and scientific societies. While some liaisons contribute to IEC processes, others are just informed of ongoing work and are granted access to IEC reports. Including liaisons, such as GOGGLA, in IEC processes allows for private sector participation in standard-setting and coordination between IEC processes and sector-led initiatives operating outside the IEC.

The current quality assurance regime aims to support off-grid solar markets by establishing common principles that can extend across country contexts. Lighting Global’s Quality Assurance framework, which began two years after Lighting Africa’s initiation, in 2009, includes: third-party product testing and verification, establishing minimum product quality standards, and coordination with IEC standards to promote wider adoption of quality assurance for off-grid solar (Lighting Global, 2014, 1). IEC standards are used by “qualification testing laboratories throughout the world in testing products submitted by manufacturers who wish to enter the PV market place” (IEC TC 82, 2010).25 Lighting Global seeks input and coordinates feedback from stakeholders to inform the IEC process, this includes discussions to develop feedback and positions on proposed changes to IEC standards that impact the off-grid solar. Lighting Global requirements extend beyond the traditional bounds of technical specifications to include consumer-facing requirements, such as truth-in-advertising and warranty requirements.

The priorities within the programs and activities associated with Lighting Global and their partners are adopted by companies and, hypothetically, trickle down to consumers of off-grid solar products via product standards and requirements. Lighting Global’s Quality Assurance framework is based on, first, the principle that quality matters to market development, and second, that the benefits of coordinated quality assurance extend across stakeholder groups, including manufacturers, supply chain actors, standards agencies, and consumers (Lighting Global, 2014, 2018). The purpose of Lighting Global is to lower the risk of private sector entry into new markets and to mobilize private sector investment, with a focus on: market intelligence, quality assurance, business support services and consumer ed-

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25 The IEC Technical Committee 82 established in 1981 addresses solar photovoltaic technology and systems, and the Joint Working Group 1 of TC 82 called “Photovoltaic off grid systems, including decentralized rural electrification and hybrid systems” is responsible for the 62257 standards series covering off-grid energy systems, including service quality.
ucation (Dalberg Advisors et al., 2018). Supported by the International Finance Corporation (IFC) and the World Bank, and with ongoing coordination with the World Bank’s Energy Sector Management Assistance Program (ESMAP) for technical assistance, Lighting Global has reach into financing, market development, and within country energy programs affiliated with the World Bank. As of 2014, Lighting Global was also supported by the U.S. Department of Energy, in addition to the IFC and World Bank (Lighting Global, 2014). Lighting Global certified companies can become affiliates, a classification which provides access to advisory services and market development or catalyzing programs (Global Off-Grid Lighting Association, 2017). The network of organizations currently – or previously – supporting Lighting Global is extensive, with reach across the globe.

Often Lighting Global standards are termed technical standards – certainly the testing that occurs focuses on technical product performance – but information requirements extend these standards into areas of awareness-building and information transparency. Lighting Global standards and suggestions for the IEC, extend beyond technical specifications to include labeling and performance reporting (Lighting Global, 2019c). Lighting Global quality standards consistently include five core aspects: truth in advertising, durability, system quality, lumen maintenance, and presence of a consumer-facing warranty.26 Lighting Global’s standards require companies to “accurately present performance metrics on product packaging and other relevant consumer-facing materials to enable retail buyers and distributors to compare products and make educated choices” (Lighting Global, 2019b). Performance measures include: light output in lumens, daily runtime (hours per day), module power in Watts, clear statement on battery replacement, company name, unique product name or model number, warranty terms on box or paper provided at point-of-purchase. Labeling and performance information that enhance awareness and transparency are more commonly associated with behavior change, knowledge development, and interpersonal interactions. While required to be on packaging, these measures that are deemed important for consumers to know are, in turn, information that should be explained to customers by frontline solar intermediaries.

Consumer education about what metrics such as lumens or runtime actually mean is far weaker than the standards themselves. Here, Lighting Global efforts are faced with a challenge: is transparency just the presence of information on packaging or does it require comprehension and use by consumers. While Lighting Global requirements ensure reporting of performance measures and truth in advertising, they do not standardize or consistently measure how these concepts are communicated to consumers. More critical academic scholarship is beginning to point out the gaps in this safeguard regime. Cross and Murray (2018, 108) argue that while Lighting Global requires members to provide warranties, that does little to address the after-sales needs beyond this time period, or address “products being re-sold, given as gifts, travelling to different regions and countries, or being separated from the packaging where warranty information is often displayed.” Further the warranty requirements support a “black-box” approach to off-grid solar technology development, as products

26There is also some indication of including health & safety considerations, including no mercury or cadmium in batteries (Global Off-Grid Lighting Association, 2017).
must be tamper-proof to be eligible for warranties (Cross and Murray, 2018). The end-user experience with quality may only be partially informed by the product standards that receive so much international attention.

Consumers are aware of the importance of technical specifications for decisions about solar, but that does not necessarily translate to actionable knowledge. Figure 3-3 illustrates that of the information provided that influences a decision about solar, company and technical specifications are ranked most important, which parallels the reporting and transparency efforts established by Lighting Global. When I asked solar users what “runtime” means for a solar product, 44% identified runtime correctly, while other respondents considered runtime to mean system lifespan, lumen maintenance, brightness, battery charging or multiple of these options. It is also, of course, possible that the specific terminology such as “runtime” is not reaching the customer, but rather actors, including frontline solar intermediaries, or company training programs translate the concept into more a salient term.

Consumers may value different pieces of information required by Lighting Global in different ways. In Figure 3-3, neither Kenyan nor international certifications ranked consistently high for respondents, although Kenyan certifications were ranked higher than international certifications. International certifications and aesthetics were considered least important by most respondents. While having a warranty is more evenly distributed – with some higher rankings than the certification – it parallels the importance of location manufactured. Measures that people use to make decisions about solar may not align with the more prominent quality assurance efforts within the sector. One solar provider shared that customers associate system quality with the weight of the battery, encouraging the company to use lead-acid rather than lithium-ion batteries to maintain this perception of quality (interview 190619). The variation in the responses in Figure 3-3 suggests that potentially what international organizations or companies expect consumers to value may not always be reflected in behavior.

Publicly available evaluations of how well Lighting Global standards work or reach consumers is limited, even for representatives in the sector. One solar company employee described that,

“Lighting Africa has been...looking at exactly these issues of quality. So, they gave us the verification system, they’re like, okay...we will help you work with governments to educate households on the importance of having warranty for sustainability. Now, that program has gone on for like I don’t know how many years, and yet, I have never seen an evaluation report” (interview 190725).

While transparency has been included as an important feature of consumer-provider relationships, there is a risk of limited (or no) transparency regarding the growing efforts to

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27 The correct selection for this question in the survey was “How many hours I can use my solar given different use options (e.g., lights, charging, radio, and appliances; or lights at different levels; radio at different volumes) on a single battery charge.” Other options included: brightness after hours of use (lumen maintenance), number of times can charge phone on full battery charge, years system will last, and brightness compared to kerosene (N = 893, respondents in Trans-Nzoia County, Kenya).
The emergence of tools or frameworks that operate between the free market and traditional regulatory tools has been long explored in environmental regulation. The notion of “regulating from the inside” illustrates the importance of assessing variation in the goals, credibility, monitoring, sanctions, and transparency stemming from regimes of self-regulation (Coglianese and Nash, 2001). In their study of historical standard-setting at the IEC, Yates and Murphy (2019, 5) describe, “private actors – final consumers, companies that produce and use various goods and services, engineers, and others who design those goods and services, and scientists whose work informs the engineers – have long had more consistent and compelling interests in setting common standards.” Both historically, and applied to off-grid solar currently, these private actors – NGOs, companies, industry associations, financial institutions – are at the forefront of considering what guidelines must be in place as off-grid solar continues to evolve.

### 3.3.2 Industry Led Consumer Protections

In tandem with Lighting Global’s effort to promote quality assurance, the Global Off-Grid Lighting Association (GOGLA) is increasingly focused on developing guidelines for consumer

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28 Transparency in decision-making for private sector self-regulation may be difficult to incentivize without state-level requirements, or requirements from other non-state actors such as NGOs.
protection and managing electronic waste. GOGLA’s industry-led consumer protection code highlights quality assurance as a key dimension of consumer protection, as well as the broader complexity of PAYGo or other financed off-grid solar systems. The principles identified in GOGLA’s consumer protection code include: transparency, good product quality, personal data privacy, fair and respectful treatment, good consumer service, and responsible sales and pricing. Based on a trial assessment tool for consumer protection, GOGLA found that companies generally rate themselves relatively high on these measures of consumer protection, although all have areas in need of improvement (Global Off-Grid Lighting Association, 2019a). This consumer protection code may be more difficult to communicate to end-users compared to specific labeling requirements, and the consumer protection code has yet to be implemented in practice.

The range of activities that may fall under these consumer protection principles illustrates the growing complexity of this industry. As providers offer increasingly large systems and pay-as-you-go payment options, new concerns associated with data collection and privacy are emerging, but not currently governed under the same international or domestic policy regimes. Consumer protections developed for the microfinance sector, such as the Smart Campaign Client Protection Principles certification program, may provide a model applicable to off-grid solar (Global Off-Grid Lighting Association, 2019a). Led by industry, these protection efforts first require self-assessments that are then used to develop a certification program. Currently, off-grid solar is at the stage of developing a set of agreed upon standards and performing early company self-assessments. So, now, it a critical time for assessing a baseline of consumer knowledge about solar services.

While some GOGLA efforts focus on reducing risk to sector growth by actively participating in efforts to guide quality standards and consumer protections, other efforts reflect more direct policy advocacy. Given policy changes – from financial changes, taxes, and technical standards – industry groups help coordinate action for the off-grid solar sector. Off-grid solar companies rely on GOGLA for international coordination across companies and coordination with country-specific industry groups for local policy support. GOGLA has adopted two primary strategies: reactive and proactive activities.

Reactive situations occur when a GOGLA member has a specific problem and then GOGLA engages directly with the government and policymakers. Whereas, proactive support address a problem that “does not just affect one member, but rather affects the whole sector, [GOGLA] prefer[s] to work through the [local industry] associations” (interview 190808). In response to discontinued import duty exemptions in the East African Community, GOGLA developed an awareness campaign targeting governments in partnership with Lighting Global, the African Development Bank, Power Africa (USAID), and Sustainable Energy for All (Diecker, 2017). Again, efforts to address off-grid solar rules and regulations involve a network of organizations acting in coordination to promote the sector.

The consumer protection framework developed by GOGLA and its members is proactive,

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29 GOGLA states that, “[t]he PAYGo business model has made modern energy services affordable for the first time in history. Yet it also introduces new risks for consumers that need to be managed and minimised” (Global Off-Grid Lighting Association, 2019a, 3).
aiming to address a recognized challenge and get ahead of future issues facing the sector. For example, recently investors in pay-as-you-go off-grid solar debated whether the inability to provide meaningful after-sales service was a critical issue for the sector or just growing pains (Neichin et al., 2017; Aidun and Muench, 2017). The private sector plays an active and influential role, involved in international, regional, and national policy issues and processes.

As the off-grid solar sector evolves—in particular for pay-as-you-go providers—issues of consumer protection illustrate that access alone is not enough, nor is access unidimensional for electricity services. Increasingly, industry actors recognize that,

“...consumer protection frameworks and laws need to be established and adopted in order to protect customers from misleading marketing and poor-quality goods, and to hold OGS [off-grid solar] providers accountable. These will include a combination of quality standards and performance testing mechanisms, as well as ways to test and report “truth-in-advertising” and marketing....Ensuring compliance will require private sector partnerships, especially with local supply-chain actors, as well as a direct line of communication with end users” (Dalberg Advisors et al., 2018, 162).

Current action and leadership on these consumer protections are associated with GOGLA-led, private-sector focused efforts. As mentioned, frameworks and laws are a recognized need, but this does not translate to an industry calling for more regulation. In fact, in the same report, industry actors call for “coordination” between the private sector and policymakers, and to “jointly find ways to address these while avoiding heavy-handed regulation” (Dalberg Advisors et al., 2018, 162). This back and forth between stronger protections but not wanting more regulations suggests some uncertainty about how governments will engage with this GOGLA consumer protection code, and critically, how this code will incorporate citizen input. Potentially, establishing this “direct line of communication” between service providers and consumers will allow for this input and is a key dimension for the self-regulation of off-grid solar.

In the face of changes in regional or national policy, association members work in tandem with GOGLA. In Kenya, this also involves coordination with the local industry organization: the Kenya Renewable Energy Association (KEREA). Rather than companies engaging independently with the government, companies work through KEREA and GOGLA (interview 190607). GOGLA and KEREA coordinate briefings and recommendations together with industry feedback and at times highlight the voluntary actions already taken by the industry, such as the preemptive action coordinated by GOGLA on managing electronic waste in response to Kenya’s draft “Environmental Management and Co-ordination (E-Waste Management) Regulations” (NEMA, 2013). But much of this remains at the lobbying or feedback stage of policy, not implementation.

Implementing these efforts continues to rely on direct points of contact between providers and customers. As described in Section 2.2.4, direct communication via frontline solar intermediaries, like solar agents, is both a key link to the consumer but also a challenge. Frontline intermediaries are currently used to mitigate issues of reaching dispersed communities and provide on-the-ground information. But they also pose a risk regarding the reliability and
“truth” of on-the-ground communication and interactions. Efforts carefully crafted at higher levels of governance, may fall short if the incentives of frontline solar intermediaries do not align with similar principles of responsible, truthful service. The frontline solar intermediaries associated with service providers remain key direct points of contact, especially as on-the-ground capacity from the government is less developed for off-grid solar.  

3.3.3 Growing State Capacity in Kenya: Consumer Safeguards

While the off-grid solar industry is growing and changing quickly, considerations about financing, loans, and data privacy play into broader conversations about consumer protections in Kenya. In Kenya, consumer protection institutions are nascent but gaining more attention. The primary legislation supporting consumer protections include the 2010 Competition Act and the 2012 Consumer Protection Act (Malala, 2018). The regulations applicable to off-grid solar rely on standards and conformity assessments aimed at ensuring consistent quality, reliability, and safety of goods and services for consumers. The Standards Act from 1974 created the Kenya Bureau of Standards (KEBS) which works with international organizations such as the IEC to develop standards for Kenya. Despite a long history with developing standards, the compliance and enforcement mechanisms for standards in Kenya remain limited.

Implementing quality assurance from voluntary IEC standards to enforced and mandatory Kenyan standards faces issues of limited capacity and coordination. While a standard may be developed internationally, KEBS provides opportunities to revise IEC standards before adoption or to develop a Kenya-specific standard. Even once adopted by KEBS, enforcement of standards for off-grid solar lighting has lagged behind policy adoption (World Bank, 2017); although, voluntary adoption of Lighting Global by companies does provide some certainty about available products. In a recent evaluation of the solar PV regulations from the Kenya Energy and Petroleum Regulatory Authority (EPRA), consultants identified that quality remains a challenge in Kenya. In particular, the continued prevalence of poor-quality products in the Kenyan market hinders the ability to identify the cause of poor quality (e.g. installation vs. components) and limits consumer assessments of quality (Sustainable Energy Initiative Ltd., 2019, 74). Possible improvements to the existing regulatory regime include: increasing awareness about standards, developing consumer-facing methods of verifying quality, using Lighting Global standards, updating Kenyan standards in tandem with IEC updates, more proactive standard development, and more stringent enforcement of standards (Sustainable Energy Initiative Ltd., 2019, 74-5). While some standards are

30 The involvement of prominent NGOs that distribute a large number of solar products, like One Acre Fund, in industry discussions remains uncertain. Currently, Once Acre Fund is not a GOGLA member (see https://www.gogla.org/about-us/our-members).
31 See Wambui (Wambui) for a recent summary on consumer protection developments in Kenya.
32 Kenya is also a part of the East African Community which adds an additional layer of policy coordination on standards and issues like duty exemptions.
33 One of the KEBS Key Performance Indicators is to increase the percent of regulations that directly refer to a KEBS standard (interview 190805).
adopted and included in regulation, more work is needed to make quality interpretable by consumers.

The on-the-ground experience with warranties reflects sector challenges in implementation. Suggested improvements to component warranties include: enhanced consumer awareness, ensure that agents are able to meet warranty obligations, establish a consumer complaint platform with regulatory follow-up on complaints, more stringent consumer protection laws and communication channels, and to require product warranties with Kenya Bureau of Standards certification (Sustainable Energy Initiative Ltd., 2019, 78). An issue with evaluations, such as this of EPRA’s solar regulations, is that so many options are provided for each issue identified but then there is insufficient discussion of the pros and cons, or how to implement any of the provided suggestions. While establishing consumer protections for solar in Kenya requires high-level coordination across international and domestic policy regimes, it also requires a concerted effort at the local-level. The experience of implementing quality assurance and warranties for solar in Kenya suggests that the current regulatory regime requires more robust consumer protection institutions.

Based on field visits in Kenya, regional KEBS representatives struggle to differentiate genuine solar products from counterfeit ones. This suggests limited knowledge of solar labeling and the process of using quality assurance mechanisms. When presented with a genuine d.light S3 and a counterfeit version of the same lantern, the KEBS representative tasked with overseeing solar did not know how to differentiate the two lanterns. Further, conversations suggest that KEBS must prioritize critical health and safety risks, such as food quality, over products such as solar. Government officials in Kenya recognize that KEBS is understaffed, so the agency focuses capacity and resources on ensuring that items sold are “fit for human consumption” (Ochuodho, 2019). Even with this focus, media commentators lament the limited enforcement of consumer protections in Kenya (Kibii et al., 2019). While international efforts are being adopted and institutionalized in Kenya, other key goods are prioritized for state enforcement over solar products.

The current enforcement focus and capacity limitations of KEBS, suggests that self-regulation or some form of private sector voluntary compliance may be a realistic need for off-grid solar in Kenya. But how to better engage consumers remains an open question for implementing and generating demand for consumer safeguards.

Coordinating at different levels (international, national, sub-national) may also reflect different areas of expertise or relative advantage for establishing the rules that govern off-grid solar. Integrating technical standards for off-grid solar from Lighting Global into IEC processes reflects a long history of private sector authority and coordination, with potential benefits to the sector of harmonizing standards across markets. This coordination requires international reach, or the opportunity to influence multiple countries. Other policy arenas

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34For issues like counterfeits, the Kenya Bureau of Standards has existing collaborations to coordinate across agencies with different mandates (namely, the Kenya Anti-Counterfeit Agency), but this is limited for other areas of consumer protection.

35It is not only KEBS representatives that struggled with solar quality, a local official also shared he lacks knowledge about solar quality and the channels for grievances and rectifying poor performance (interview 190709).
for off-grid solar remain primarily driven by state regulatory agencies. For example, country-specific regulations include licensing technicians who are able to provide after-sales services or accrediting vendors who sell quality products (Ben Hagan et al., 2015). In Kenya, the Energy and Petroleum Regulatory Authority is responsible for solar technician licensing, and has licensed over 2,000 technicians. This effort was co-funded by USAID and established in conjunction with the National Industrial Training Authority (Dalberg Advisors et al., 2018, 155). Kenya is one of only a handful of countries with active training programs.

While a full list of licensed technicians is not available from EPRA, data from July 2019 identified 375 licensed technicians. Figure 3-4 illustrates where technicians are located, with 201 (a large majority) registered in Nairobi. The active training and certification program in Kenya suggests that government agencies are taking steps to build more robust requirements for consumer protection and safety regarding solar installations, but this remains geographically focused on capacity in Nairobi. To build the necessary consumer knowledge and local capacity work is needed to get training and licensing efforts into the more rural areas with more solar use.

**Figure 3-4:** Map of Energy and Petroleum Regulatory Authority registered solar technicians, as of July 2019

Access to the expertise designed to ensure high-quality design, installation, maintenance, and repair of solar systems in Kenya is uneven and not concentrated in the areas with the most solar use. Figure 3-4 illustrates that the most technicians are in Nairobi, with fewer technicians in Western Kenya where solar is most commonly used. This highlights that solar services are more than access to technologies, but rather access requires continued engagement and a knowledge-base with expertise in solar services (Cross and Murray, 2018).
While frameworks may exist at national and international levels, how that knowledge is translated locally via programs and interpersonal interactions is a critical dimension to the viability of off-grid solar systems.

### 3.4 PAYGo Solar Needs More Than International Efforts on Quality Assurance

The increase in PAYGo solar services in Kenya goes hand-in-hand with stronger industry leadership on consumer protections. With PAYGo the risks associated with financing solar products or providing other financial services are becoming more apparent. Blurring across sector boundaries in off-grid solar is already well documented for NGO and private sector hybridity (MacLean and Brass, 2015), yet there is also hybridity in the type of service itself, rather than just the sector. Off-grid solar providers are expanding beyond the traditional confines of either a product manufacturer or a utility (see Table 2.1 and the discussion in Chapter 2). Given the vertically integrated nature of many off-grid solar companies, the sector sits at a juncture between distribution, technology design & manufacturing, customer education, and financing.

Revisiting the dimensions of consumer protections outlined by GOGLA, many are related to an ongoing relationship with customers, tied to repeated interactions, data collection, and financing. Figure 3-5 illustrates the type of additional services provided by solar companies that extend beyond just solar home systems and associated appliances. Companies like M-Kopa Solar use solar as collateral to develop credit ratings for future loans. This was introduced in Chapter 2, with M-Kopa as more of a finance company, than only a solar company. While existing efforts focus primarily on solar quality, the growth of PAYGo solar is heightening the importance of broader consumer protections. Options such as SOLAPESA, in Figure 3-5, suggest that at least some of the big players, like M-Kopa, are leveraging their unique information on previous payment behavior to offer new financial products and services to customers with a reliable repayment history. Advertisements for SOLAPESA address common financial struggles like paying for school fees and offer those eligible loans of KES 5,000 or KES 7,000 (USD $50 or $ 70) (Pesa Plus, 2019). Such emerging services provide opportunities for needed financing, but also, as mentioned in Chapter 2, are entering into the Kenyan market that is already known to have high digital loan default rates.

Even with existing consumer protection policies, the diversity of services provided by off-grid solar companies is a challenge. For quality considerations, Lighting Global recognized that the Kenya Bureau of Standards (KEBS) was already experienced with adopting IEC standards, which provided a direct link from international work with the IEC, Lighting Global, and GOGLA to national policymaking (Lighting Global, 2017). Quality is only one dimension of consumer protection, and while there is more action on solar quality than other

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36M-Kopa’s Twitter advertised in August 2018, “Worried about School fees? Get a cash loan with M-KOPA SOLAPESA. Send an SMS to 22624 or visit an M-KOPA service center & learn more #Backtoschool #UpgradeyourLife.”

81
areas of consumer protections, these emerging concerns about data and financial services
highlight existing regulatory gaps. Even for the technical aspects of off-grid solar, existing
regulations in Kenya apply to component-based systems rather than the “plug-and-play”
solar home systems that are provided by many PAYGo companies (interview 190806). Ex-
isting regulations in Kenya reference the appropriate Kenyan and international standards
for design, installation, repair, and maintenance, but do not specify exactly the standard,
and in practice, there are limited inspections of installed solar systems (Sustainable Energy
Initiative Ltd., 2019). Implementing these policies in an effective manner in Kenya is a
challenge for both agencies with limited capacity and companies competing with leakage of
cheaper, non-complying products.

Increasingly, to sell solar products requires additional information beyond a product
demonstration, as financing options vary by provider. Even if two providers are selling the
same solar product, the financing terms may differ. Sun King, by Greenlight Planet, and
d.light each manufacture their own line of solar products, some are sold and distributed
by other companies or NGOs, while each company also has their own direct sales model
with local shops and solar agents. While solar companies provide a range of solar products,
the extent of financing provided suggests they are also financial institutions, although not beholden to the same rules and regulations as recognized financing organizations (interview 191002).

The PAYGo model has increased short-term affordability of solar products and continues to gain investment attention. PAYGo allows for repayment of solar systems “over time with small, high-frequency payments, often on terms far more flexible than those of traditional lending models and microfinance” (Sotiriou et al., 2018, 1). In Kenya, M-Kopa Solar generated 72,000 mobile money transactions per day in 2018 and is the third largest recipient of mobile money in Kenya (M-Kopa Solar, 2018). Other financing models include group liability loans and asset-based financing (One Acre Fund, 2014a), and group lending (but not necessarily group liability) (ICRW, 2018). The frontline intermediaries that introduce solar to end-users are also key to explaining the terms of financing and repayment plans, this includes dimensions such as interest, repayment frequency, and loan duration.

As a form of asset financing, solar home systems serve as the main collateral for PAYGo financing models. So, remote deactivation and possible repossessions must also be explained to customers at the start of PAYGo solar leases (Waldron, 2018). The dominant model for off-grid solar is lease-to-own, with a repayment period of less than two years (Dalberg Advisors et al., 2018). While originally companies experimented with longer repayment periods, shorter periods reduced default rates. Overall nonpayment and periods of remote lockout from systems are higher than originally expected by providers (Waldron, 2018). The prospect of ownership serves as an incentive for repayment, as the systems are unlocked upon completing of full loan repayment.

The experience of understanding the financing model, options, and the repayment process are important dimensions of the overall experience with financed off-grid solar. Explaining these terms is one of the factors that underpins the importance of solar agents – one type of frontline solar intermediary – for effective solar consumer protections (Global Off-Grid Lighting Association, 2019a). For PAYGo, remote lockouts are important to incentivizing payments, but these lockouts are received with mixed sentiments from users (Waldron and Swinderen, 2018). For other financing models, the nonpayment may result in an inability to access future loans, personally or for the entire group, depending on the model. For PAYGo solar in Kenya, the repayment model relies on mobile money payments, an approach also common to other East African countries with substantial mobile money penetration, but less common elsewhere.37

The experience of the payment process is only partially tied to the technologies deployed (e.g. digital communication, lockout). The consumer experience is also related to the expectations established at point-of-sale and the consumer education that underpins use or engagement with after-sales services. For PAYGo in Kenya, credits to a solar home system will be automatically reflected upon receipt of mobile money payment.38 Other models uti-

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37 In countries that do not rely on mobile money, companies are experimenting with other models such as mobile airtime, or rely on in-person payment collection. Some providers are innovating to provide additional incentives for repayment, such as a “Good Payers’ Club” that provides one month of free insurance (Dalberg Advisors et al., 2018).

38 This is becoming more easily integrated into systems with the development of companies like Angaza.
lize numeric codes or tokens that a customer enters into the system upon making a payment to a designated payment agent or via a mobile app (Winiecki and Kumar, 2014). Both users and providers describe challenges with these codes, including codes not recognized by the system or not resulting in the credit amount they paid (field visit 180314, interview 190607). Survey respondents in Trans-Nzoia with solar, identified payment issues to be the third most common issue with their systems after issues with their battery and then wiring, followed closely by reported issues with their solar panel.  

The incentives underlying frontline intermediary models remain critical for PAYGo repayment. Some solar agents have used their knowledge of solar systems to help circumvent the payment systems on behalf of customers willing to pay them directly to disconnect the remote monitoring capability (interview 190712). Given the prevalence of PAYGo, tampering with systems to prevent remote monitoring and enable customers to avoid their remaining payments is an early, but developing, problem not yet addressed by the industry (interview 190619). The ability to make solar payments is associated with other regular demands on a household budget, unexpected expenses, misunderstanding terms, and payment logistics (Zollmann et al., 2017). Some misunderstanding of the terms (e.g., payment amounts or remote lock-outs) may stem from inaccurate explanations of unfavorable contract terms (which may otherwise hinder a sale), rushed sales, or assumed prior knowledge (Zollmann et al., 2017, 26). Ensuring PAYGo solar users understand these dimensions of financing – spurred by providers or required by international organizations or government agencies – relies on frontline solar intermediaries.

3.5 Communicating Safeguard Principles Through Intermediaries

In response to the challenges of intermediary-customer interactions, companies started call centers designed to ensure customers receive and understand product information, including key protections such as warranty terms, repairs or replacements, and payment requirements. Such call centers are common across solar companies that provide PAYGo options. Anecdotally, solar agents suggest that customers prefer to contact the agent, rather than a call center, as an agent is someone they met personally, rather than a representative off in Nairobi (field visit 190719). Solar providers aim to use solar agents just for sales and then use the call center to ensure better information quality control, but nevertheless, the agent-customer relationship continues beyond sales.

39 Of the 504 respondents with solar, 202 reported problems with their system. 80 respondents identified the worst problem with their solar to be the battery, 33 reported wiring, 27 reported payment, and 24 reported an issue with the panel. Other respondents indicates issues with appliances, unsure of the source of the problem, or issues with receiving all the expected or ordered components. Most respondents reported having 1-2 problems with their system.

40 This was shared in reference to the early phase of one company in particular, since then they have rebranded and now distribute a new version of their system that aims to be more tamper-proof.
Kenyans do not rely only on the government for information about solar or to ensure high quality products (see Figure 3-3). Rather, they also rely on the private sector and informal actors at the local level. In conversations with county leaders in Trans-Nzoia, Kenya, even local leaders suggest that they lack adequate education and awareness about solar options and quality (interview 190709). Graham and Woods (2006, 879) argue that in developing countries with limited capacity to enforce regulations, “transparency can bolster government action,” which also can be supported and strengthened by civil society organizations that help generate demand for information and monitor compliance. But so far, in Kenya, making information relevant relies on the private sector and their connections to on-the-ground actors.

While solar users continue to rely on frontline intermediaries, they also may remain hesitant about their recommendations. In fact, people seem to trust information about solar from packaging the most, despite issues of counterfeits in Kenya. In response to the question “Which do you trust more, an in-person recommendation about a solar product or information provided on packaging,” 56% said information on packaging while 44% said in-person recommendation (Trans-Nzoia County, Kenya). Efforts to comply with quality assurance certifications include this consumer-facing information on product packaging. The importance of labeling information is also supported also by how people judge relative quality of products indicated in Table 3.1. Packaging information is second only to the company. While price is often considered a consumer measure of quality (Völckner and Hofmann, 2007), survey respondents prioritized company and information provided on packaging over price as a quality measure. Information about pricing, payments, system components, runtime, and warranties can be reliably provided on product packaging, designed to facilitate comparisons across solar products.

Table 3.1: Responses to “If you were to see two different solar products, what is the first way you would judge their relative quality?” Trans-Nzoia County, Kenya (N = 893)

<table>
<thead>
<tr>
<th>Relative Quality Indicators</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>27%</td>
</tr>
<tr>
<td>Packaging – information provided</td>
<td>26%</td>
</tr>
<tr>
<td>Price</td>
<td>19%</td>
</tr>
<tr>
<td>Shop/seller recommendation</td>
<td>11%</td>
</tr>
<tr>
<td>Ask a friend or family member</td>
<td>10%</td>
</tr>
<tr>
<td>Packaging – how it looks</td>
<td>4%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
</tr>
</tbody>
</table>

Information does not necessarily translate to action, trust in packaging does not mean that the information provided will be used to hold providers accountable. In Kenya, while consumers “are aware of the warranty, very few use it to get a replacement of their faulty

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41 This needs further research, as conversations suggest that a primary challenge is consumer awareness, because consumers do not look at quality but just at price (interview 190618).
product” (Kenya Climate Innovation Center, 2017, 5). The mix of quality standards and performance mechanisms contributing to consumer protections aims to enhance accountability. Figure 3-6 is an example of the type of information provided on packaging. While the common and required pieces of information are available on the packaging, there is limited information about how to actually use safeguards such as the 2-year warranty indicated in the righthand corner. Quality issues illustrate reduced accountability to consumers, with a need for promulgation and enforcement of regulations. Prior experiments with promoting brands that do meet existing standards have the potential to “create trust in the market” which may enhance accountability between providers and consumers (MacLean and Brass, 2015, 74). The importance of brand in Figure 3-3 and Table 3.1 suggests that consumers in Kenya do associate quality with certain companies. Frontline solar intermediaries have the potential to help consumers translate packaging information to actual use of after-sales services and quality assurance mechanisms.

Figure 3-6: Image of Sun King Boom product information indicating product features, technical specifications, and warranty length

On-the-ground, the consumer experience is driven by sales incentives both at the provider and frontline intermediary-levels. Historically, the “primary incentive of vendors is to sell modules, not to provide their customers with the most value per dollar” (Duke et al., 2002, 484). Even with improvements to the governance of solar products with quality standards, limited enforcement and leakage of poor-quality products into the Kenyan market suggests that product sales remain the primary incentive for providers and that Kenyans are interested in purchasing a range of solar products. Company priorities, as well as opportunities for side-deals, continue to influence the activities of frontline solar intermediaries in off-grid solar distribution.
3.6 Summary

In this chapter, I described the balance of authority – and responsibility – in the off-grid solar sector for quality and consumer protections, which are key to supporting more robust off-grid solar after-sales service models. I describe the initiatives led by Lighting Global and GOGLA to guide the sector with coordination at the international level. Such efforts indicate what type of information frontline solar intermediaries should be reinforcing in the awareness, sales, and after-sales processes with end-users. The consumer protection effort led by GOGLA is far more nascent than the quality assurance framework.

The importance of consumer protection is reinforced by examples of PAYGo solar from Kenya. With strong players operating in Kenya, like M-Kopa, and an active mobile money sector, the blurring of solar and financial services is increasing in Kenya. Solar providers advertise new loan products, while not falling neatly into existing regulatory regimes for financial institutions. Thus, the consumer protection codes for off-grid solar providers are all the more important for consumers.

Using survey data from Trans-Nzoia county, I illustrate how these trends of international standard-setting, policy coordination, and self-regulation are reflected back in responses about quality and trust. While respondents indicate it is the government’s “job” to ensure quality, they are split between if the government or private sector is most capable of ensuring quality products (Figure 3-2). In their personal judgements of quality, company is frequently ranked higher than any kind of certification, Kenyan or international (Figure 3-3) – although Kenyan certifications rank higher than international ones.

Efforts from the private sector to provide information about quality relies on labeling. Kenyans, in my survey sample from Trans-Nzoia, seem to trust labeling on solar products – the information on packaging – but labeling alone may not provide enough education about how to actually use safeguards, such as warranties. Solar consumers continue to rely on local actors, frontline solar intermediaries, for information about and help with solar.
Chapter 4

What It Means to Act in the Middle: Intermediaries in Off-Grid Solar

4.1 Introduction: An Interdisciplinary Lens

While this work explores the case of frontline solar intermediaries in off-grid solar in Kenya, intermediaries operate at multiple scales and across issues. Academic scholarship tends to speak of intermediaries in broad terms, without discussing the implications of variation in form and function. Further, why intermediaries act is often limited often to measures trust or social capital but these discussions lack a multidimensional assessment of those motivations. As introduced in Chapter 2, intermediaries are an example of the prevalence of mediated and indirect political communication (Krishna, 2011). The concept of an intermediary encourages scholars to check assumptions about how people engage in political processes and receive those associated services.

While the focus in this work is on developing country contexts, in particular those operating with weak government regulation and enforcement of solar safeguards, the study of intermediaries is broadly applicable. Mediated political action and relying on local individuals and organizations to interpret and convey political messages is a broad phenomenon. Political scientists frequently refer to a World Bank report which defined a model of a short and long route to accountability (see Lieberman et al. (2014) and Kosack and Fung (2014)). This model posits that in the short route, consumers directly hold providers accountable (assuming choices among providers), and in the long route, consumers or citizens hold providers accountable through politicians and policy-makers (Ahmad et al., 2003). The previous chapter suggests that in Kenya, the short route better approximates the current accountability and policy dynamics for off-grid solar. Independent of short or long route, both paths have intermediaries that play a role in how people are experiencing the process of receiving services. This includes awareness and initial receipt of services, building knowledge about what standard a provider can even be held accountable to, and then communication back to providers or policymakers about what is, and is not, working. Often overlooked, frontline

\[1\text{See Skocpol and Fiorina (2004) and Putnam (1994).}]}
intermediaries play an important role in these routes to accountability. Additionally, frontline intermediaries respond to incentives that are designed into service models, this research on the forms and functions of frontline intermediaries has direct implications for improving existing solar service models.

While there is an increasing focus on the business or service models associated with off-grid solar, there is little attention on the intermediaries that work in the middle to help link service providers to local communities. This work focuses more on the “short route” to accountability – the links between providers and consumers. Chapter 2 described the gap in scholarship on off-grid solar policies and programs beyond adoption. Chapter 3 described the priorities associated with self-regulation of the off-grid solar sector and, therefore, the principles of quality and consumer protections that intermediaries should convey to end-users. While academic scholarship is beginning to recognize the need to look at after-sales services, assessing frontline intermediaries requires a deep-dive into interdisciplinary scholarship. Issues of consumer protections in off-grid solar underpin the importance of frontline solar intermediaries, such as solar agents. Building on the importance of actors, such as solar agents, in implementing off-grid solar safeguards, this chapter examines the analytical dimensions that explain who intermediaries are, what intermediaries do, and why they do it.

Looking across disciplines highlights that intermediaries are not often examined in private sector contexts, and few scholars focus on energy. While previous studies of intermediaries identify a positive relationship between intermediaries and social services (Krishna, 2011; Saha et al., 2013; Grantham and Baruah, 2017), to the best of my knowledge, the role of intermediaries in establishing knowledge and expectations for quality assurance and consumer protection is unstudied. For off-grid solar it is possible that the intermediaries have both positive and negative effects on consumers based on the incentives and related behaviors associated with different provider-intermediary models. The functions and features explored in this chapter help identify what may enhance or diminish an intermediary’s effectiveness.

To understand the broad variation in intermediaries, I examine literature from sociology, innovation systems, infrastructure transitions, public policy, and political science. Across different disciplines, specifications of intermediaries vary, but rarely does academic literature synthesize across different areas of scholarship. Within political science and sociology, “brokers” are more commonly discussed as links in social and political processes. I follow others (see Stovel and Shaw (2012)), that identify brokers as one type of intermediary. This chapter illustrates, based on prior scholarship, when intermediaries may be acting as a broker, or performing other kinds of intermediation.

Across different disciplines scholars examine intermediaries acting in different contexts and processes. The two primary divisions are those studying innovation processes and socio-technical transitions that examine intermediaries as links between organizations and scholars studying distributive politics and service, which more commonly examine the role of intermediaries in access to resources or services. Issues of governance and politics often span across

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2Baruah (2010) focuses on grid electricity access in urban areas, Heuër (2017) examines women-to-women sales for off-grid solar, and Moss (2009) examines the context, role, and interests of intermediaries in energy and water in Europe.
socio-technical transitions, distributive politics, and service delivery (Moss, 2009; Krishna, 2011; Kivimaa, 2014; Auerbach and Thachil, 2018). Even sociologists apply the concept of brokerage to public policy issues, studying the role of brokers in coalition-building (Fernandez and Gould, 1994). Scholars focused on innovation engage less with issues of distributive politics or service, but focus on the transfer of ideas (Stewart and Hyysalo, 2008) and do recognize policy aspects, such as standards and accreditation (Howells, 2006). Prior scholarship on intermediaries is well positioned to engage with issues of technology deployment and adoption, citizen engagement on consumer issues, and provision of key services to underserved populations – all central to off-grid solar.

In this chapter, I provide a theoretical framing to help synthesize across intermediaries operating in off-grid solar. While eventually I narrow my analysis to individual intermediaries working on the “frontline” or to implement service on-the-ground, other intermediaries operate in the off-grid sector at organizational levels or between other actors to bridge gaps in services and policymaking. I call this broadest classification “solar intermediaries” – frontline solar intermediaries are one type of this broad category.

After establishing the broad applicability of intermediaries for electricity access, this chapter explores how the literature defines intermediaries and examines descriptions of intermediaries to understand what intermediaries do. I identify three dimensions of variation in the forms of intermediaries: formality, scale, and durability. While examining literature from multiple disciplines does broaden the concept of an intermediary, this synthesis also highlights key distinctions that arise between actions of facilitation, configuring, and brokerage (Stewart and Hyysalo, 2008). Finally, I examine the economic, social, and political incentives to act as an intermediary and the benefits accrued from intermediation. Ultimately, this chapter seeks to provide a basis from the literature on: who are intermediaries, what do they do, and why do they do it?

Scholars are also interested in identifying what makes intermediaries effective as this can help explain issues of resource distribution or consumer demands. Effectiveness for intermediaries is frequently related to their trustworthiness. While this dimension is explored in further detail in Chapter 6, an effective intermediary can often span across interests, groups, or contexts because they are trusted by both other parties. Trust in an intermediary brings credibility to their actions and is tied to their social capital and expertise. Other aspects of trust are tied to the social motivation for intermediaries, as actions within their local communities or networks may enhance their reputation or future acts of reciprocity.

The analytical frame provided in this chapter is applied qualitatively to cases of intermediaries in Chapter 5 and dimensions highlighted in the literature are tested in Chapters 6 and 7. Given the gap in scholarship on intermediation “occurring at the grassroots” (Krishna, 2011) subsequent chapters focus on frontline intermediaries, but key dimensions underpinning variation in intermediaries can be applied to intermediaries more broadly.

Intermediaries help build connections between other parties to promote new ideas, en-

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3This frontline emphasis is akin to focus on street-level bureaucrats in implementing government policy, with substantial discretion in how people receive government services (Lipsky, 1980).

4See Table 4.1 in Section 4.4.
hance existing policies, or provide services. For energy access, the study of intermediaries contributes to understanding “the need for NGOs, universities, and other civil society engagement in electricity reform to provide adequate means of participation and oversight in order to create checks and balances between financial and development goals” (Baruah, 2010, 1015). Intermediaries work between different actors, such as service providers, consumers or end-users, and policymakers (Moss, 2009), and can open markets and new distribution channels (De Silva et al., 2018). To reach hard to access populations, ranging from last-mile households to households in informal or slum settlements to refugee camps, solar manufacturers and electricity service providers build networks that require local social connections: someone to interface between end-users (or citizens, or consumers), service providers, and oversight authorities.

These actors in off-grid solar are “solar intermediaries” and across models they vary in form and function. Up until this point my discussion of intermediaries has been constrained mostly to what I call frontline solar intermediaries, those acting on the ground in rural Kenya. Not all intermediaries are frontline actors operating between consumers and providers, some provide functions within an industry or sector, or between providers and government. Here, I briefly take a step back to illustrate that there are a range of what scholarship considers intermediaries active in this sector. Recognizing the variety of intermediaries even in just one sector speaks to the literature on intermediaries. The term is quite broad and used in many different ways. Stepping back to broadly examine the notion of intermediaries also shows other ways that connections within the sector are assist in promoting a regime of responsive service.\(^5\)

Intermediaries play a role in energy access and electrification in on-grid and off-grid electricity options. In Figure 4-1, UOMA (2019) provides examples of how off-grid solar companies are partnering with different organizations to reach populations ranging from refugees to farmers. Utilities, governments, and financing organizations are sharing best practices based on emerging intermediary models across contexts to influence household behaviors and community engagement. For electricity utilities, community-based intermediaries can help reduce non-technical losses due to theft or encourage customers to pay bills before resorting to power shut-offs in informal or slum settlements. In New Delhi, India, Tata Power Delhi Distribution Limited’s CSR (corporate social responsibility) program employs women from local slums to assist in bill distribution, recovery, and complaints. In return, women receive literacy classes, and training sessions in soft and vocational skills. These women “change agents”, called \textit{abhas}, also advertise other programs provided by the CSR program to the community, including training sessions, health services, and scholarships (Goyal, 2019). This effort has been promoted by the World Bank and piloted in Kenya by Kenya Power, and

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\(^5\)Intermediaries play an important role in urban, especially slums or informal settlements, contexts as well. While the focus of this research is on rural networks and adoption of off-grid solar, the principles likely extend to urban areas with strong social networks as well. Existing programs highlight the role of intermediaries in electricity and renewable energy adoption in other contexts, such as the \textit{Abhas} program developed by Tata Power DDL in New Delhi, India (Shrivastava, 2017). Or the “Units of Pacifying Police (UPPs)” established in Rio de Janeiro to rebuild trust between the distribution company and favela residents (Lins, 2014).
elsewhere, with early findings suggesting “improved connection rates by doing more community engagement” (Shrivastava, 2017). NGOs can function as intermediaries between utilities and communities for both electricity and sanitation efforts. Intermediaries build on the trust generated by successful past projects to motivate and mobilize the community for new efforts (Baruah, 2010). Increasingly, intermediaries are being examined in the low-carbon energy transitions and innovation processes (Barnes, 2019; Bush et al., 2017; Hargreaves et al., 2013; De Silva et al., 2018; Gliedt et al., 2018). Thus, the study of intermediaries in off-grid solar is speaking to a literature with a growing focus on electricity services and infrastructure change given pressing policy goals.

**Figure 4-1:** Figure from UOMA (2019) illustrating how “Several businesses are exploring different distribution models to reach last mile” households

Examples of intermediaries – local women employed by a utility, an NGO, or the range of distribution partnership indicated in Figure 4-1 – illustrate the diversity of these intermediary actors linking service providers and consumers. These examples beyond the frontline or acting in other areas of electricity access, indicate the broad applicability of this framing to other contexts. Across electricity access – on and off-grid – the examples of establishing local connections highlight not only the need to understand what intermediaries exist and are emerging, but their forms, functions, and motivations or interests. As efforts like the abhas program illustrate, successful models of intermediaries are being ported from one context to another. Understanding the on-the-ground variation can inform future program and policy design for energy services in underserved contexts. Scholars categorize intermediaries operating in the energy sector in relatively broad strokes and the concept is in need of more testable and actionable specifications.
4.2 What are intermediaries?

As implied in the introduction to this chapter, intermediaries vary widely. Different types of intermediaries are analyzed to show varying capabilities or to identify different impacts. Intermediaries can be understood as organizations, individuals, networks, or even a project or process (Moss, 2009; Hargreaves et al., 2013; Howells, 2006). The broad use of the term across contexts suggests that further definition and specification will aid in the application to off-grid solar. The organizational focus on intermediaries emphasizes their role in networks and ability to act between geographic scales (Medd and Marvin, 2008). While an individual as an intermediary emphasizes more of the brokering role, and individual characteristics such as affiliation and identity (Gould and Fernandez, 1989). The unifying feature of intermediaries across these different notions of intermediaries is their role in:

- relational work between other actors (Moss, 2009; Medd and Marvin, 2008; Krishna, 2011),
- translation or processing of knowledge and information (Lee, 2011), and
- mediating different interests (Medd and Marvin, 2008).

Intermediaries can be distinguished from one another by both their form, function, and motivations (underlying interest or designed into service models to encourage action). Rather than conducting only one function, some intermediaries may perform multiple functions, including increasingly complex functions such as moving from awareness-building, to best practice transfer, to coordination, and belief or behavior change (Boari and Riboldazzi, 2014). The discussion in Chapter 3 of intermediaries in off-grid solar performing a minimal function of introducing information, to maximally building actionable knowledge reflects this ability to carry out multiple functions.

There is a substantial amount of overlap between the concept of a broker and the broader scholarship on intermediaries. The strongest distinction between theories of brokerage discussed in political science and sociology and the literature associated with management and innovation is the level at which intermediaries are analyzed and the scale of their impact. As one type of intermediary, brokers focus primarily on the individual-to-individual relationship, although these one-on-one interactions can have implications for higher levels of organization (Gould and Fernandez, 1989; Kirkels and Duysters, 2010). The broader concept of intermediaries include more collective and organizational forms and functions. Table 4.1 illustrates examples of solar intermediaries that align with different intermediary forms. Synthesizing across literature from multiple disciplines allows for a broadening of the notion of an individual broker to larger scales of governance, while also more carefully specifying the functions of intermediaries. In off-grid solar, studying intermediaries at multiple scales provides a broader understanding of the governance mechanisms and influence of state and non-state authority in off-grid solar.

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6See Auerbach and Thachil (2018); Stokes (2013) for Political Science examples, and Stovel and Shaw (2012) for Sociology.
Table 4.1: Examples of Off-Grid Solar Intermediaries

<table>
<thead>
<tr>
<th>Form</th>
<th>Title</th>
<th>Function</th>
<th>Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>Global Off-Grid</td>
<td>Coordination &amp;</td>
<td>Supporting member companies</td>
</tr>
<tr>
<td>Organization</td>
<td>Lighting Association</td>
<td>advocacy</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>Practical Action (NGO)</td>
<td>Provide training sessions</td>
<td>Support energy access goals and market development</td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>Self-Help Group</td>
<td>Collective support &amp;</td>
<td>Support for resource access and livelihood activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>solidarity</td>
<td></td>
</tr>
<tr>
<td>Individual</td>
<td>Company Agent</td>
<td>Sales &amp; basic information</td>
<td>Commission &amp; reputation</td>
</tr>
</tbody>
</table>

Broadly, different disciplines illustrate intermediaries as a wide range of actors. More recent scholarship, argues that the literature lacks specificity in “how intermediation is defined, where it begins and ends, and where interaction in general becomes intermediation” (Kivimaa et al., 2019). Intermediaries as organizations be differentiated also from the process of intermediation (Howells, 2006). The inclusion of intermediaries as influences in innovation processes aligns with a shift to understanding innovation as a more uncertain and non-linear process, with complex interactions between multiple actors (Stewart and Hyysalo, 2008). By unpacking the process of intermediation, scholars identify distinct roles, including a primary role of “providing information scanning and exchange” (Howells, 2006, 719) and a second, more active role, of transferring technologies between organizations by finding new uses and applications. This second role focuses more on the transfer of technologies themselves, rather than solely associated information about innovation or technology. This is generally considered a “bridging” function for intermediaries in innovation-focused literature (Sapsed et al., 2007; Moss, 2009; Hargreaves et al., 2013). Bridging activities are more commonly discussed in innovation than literature focused on intermediaries in policy or service provision.

While some intermediary functions extend beyond information transfer or exchange, almost all descriptions of intermediaries emphasize communication (of ideas, information, claims) between others who would not regularly interact, otherwise have access to one another, or lack trust in one another. In particular for complex policy issue areas with changing or fluid participation, communication – and in particular the role of facilitating communication between others – may help build new coalitions in support of particular agendas (Fernandez and Gould, 1994). With mixed evidence on information provision alone (Lieberman et al., 2014), multiple scholars emphasize that intermediaries do more than just provide information, but gather, process, and disseminate information in a manner that evokes an

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7 Applied to innovation studies and processes, Howells (2006, 718) identifies a range of studies from the late 1980s to early 2000s that examine intermediaries and intermediation in innovation, with a focus on agencies, organizations, and consultants that support technology transfer, diffusion, or adoption, or extend technology applications to other uses or fields.
active learning process, rather than passive information transfer (Kivimaa, 2014). Lee (2011, 141) identifies the intermediary actions of “information mediation” comprised of “coding and linking different types and sources of information,” where coding is a process of making information relevant and comprehensible, and linking is intentionally combining information together to ensure coherence of information. Associated with technological change and development issues, intermediaries participate in a process of knowledge aggregation, first collecting local experiences and findings, then transforming them into knowledge useful for multiple contexts (Geels and Deuten, 2006). Such actions of processing information into knowledge illustrate the stronger potential roles for intermediaries in off-grid solar.

Off-grid solar has elements of technological change and innovation, as well as provision of key services and ongoing political or regulatory processes. Scholarship on intermediaries working across these contexts is relevant to the conceptualization of solar intermediaries. In processes of technology innovation, as described in Table 4.2, innovation intermediaries “gather, develop, control and disseminate knowledge, collect and disseminate financial, technical and institutional resources” (Stewart and Hyysalo, 2008, 297). These actions by innovation intermediaries establish relationships between users, the technology itself, providers, and the broader context, but they are not in control of the final use or technology. Without intermediaries actively involved in the process, the innovation is not sustainable. This contrasts with a more policy and service focused lens for intermediaries, termed interest intermediaries, which focuses on the role of intermediaries in overcoming different interests, most often in a specific policy setting. Lee (2011) describes intermediaries as similar to interest groups but distinct in their actions as a “collaborative capacity builder” (Weber and Khademian, 2008) and their function in coding and linking information. The collaborative capacity building of an intermediary involves going beyond just serving members of a group, to making independent decisions that may influence the members. Members then rely on the intermediary’s discretion, steering power, and socializing effect (Lee, 2011, 141). Here we see some boundaries of intermediaries emerging. Some industry groups or member organizations – but not all – function in this influential, intermediary role.

Table 4.2 indicates differences in defining intermediaries across research areas. Early studies on social networks and intermediaries as those who broker between two other actors (Marsden, 1982; Gould and Fernandez, 1989) parallel more recent political science conceptions of political or vote brokers. The focus on user experiences with intermediaries for

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8Applied to the Global South, scholars show that intermediaries operate in both urban and rural settings (Jha et al., 2007; Krishna, 2011; Auerbach and Thachil, 2018).

9The description of collaborative capacity building (Lee, 2011; Weber and Khademian, 2008) as a differentiating feature of intermediaries can clarify when organizations or actors are acting as intermediaries or acting in other capacities. Howells (2006, 725) also describes that innovation intermediaries may provide direct services to clients that do not involve interactions with other organizations, and therefore may not always function as an intermediary. This is relevant for understanding the durability of intermediaries in a given setting.

10While empirically I focus on individual intermediaries with individual-level survey data, more descriptively the context provided by sector-scale organizational intermediaries, such as GOGLA, influence the expected individual-level outcomes on the ground, such as measures of quality assurance or transparency of particular information (see Chapter 3).
key services, such as electricity, addresses “mediation occurring at the grassroots – and its consequences in terms of equity of access to social welfare – [which] are issues that have received relatively little attention so far” (Krishna, 2011, 100). This approach of examining grassroots relationships is reflected in the intermediary definitions associated with networks, service provision, and political behavior. Broadly, the studies in Table 4.2 stem from sociology (Marsden, 1982; Gould and Fernandez, 1989), innovation systems (Stewart and Hyysalo, 2008), infrastructure transitions (Medd and Marvin, 2008; Moss, 2009), public policy (Lee, 2011; Krishna, 2011), and political science (Auerbach and Thachil, 2018).

Context does matter for the study of intermediaries, particular issue areas tend to direct scholars to certain sub-topics, framings, or analyses. Applied to issues of change and transitions, scholars focus on intermediaries as brokers in social network theory and analysis (Marsden, 1982) and brokerage to create “novel combination and recombination of ideas” (Obstfeld, 2005, 101). While political scientists studying Western democracies examine “the intermediary space between citizens and agencies of the state,” (Krishna, 2011, 100) such as interest groups (Dahl, 1961) and street-level bureaucrats (Lipsky, 1980), scholars studying comparative politics focus on brokers in clientelistic regimes, where goods or services are offered in exchange for political support (Stokes, 2013). Even within clientelism, the topic is more often studied from a party-centric perspective, rather than examining the influence of citizen choices and preferences on selecting political brokers (Auerbach and Thachil, 2018). Across studies, intermediaries operate to connect resources or ideas in ways that provide more political power or result in new configurations of ideas.

Social capital underpins the function of intermediaries across studies of political arrangements and innovation networks. Fukuyama (2002, 23) identifies social capital as “a means of understanding the role that values and norms play in economic life” which relies on cooperation for common goals based on those shared values and norms. Formal membership in organizations may be insufficient to capture social capital in developing country contexts where informal, rather than formal, relationships and associations often provide the most value (Krishna, 2002, 5). These interactions range from assistance from neighbors to collective support from a village for crops, childcare, or other daily activities.

Social capital matters for far more than just economic interactions. Krishna (2002, 31) argues that “Social capital matters for development, for communal harmony, and for democratic participation, and it matters even more when [it] is activated and made productive through the intervention of capable agents.” In this framing, social capital does not necessarily determine development outcomes nor is it purely a product of existing institutions, but rather it is mediated by local agents, or intermediaries.13

11 This reflects the subsequent focus on “frontline” intermediaries in this dissertation.
12 See Burt (2004) for more discussion on the role of brokerage across “structural holes” in social networks to allow for new ideas.
13 The importance of effective agents to mediate social capital is supported by Tsai (2007) who finds that in rural China, public good provision cannot solely be explained by social capital but relies on local groups that are encompassing (open to everyone in the local jurisdiction) and embedding (includes local officials as members). Other studies of intermediaries, such as naya netas by Krishna (2011), allow for more variation in this specification with some representing entire constituencies, and others with more targeted representation.
Table 4.2: Definitions of Intermediaries

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Focus</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marsden (1982)</td>
<td>Social Networks</td>
<td>“intermediary actors facilitate transactions between other actors lacking access to or trust in one another” (202).</td>
</tr>
<tr>
<td>Gould and Fernandez (1989)</td>
<td>Transaction Networks</td>
<td>“any brokered exchange can be thought of as a relation involving three actors, two of whom are the actual parties to the transaction and one of whom is the intermediary or broker” (91).</td>
</tr>
<tr>
<td>Stewart and Hyysalo (2008)</td>
<td>Innovation Processes</td>
<td>“innovation intermediaries: actors who create spaces and opportunities for appropriation and generation of emerging technical or cultural products by others who might be described as developers and users” (296-7).</td>
</tr>
<tr>
<td>Medd and Marvin (2008)</td>
<td>Resource Management</td>
<td>“intermediary organisations are significant because of their intentional positioning between the interests of the established institutional representations of the water sector namely, utility companies, regulators, and the consumers” (282).</td>
</tr>
<tr>
<td>Moss (2009)</td>
<td>Socio-technical Networks</td>
<td>“actors are working in between the service providers, users, and regulators, often with the capacity to reorder relationships between these groups” (1481).</td>
</tr>
<tr>
<td>Lee (2011)</td>
<td>Regulatory Compliance</td>
<td>“a third party that bridges potentially opposing interests pursued by different groups of actors...in a given regulatory setting... (141).”</td>
</tr>
<tr>
<td>Krishna (2011)</td>
<td>Service Provision</td>
<td>“intermediary institutions help individuals and groups gain access to the agencies of the state....mediating between citizens and the state” (99).</td>
</tr>
<tr>
<td>Auerbach and Thachil (2018)</td>
<td>Voting Behavior</td>
<td>“political brokers...who facilitate the exchange of electoral support for access to goods, services, and protection in clientelistic settings” (775).</td>
</tr>
</tbody>
</table>

Scholars are recognizing the importance of intermediaries in technology transitions and sustainability, with recent applications to both energy and water systems. An emerging sub-category in innovation scholarship is a “transition intermediary”, which links the innovation and infrastructure transitions literature to understand how intermediaries aid in

These differences also reflect the form of a solidary group that have shared moral obligations and interest (Tsai, 2007), compared to individual actors with individual interests (Krishna, 2011).

14See Kivimaa et al. (2019); Gliedt et al. (2018)
transitions to more sustainable social-technical configurations. Such intermediaries can influence change in technologies, institutions, and market dynamics (Kivimaa and Martiskainen, 2018). Across the definitions of intermediaries in Table 4.2, common framings of intermediaries include the role of facilitating and brokering transactions or exchanges among two or more parties and the ability to translate information or technologies across disparate groups or contexts.

From this discussion so far, it is clear that intermediaries act in many ways to process and reformulate knowledge and technologies. Prior scholars identify intermediary roles broadly grouped into: facilitating, configuring, and brokering (Kivimaa, 2014). How those processes interact or if a single intermediary is responsible for all of them in a single process requires further study (Barnes, 2019). Examining the similarities and differences in these roles of types of intermediation helps specify when an intermediary is acting as a broker, or acting in another capacity. Stewart and Hyysalo (2008) provide three distinctions in these roles:

1. intermediaries as facilitators includes “providing opportunities to others, by educating, gathering and distributing resources, influencing regulations and setting local rules” (Stewart and Hyysalo, 2008, 306);

2. while configuring involves creating “the space that facilitates appropriation by others and influencing the perceptions and goals of sponsors and users” (Stewart and Hyysalo, 2008, 307);

3. and brokering processes include raising support by representing individuals or groups in negotiations with other actors.

These three different actions – facilitation, configuring, and brokering – can help differentiate between the actions of intermediaries. Brokerage does have much broader definitions, such as, “connecting actors in systems of social, economic, or political relations in order to facilitate access to valued resources” such “that (a) they bridge a gap in social structure and (b) they help goods, information, opportunities, or knowledge flow across that gap” (Stovel and Shaw, 2012, 141). This definition from Stovel and Shaw (2012) encompasses all three of the roles described by Stewart and Hyysalo (2008).

Across disciplines, there remains little consensus on exactly when an intermediary is acting as a broker or how that is distinguished from a broader set of intermediary roles. There is, however, support for understanding a broker to be a type of intermediary (Stovel and Shaw (2012, 141) illustrate a “broker as simple intermediary”). Despite this lack of consensus, I find the more granular distinctions from Stewart and Hyysalo (2008) a helpful step in identifying what intermediaries do. The range of example intermediaries from select literature in Table 4.3 parallels the broad activities and definitions, with scholars emphasizing the role of intermediaries involved in different process (e.g. innovation, adoption, policymaking, compliance) and with different forms.

Differentiating between intermediaries may help identify when or how they may be most effective at various acts of intermediation. Often, differences in intermediaries depend on their ability to establish social links that help spread ideas or resources, and illustrate to the
Table 4.3: Examples of Intermediaries

<table>
<thead>
<tr>
<th>Author</th>
<th>Topic</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Howells (2006)</td>
<td>Innovation</td>
<td>organizations (private, non-profit, charity), individuals, professional bodies, research councils, trade unions</td>
</tr>
<tr>
<td>Krishna (2011)</td>
<td>Service Provision</td>
<td>political parties, trade unions, community organizations, producer associations, residential organizations, civic associations, ethnic groups, &amp; religious congregations</td>
</tr>
<tr>
<td>Kivimaa (2014)</td>
<td>Socio-technical transitions</td>
<td>consultants, agencies, innovation centers, &amp; science parks</td>
</tr>
</tbody>
</table>

other parties that they can do so in a trusted and knowledgeable manner; that they are effective. Kirkels and Duysters (2010) differentiate intermediaries based on sector affiliation, kind of partner (including a range of actors from customers to informal discussion partners), and kind of information. They provide five types of intermediaries based on the intermediary’s group membership compared to the two other parties involved (e.g. all in the same group; in the same group as one party; not affiliated with a the same group as either). This conceptualization of intermediaries emphasizes, first, the role of an intermediary in the transfer of knowledge between two other parties, and second, the influence of group affiliation.

The influence of group affiliation is operationalized by scholars in multiple ways. Some scholars examine group as sector affiliation, noting how “Working in a profit, non-profit or science organization will influence behavior of people and consequently impacts on their personal network” (Kirkels and Duysters, 2010, 377). While others consider group defined by personal characteristics, such as ethnicity (Auerbach and Thachil, 2018). In developing country contexts, the groups most important to social capital may be informal (Krishna, 2002). Examining prior scholarship on the variation in intermediaries across organizational levels (from individuals to organizations) illustrates similarities and differences in intermediary characteristics, roles, and potential outcomes.

4.2.1 Individuals, Groups, and Organizations

Intermediaries span gaps in social structures and political processes, ranging from voting to more bureaucratic actions. They conduct such functions with varying forms and characteristics. Table 4.1 illustrates that in off-grid solar, for example, some of the organizations described in Chapter 3, such as GOGLA, may play an intermediary role between companies...
or between companies and governments. The roles of facilitation, configuring, and brokering are broadly applicable to intermediaries ranging from organizations to individuals. The applications presented in Figure 4-1 illustrate the role of individuals, such as solar agents, or groups, like farming cooperatives, in the network of off-grid solar distribution. Given the range of previous scholarship on intermediaries, classifying across levels of organization can identify both commonalities and differences, and when possible, links across these levels. This builds on prior examples of individuals in intermediary roles having networked impacts at higher levels in innovation networks or industries (Kirkels and Duysters, 2010). I argue that three dimensions important to the variation in intermediaries include: formality, scale, and durability (as indicated in Figure 4-2). In off-grid solar, or other applications, there is not one single intermediary form, but rather a spectrum of intermediaries that vary along key dimensions.

Figure 4-2: Variation in intermediaries along three key dimensions: formality, scale, and durability

In the political processes associated with access to or the distribution of resources (including goods and services), individual intermediaries in the Global South often fill broker roles. “New leaders” (naya netas) in rural Indian villages connect villagers to one another and connect them to more powerful actors with authority over key goods and services (Krishna, 2011). Similarly, “informal leaders” (pradhans) operate in urban slums in New Delhi, India to provide access to political leaders and protection from the police (Jha et al., 2007). In India, both of these intermediaries conduct acts of netagiri, what Krishna (2011) translates to “leadership” and Auerbach and Thachil (2018) translate to “politicking.” These on-the-ground or frontline intermediaries play a connecting role in how citizens – predominately rural and urban poor – gain access to political leaders and key services.

Interpersonal relationships are often considered the basis for intermediaries. A commonly referenced sociological foundation for intermediaries is the concept of the “strength of weak ties” (Granovetter, 1973). Weak ties are bridging and allow for the introduction of new opportunities and to diffuse information or innovations.16 Kruks-Wisner (2018, 135) argues that weak ties are due to “porous social and spatial boundaries” which allow for more access

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16The work stemming from Granovetter (1973) illustrates the broad applicability of social ties to multiple scales and topics from innovation diffusion and community organization (Granovetter, 1973) to electricity pricing (Yakubovich et al., 2005) and the electricity industry (Granovetter and McGuire, 1998).
to information and narratives of political organization. This access is available via direct and mediated channels. Within mediated channels, “fixers” – people with influence or knowledge and can get things done – act as claim-makers. While Kruks-Wisner (2018) examines this idea of claim-making, not access to a good or service, it is a first step towards access or advocating for citizen rights. When an intermediary, such as a “fixer”, was available, local citizens reported using them to make claims to the state. Interactions with service providers – government or non-state – are often mediated.

Often links to service providers may be informal, spanning unforeseen gaps or bridging insufficient capacity to reach to underserved communities. Informality in intermediaries is an important dimension in gaining access to services (Jha et al., 2007). Hargreaves et al. (2013) argue that “grassroots innovation” is innovation than occurs in civil society arenas and includes a wide range of intermediary forms, from informal community groups to voluntary associations. While Hargreaves et al. (2013) focus on small-scale energy development the UK, the notion of a “grassroots” intermediary resonates with the varied forms, scales, and ownership of electricity infrastructure at the local-level in the Global South.

Informality also provides connections between organizational levels, as informal relationships and networks underpinning intermediaries may influence opportunities at the organizational level. In sustainability transitions, Kivimaa et al. (2019) identify forms of informality in emergent, rather than established, modes of intermediation to support processes of change or transition. They highlight that intermediaries are most needed at these points of transition. Intermediaries can span across formal arenas with “informal contacts outside the organization...for importing novel information and linking the organization with its environment” (Obstfeld, 2005, 100). Even in studies of organizational intermediaries, specific actors play important roles suggesting a link between organizational and individual intermediaries.

Even the framing of brokers has been used to describe both individuals and firms. Kirkels and Duysters (2010) describe brokers as individual agents, but they apply this framework to high-tech small & medium-sized enterprises, drawing connections between individual brokers and the performance of industry networks. The emphasis on brokerage and forms of brokers builds on Gould and Fernandez (1989) who argue that brokers are relational and social network data and analysis is particularly well suited to identify brokers. The study of intermediaries, even at organizational levels, may benefit from examining the networks of actors that allow that organizational-level activity to occur. These multiple levels of analysis are often linked and both individual and organizational analysis can be useful to determine the flow and linkages of information, ideas, and services.

Across intermediary forms and functions, much of the literature on intermediaries highlights key cases of innovation, services, or political processes. The durability or temporality

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17 In scholarship on the Global South, informality in politics and political processes continues to gain traction and clarity (Helmke and Levitsky, 2004, 2006). The effort to more clearly distinguish informal institutions as “socially shared rules, usually unwritten, that are created, communicated, and enforced outside of officially sanctioned channels” (Helmke and Levitsky, 2004, 727) helps distinguish the role of informal and shared rules, and the actors that might act informally to enforce, garner support, and devise those rules, or provide completely separate connections or services.

18 See Zerriffi (2011) for more in-depth picture of this variation in rural electrification.
of intermediaries is rarely studied (Kivimaa, 2014). Often studies strive to explain differences in observed outcomes (Lee, 2011; Tsai, 2007), how people receive access to services or engage with the state (Jha et al., 2007; Krishna, 2011; Kruks-Wisner, 2018), and cases of innovation, change, or transition (Sapsed et al., 2007; Hargreaves et al., 2013; Bush et al., 2017). Some scholars emphasize the study of a specific project (Baruah, 2010), while others examine access to resources not in relation to a specific project or policy period (Krishna, 2011; Auerbach and Thachil, 2018). For technology change and diffusion, such as off-grid solar with quickly changing technologies and service models, the extent to which intermediaries are, should, or need to be durable is not yet settled.

The broader context or specific case of an intermediary may influence how lasting their influence may be on policy outcomes. Policy issue areas, determined by a particular policy push or interest, are considered less stable than the continued influence of interest groups or organizations (Fernandez and Gould, 1994). In some cases, the effect of an intermediary may more easily studied post-hoc and identified only in order to solve a puzzle or make sense of an extreme outcome. For example, Lee (2011) illustrates the importance of an industry group to improve compliance with the Clean Water Act through information mediation, establishing trustworthiness, and reconciling individual and collective interests. This case study illustrates an intermediary’s role in achieving high rates of compliance over time, but the activities and interventions documented in the research are only at one point of observation. It is unclear if and how the intermediary activities continue. For policy applications, the role, function, and presence of intermediaries likely change with the policy environment.19

For access to goods and services in underserved or last-mile communities, such as naya netas or pradhans, intermediaries may be responding to longer-term or more systemic issues of resource allocation. Challenges between the state and providers or providers and users are common in transitions of socio-technical systems (Moss, 2009). Given the ongoing challenges of access in Global South contexts, the need for intermediaries may be somewhat constant, although, again, scholarship leaves the question of longevity of these intermediaries unanswered. The case of naya netas illustrates that while the need may be constant, and individual intermediary is not stable or predictable (Krishna, 2011). Baruah (2010) identifies two NGOs in Ahmedabad, India as intermediaries working in collaboration with the utility and government. These intermediaries provide demonstrated expertise, the ability to carry out complex projects, and offer services where the utility fell short (such as microcredit). Additionally, the NGOs coordinated community-based organizations (CBOs) to support local awareness-building, payment collection, community meetings, and effective communication between the utility and community.20 The creation of CBOs as an ongoing link between the utility and community suggests that some activities were designed to proceed without NGO intermediation. Other scholars suggest that some of the lasting impact of intermediaries is their ability to formalize informal collaborations (Howells, 2006).

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19 In the understanding of an interest intermediary provided by Lee (2011), it is possible that an interest group play an intermediary role by conducting these coding and linking functions for a period of time, and then return to the more typical activities of an interest group (e.g., advocacy or bargaining).

20 This model is similar to the abhas model in New Delhi, although in this case it is spurred by an NGO and in the former the CSR-arm of the utility.
The literature on what intermediaries are and what they do is varied with scholars emphasizing different attributes of intermediaries given applications to innovation, policy processes, and access to services. Table 4.4 provides a summary of the types of activities or functions associated with intermediaries in the literature. Understanding what intermediaries do in a specific act of intermediation may provide further insight into when variation along formality, scale, and durability is most useful or applicable to processes of policy, innovation, and service-provision. Future research may be able to better specify different functions along the lines of facilitation, configuration, and brokerage (Table 4.4). In Table 4.4, I illustrate more broadly how intermediaries accomplish functions such as network building or establishing learning processes.

<table>
<thead>
<tr>
<th>Action</th>
<th>Operationalization</th>
<th>Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate</td>
<td>Distribution of resources &amp; information processed in relevant manner to generate knowledge, including coordinating with decision-makers to establish context-relevant rules</td>
<td>Lee (2011); Fernandez and Gould (1994); Kirkels and Duysters (2010)</td>
</tr>
<tr>
<td>Configure</td>
<td>Appropriation and arbitrage of ideas, information, resources, and connections from one context to another to add value and improve practices</td>
<td>Baruah (2010); Kivimaa (2014); Obstfeld (2005); Moss (2009)</td>
</tr>
<tr>
<td>Broker</td>
<td>Active negotiation, bargaining, or representation that bridges a gap in social connection or interaction to provide access to resources, goods, or services</td>
<td>Krishna (2002); Jha et al. (2007); Auerbach and Thachil (2018); Moss (2009)</td>
</tr>
</tbody>
</table>

### 4.2.2 Effective Intermediaries: Trust

Effective intermediaries reflect the inherently social and interpersonal position of an intermediary. Lee (2011, 151-2) identifies that effectiveness depends on an intermediary’s ability to synthesize information, act in a trustworthy manner, and to reconcile individual and collective interests. Trustworthiness brings credibility in the eyes of both other parties, which enables the other key activities of an intermediary. For access to key services, Krishna (2011, 106) describes that “transactions in both directions help consolidate their positions, enabling parties to trust the information being exchanged.”

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21Kivimaa (2014) describes four intermediary roles: articulation of expectations and visions; building of social networks; learning processes and exploration at multiple dimensions; and other (including activities such as arbitration, and standard setting). Table 4.4 aims ways an intermediary may accomplish some of those roles.

22Lee (2011, 151) describes that “an effective interest intermediary should have a high level of trust if the mediated information is to be credible.”
naya netas rely upon forging two sets of trustworthy bargains. On the one hand, they strike bargains with their fellow villagers needing access to welfare benefits, and on the other hand, they strike deals with the service providers.” Underlying effective relationships is the notion of a trusted intermediary stemming from their social capital and expertise.

Trust is an important component of social capital and where trust is low in society, social capital tends to be built among small and more isolated groups, rather than cooperating across a larger network of groups. To provide access to goods and services, intermediaries use connections to key actors beyond their small group boundary to span networks to enhance access. Fukuyama (2001) describes this as a “radius of trust” and argues that more traditional groups (based on kin and familial relations) have more narrow radii, which reduces cooperation with outsiders with potential impacts on resource allocation and political corruption. As described by Krishna (2002), the development of social capital is a mediated action, with agents or intermediaries critical to the construction of local social capital.

Embeddedness is a recognized element of social capital and it is important to the ways that civil society actors, including non-profits, shape for-profit markets (Obstfeld, 2005; Child, 2016). Embeddedness – defined as activities and transactions rooted in personal relationships and networks – generates trust and can encourage compliance. Trust and reputation are important to the personal relationships that underpin embeddedness (Granovetter, 1985). Ongoing relationships motivate people to act in trustworthy ways and broader social expectations may encourage trustworthy behavior (Granovetter, 1985, 490).

For development issues, forms of social organization, such as self-help groups, provide communities with opportunities to discuss issues and help establish solidarity through shared experiences, visions, and goal-setting. In such cases, the building of trust and the development of social capital related to development goals, such as health services, can have both community and individual-level impacts (Saha et al., 2013). For solar technologies, the embeddedness of intermediaries has the potential to provide “direct real time customer feedback from the community on what products customers particularly respond to in order to meet their unique energy needs” (Heuër, 2017, 118). For both access to services and the introduction of new processes or technologies, “[t]he advantages of dense social networks, and the more frequent communication and strong ties they usually entail, include trust, norms of cooperation, and more effective exchange of complex knowledge, all of which are crucial to the coordinated action necessary for sustained innovation effort” (Obstfeld, 2005, 106). For intermediaries operating in social and transaction networks, if the group affiliation of the parties involved is important for trust, then so is the affiliation – and therefore relationships and interests – of the intermediary (Gould and Fernandez, 1989).

Trustworthy relationships are associated with enhanced knowledge flow that can improve access to a wider variety of knowledge and enhance performance and opportunities for innovation (De Silva et al., 2018). Trusted intermediaries can help build trust in the associated technologies or services (Heuër, 2017). Trust can be difficult to pinpoint and to measure as it “both an outcome and an antecedent of relationships. It forms the basis for relationships, and thus generates social capital” (Nooteboom, 2007, 29). Critically, intermediaries can help facilitate trust between parties that may not have a prior relationship (Nooteboom, 2007).
To extend trust, an intermediary can utilize their close relationship and personal knowledge to assure other parties of trustworthiness (Granovetter, 1973).

In addition to social capital, trust in intermediaries stems from their experience or expertise. With respect to facilitation activities associated with information processing, intermediaries with the expertise to collect and process information to identify what is most relevant to different parties can reduce uncertainty and complexity (Lee, 2011). In different contexts, such as emerging versus mature technologies, intermediaries may need different types of expertise varying from depth to breadth (Sapsed et al., 2007).

The interaction between trust and established expertise, also enables intermediaries to extend their role into other needs or contexts. For example, Baruah (2010) describes that it was the implementation of prior, successful sanitation projects between the community and the local NGO that enabled the NGO to later play an intermediary role in electrification. The initial relationship between the community and NGO was established by repeated interactions and targeted efforts to engage the community (Baruah, 2007), then strengthened and transferable based on the successful experience together and proven expertise of the NGO (Baruah, 2010). This transfer of trust is also illustrated by interactions between local NGOs providing a service and citizens who are seeking other advice or expertise. Applied to health services, Grantham and Baruah (2017, 935) illustrates that, “[t]he community trusts us, not just because we make yogurt that improves the health of the community, but also because we have knowledge and advice to give them about business, and domestic issues like violence or inheritance.” Trust is linked to proven interactions and the relevant expertise of the intermediary.

Within the literature – especially across disciplines – the neutrality of intermediaries and the relevance of neutrality for trust is unsettled. Kivimaa (2014, 1378) describes that neutrality plays a role in successful intermediaries, and that neutrality is an “independence from public administration and politics, finance, or technology neutrality. These types of neutrality aid the intermediaries to gain trust and get different parties into new networks.” Activities such as arbitration rely on both neutrality and trust. On the other hand, complete neutrality may be impossible and, in some cases, an intermediary’s preference toward a new vision or opportunity may aid in technology transitions (Kivimaa, 2014). The role of intermediaries in the governance of socio-technical systems suggests that intermediaries are actually not neutral and aim activities towards opportunities that provide collective benefits, which may reflect their own interests (political, social, commercial, or organizational) (Moss, 2009). Trust remains a critical dimension to intermediary relationships as it provides some expectation or assurance that an intermediary will behave in a certain way given incentives that may support more opportunistic behavior (Nooteboom, 2007).
4.3 Intermediary Behavior

Motivated by a range of factors to engage in activities of facilitation, configuring, and brokering, intermediaries utilize their social capital and expertise to achieve beneficial goals, often with benefits accruing to multiple parties. But, why do intermediaries do what they do? The literature on intermediaries suggests insights into the incentives that motivate intermediaries and the benefits they may accrue from their actions.

Both incentives and benefits stem from economic, social, and political arenas for intermediaries. Just as intermediaries are not completely neutral actors, they respond to, create, and receive different forms of value. Intermediaries respond to financial and non-financial value stemming from acts connecting others (De Silva et al., 2018). Scholars emphasize the role of commissions for brokering transactions (Marsden, 1982) and other indirect or diffuse rewards (Gould and Fernandez, 1989). Krishna (2011, 107) notes that the gains observed by local intermediaries are varied, with some “extracting commercial advantage” but with most “in it more for social and political rather than economic gains.” The benefits intermediaries receive vary from direct economic gains, specialized access to valuable information or resources, reputational benefits, or future obligations (Stovel and Shaw, 2012). Some rewards may be “diffuse or even nonexistent,” (Gould and Fernandez, 1989, 91) thus not all acts of intermediation inherently require rewards, although many have some kind of (not necessarily financial) benefit.

Being an effective and well-connected intermediary begets more opportunities for action and connections. Given “monitoring costs [actors] should focus their communication efforts on actors likely to provide them with useful information, that is, actors who themselves have many communication links” (Fernandez and Gould, 1994, 1460). The reputation and connectedness of an intermediary are likely associated with the rewards they receive. Linked to trustworthiness, reputation can indicate credibility and provide enough information for perceived trustworthiness to spread, or at least can serve as an indicator for reliability or confidence (Levi and Stoker, 2000). Concerns for reputation may encourage strategic use of capacity, even if a relationship exists it may only be used by an intermediary if they are confident in the need for action (Marsden and Campbell, 2012). Intermediaries can build their reputation by associating or partnering with others that have a favorable reputation or status (Boari and Riboldazzi, 2014). Reputation is critically linked to the measures of expertise (Boari and Riboldazzi, 2014) and social capital that also build trust in an intermediary.

While at times intermediary activity stems from entrepreneurial opportunities or targeted programs, at other times the work of intermediation needs to be funded and institutionalized. Baruah (2010, 1023) argues that “NGO participation in propoor electrification activities requires strong state involvement in securing financial resources and developing a policy framework for NGOs to participate in the design and implementation of partnership projects and in the oversight of the electricity reform process in general.” Some intermediary actions are the result of concerted efforts to establish collaborations on specific projects or processes, while others exhibit a more organic or entrepreneurial identification of opportunities. In the
example of a *naya neta*, behavior is somewhat unpredictable across individual actors, with implications for future access to resources (Krishna, 2011). Certainly, personal goals and aspirations, as well as the purpose of the exchange influence an intermediary’s behavior (Gould and Fernandez, 1989), but some of the variation or unpredictability of behavior can extend to non-exchange or non-monetary motivations.

Social connections may instill a separate set of incentives rooted in norms of obligation and reciprocity, especially given close social ties. Given the importance of trust and its relation to social capital for effective intermediaries, the strength of social ties underpins the behavior of intermediaries. While leveraging weak ties may provide an intermediary with a strategic position to identify and leverage new information or relationships, strong ties may encourage reciprocity or intermediaries may seek to strengthen their relationships by exhibiting norms of reciprocity (Marsden and Campbell, 2012). Informal institutions, such as social reciprocity, can be mediated by other formal institutions to mitigate risks (MacLean, 2014). Acts of reciprocity are tied to reputation and visibility of actions, where “ethical reciprocity” (“the norm of contributing one’s fair share as long as others are also doing their part” (Levi et al., 1998)) can encourage compliance.

**Table 4.5: Incentives for intermediaries to act and benefits for their actions**

<table>
<thead>
<tr>
<th><strong>Incentives</strong></th>
<th><strong>Benefits</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>commissions, payments, future financial gain</td>
</tr>
<tr>
<td>promise of financial gain, entrepreneurial connections</td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>reputation-building, reciprocity</td>
</tr>
<tr>
<td>accessing collective benefits, community or group obligations</td>
<td></td>
</tr>
<tr>
<td>Political</td>
<td>new ideas or knowledge, connections to those with value (future favors, bargains), demonstrated value to multiple other parties (established strategic importance)</td>
</tr>
<tr>
<td>allocation (or re-allocation) of resources or knowledge</td>
<td></td>
</tr>
</tbody>
</table>

While the literature on intermediaries tends to focus more on forms and to some extent outcomes of intermediaries, the motivations underpinning intermediaries provides some insight into the variation in intermediaries. Table 4.5 illustrates economic, social, and political motivations that may exist as incentives to encourage intermediaries and associated benefits received upon successful action. Examining formality, scale, and durability (see Figure 4-2), what motivates intermediaries may provide a set of factors that help explain why intermediaries operate as individuals or contribute to a larger organization, and when more or less formal or more or less durable intermediaries may best fit the need of the others involved. Further, tracing the different types of incentives (for example, financial but not social) may illustrate gaps in intermediary models where one party may fail to hold an intermediary accountable or may receive comparatively less value.

Across the scholarship on intermediaries, typologies of intermediaries tend to narrow to one discipline but do not cut across the existing, and growing, scholarship on intermediaries.
Gould and Fernandez (1989) focus mostly on group membership (for an individual or an entire network), while Kivimaa (2014) focuses specifically on the roles that intermediaries play in niche innovation, and Howells (2006) classifies types of intermediation in innovation. Gliedt et al. (2018) differentiates between innovation intermediaries, niche actors (e.g., champions), and regime actors (e.g., policy entrepreneurs). In a more recent study, Kivimaa et al. (2019) identify a typology of five broad types of intermediaries: systemic, regime-based, niche, process, or user intermediary. Looking with an interdisciplinary lens, there appear to be two streams of classifying intermediaries, the first focusing much more on their social position, and the second, on the activities that comprise the role of the intermediary. Each of these approaches highlights different dimensions of intermediaries that help provide both broad and case specific understandings of what intermediaries do to facilitate exchanges of varying kinds.

4.4 Intermediaries in Off-Grid Solar

The incentives that underpin the behavior of intermediaries in electricity services may have implications for how citizens participate in processes associated with electricity decision-making. As described in Chapter 3, private sector authority and local connections, like solar agents, play important roles in promoting an effective consumer protection regime for off-grid solar. While off-grid solar companies are not utilities, they are service providers that rely on ongoing customer relationships for pay-as-you-go repayment and for up-selling or cross-selling customers to new systems with more appliances, or even services, such as loans. Focusing on this provider-consumer relationship, Moss (2009, 1487) emphasizes that intermediaries act to reorder provider-user relationships with respect to consumer protection and user empowerment. Even for initial distribution of solar, Figure 4-1 illustrates that businesses are engaging in a wide range of partnerships and models to reach those most likely to use or afford off-grid solar.23

The complexity of strengthening off-grid solar services in Kenya and the limitations in state capacity, motivate this focus on off-grid solar intermediaries. While scholars have developed categories and typologies for intermediaries broadly (Kirkels and Duysters, 2010), the application to the off-grid solar sector aims to trace dimensions described by different disciplines applied to one sector. There are multiple intermediaries operating between actors with different functions in off-grid solar (see Table 4.1). In their efforts to reach last-mile or other vulnerable populations, off-grid solar companies are developing multiple distribution strategies for off-grid solar. These approaches include partnerships with: development orga-

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23This does not always mean those most in need of off-grid solar, as Dalberg Advisors et al. (2018, 59) describe “most companies have focused on relatively easier commercial options. These include targeting customers that are closer to cities, have higher spending power, and are often already connected to some level of electricity. Even relatively mature markets see affiliate pico products concentrated in denser urban and peri-urban areas. In Kenya, suppliers struggle to reach lower density areas in the North and East; sales in Tanzania are concentrated in densely populated areas around Arusha, Dar es Salaam, Highlands, and Lake Zone.”
nizations (e.g. Barefoot Power’s partnerships to reach refugee camps), financial institutions
(Brightlife-FINCA), charity institutions (EnVenture trains grassroots organizations), other
specific NGOs such as farming organizations (e.g. One Acre Fund), or small, local retailers
(e.g. Sunshine solar). Other models, such as women-to-women networks (Solar Sister, Simpa
Networks) and partnerships with local retailers require the creation of internal company net-
works of agents or other retailers. The next chapter, Chapter 5, delves into examples of
distribution models and associated intermediaries. Ultimately, the ways that people learn
about, purchase, and receive continued service and support vary widely across contexts and
companies.

Organized industry plays an important role in off-grid solar policy at a national and
international level, but has limited extension to the household. Household experiences are
translated through companies to coordinating bodies, such as GOGLA. Intermediaries can
mediate between policymakers and industries to encourage compliance with regulations and
industry associations function as a key intermediary (Lee, 2011). Industry groups, such as
GOGLA or the Kenya Renewable Energy Association, work through their member compa-
nies, and rarely have a direct connection to the user. In fact, these organizations operating
at international levels, recognize the importance of frontline intermediaries in the progress
and on-the-ground processes of key elements of off-grid solar services, such as consumer
protections (see Section 2.2.4).

The off-grid solar model has built on and learned from other sectors and services, includ-
ing efforts by microfinance and other rural savings models. In Kenya, the long history of
social organization for financial services, agriculture, and livelihoods has informed the forms
and functions of current distribution models, including key intermediaries for solar. Group-
based services and activities are associated with the harambee culture in Kenya (Vershinina
et al., 2018) which relies on values including resource mobilization, collective reliance, social
responsibility. Other existing collective models in Kenya include rotating savings and credit
organizations (Gugerty, 2007) or savings and credit co-operatives (or SACCOs) and chamas
or community groups (Mwiti and Goulding, 2018). The models deployed in Kenya can be
seen in communities in other parts of the world as well, with Self-Help Groups common
in India (Joshi et al., 2019) and rotating savings and co-operatives common in many other
country contexts.

Important to rural communities and emerging services such as solar, group-level organi-
zation illustrates a model for off-grid solar intermediaries. In Rajasthan, India, Joshi et al.
(2019) study the role of self-help groups in sustained access to solar services for lanterns,
finding that the inclusion of self-help groups for assembly and maintenance of solar lanterns
increased the lifespan of the lantern and therefore confidence in the product. Ouko (2018)
describes that in Kenya, collectives emerged at times informally to improve livelihoods and
engaged in collective enterprises that provide safety nets. Groups, such as self-help groups,
do not necessarily fit within the classification of an individual or organization. In some cases,
groups operate as an extension of either category, while in others cases they operate more
independently.24 In some cases, group functions may provide intermediary functions not

24Gould and Fernandez (1989) include group relationships to the individuals involved in any brokerage
found at the individual or the organizational levels.

Intermediaries can work between different actors (providers, users, regulators) to improve services, policies, and diffusion of new innovations by leveraging existing or building new connections. Intermediaries can “develop networks of contacts including new markets and distribution channels” (De Silva et al., 2018, 71). NGOs as intermediaries illustrated in Table 4.1 and discussed by (Baruah, 2010) can be directly involved in entrepreneurial activities, as “marketization of NGO activities is extremely common in the energy sector in East Africa” (MacLean and Brass, 2015, 64). NGOs can distribute directly or train others in marketing, distribution and sales. Many entrepreneurial activities in this sector are focused on models of financing and distribution with broad applicability or replicability (Baldwin et al., 2015). Heuër (2017, 117) describes that female solar entrepreneurs can uniquely “create trust in the products and obtain direct customer feedback by using existing formal and informal networks, which gives them a unique market position.” For off-grid solar, frontline solar intermediaries may focus more on market development and building distribution channels than on broader policy positioning or development goals.

Intermediaries are also uniquely positioned to provide feedback to providers on the function and use of new technologies, such as off-grid solar technologies. Moss (2009, 1482) describes that “distinctive to all of them [intermediaries], though, is the relational work that they perform and their positioning between other actors, or between actors and artefacts, such as a technology.” For off-grid solar, understanding how end-users interact with new technologies is an important dimension as distributed energy technologies require more end-user operations and maintenance than grid connected options (Baldwin et al., 2015). While Table 4.1 illustrates that indeed there are intermediaries operating at multiple levels, this remainder of this work focuses on local interactions between solar intermediaries and users influencing the on-the-ground consumer experience with off-grid solar technologies and services; I call this sub-set of intermediaries: **frontline solar intermediaries**. They are the on-the-ground actors that link consumers, or end-users, and providers and have the ability to perform different acts of intermediation.

### 4.5 Analytical Frame

Examining intermediaries across disciplines provides commonalities and differences in how these actors are conceptualized and operationalized. Throughout this chapter, I described the variation in form, function, and motivations of intermediaries. The application of intermediaries to such a broad set of contexts illustrates the relevance of understanding how intermediaries effectively perform relational activities to bridge the needs and interests of different parties, from innovation to policymaking. Based on prior scholarship, I identified key analytical dimensions of forms (formality, scale, and durability), function (facilitate, configure, and broker), and motivation (economic, social, and political) (see Table 4.6). This synthesis provides a frame for how to understand and operationalize their forms, functions, relationship, including the broker’s – or in this case, intermediary’s – group affiliation compared to the other actors involved (e.g. all from the same group, two different groups, three different groups).
and motivations. Clearly defining analytical dimensions can help improve the application of this concept to pressing challenges and identifies key dimensions that can be incorporated into other scholarship and applied to distribution models for off-grid solar providers and policymakers.

<table>
<thead>
<tr>
<th>Variation</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>Formality, scale, durability</td>
</tr>
<tr>
<td>Function</td>
<td>Facilitate, configure, broker</td>
</tr>
<tr>
<td>Motivation</td>
<td>Economic, social, political</td>
</tr>
</tbody>
</table>

Intermediaries provide a lens into off-grid solar services with implications for service provision, technology diffusion, and implementing policy goals. As frontline solar intermediaries are subject to designed and, to some extent, malleable incentives, lessons from this research have direct applicability for off-grid solar service models. The effectiveness of intermediaries is related to their ability to be trusted or trustworthy. Trust is associated with credibility and the interpersonal relationships that allow for intermediary activities. Across different applications of intermediaries, trust remains an important dimension of an effective intermediary. In studies of organizational intermediaries, trust is associated with independence (Kivimaa, 2014), credibility, and rooted in ongoing relationships and dialogue (Lee, 2011). While in grassroots or frontline intermediation, trust often stems from strong interpersonal or community relationships (Baruah, 2010; Grantham and Baruah, 2017). While intermediaries gain strategic advantage from connecting disparate networks, or spanning “structural holes” which is beneficial to innovation and integration of new ideas, the density of social networks has trust that can mobilize interests and exchange complex information (Obstfeld, 2005). The following chapters explore this variation in intermediary form applied to off-grid solar, test which features of intermediaries are associated with trust, and examine the effect of intermediaries on knowledge about consumer protections for solar.

4.6 Summary

Descriptions of intermediaries – who they are and what they do – span multiple disciplines and research topics. In this chapter, I reviewed the literature on intermediaries from different disciplinary perspectives to characterize intermediaries across their forms, functions, and motivations. Much of the literature on intermediaries recognizes the lack of definition and broad applicability, but does not provide specific dimensions by which to assess variation in intermediaries. To fill this gap, I provide three dimensions associated with the form

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25 Trust can be measured in multiple ways as interpersonal trust, civic trust, and political trust, while other forms of trust are important for off-grid solar such as institutional trust in quality assurance, the discussion of trust and intermediaries included here focuses on interpersonal trust (OECD, 2017).
of intermediaries: formality, scale, and durability. Further, I describe three actions that intermediaries do: facilitate, configure, and broker. Finally, I look at economic, social, and political motivations that underpin acts of intermediation.

Focusing on intermediaries in off-grid solar, I present examples early in this chapter to illustrate the potential for intermediaries to bridge between solar manufacturers and users in a variety of contexts. Concluding this chapter, I review the wider set of solar intermediaries operating in the off-grid solar sector and narrow the focus of the remainder of this research to frontline solar intermediaries, rather than those operating at larger scales or connecting a broader set of actors. Subsequent discussions in Chapters 5-7 focus on the role of intermediaries in the consumer-provider relationship, although there are intermediaries connecting a range of actors more broadly in off-grid solar, such as company field staff to leadership or companies to policymaker.
Chapter 5

Variety of Solar Intermediaries

5.1 Introduction

In this chapter, I describe the role of intermediaries in off-grid solar and apply the framework developed in Chapter 4 to the frontline solar intermediaries linking off-grid solar providers to consumers. I integrate across the literature to incorporate the social and political dimensions of solar services in rural, often underserved, communities. Up to this point, my references to intermediaries as frontline actors in off-grid solar have been in relatively broad terms. Most references (in the introduction in Chapter 1 and in Chapter 2) focus on solar agents. While solar agents are one of the most common intermediaries operating in rural Kenya, they are not the only type active in sales and service models for off-grid solar. I illustrate the solar agent model and other types of frontline solar intermediaries in off-grid solar and reinforce their importance in both sales and implementing safeguards for the sector. In Table 4.1 in Chapter 4, I identified the variation of intermediaries possible in off-grid solar and in this chapter, I highlight some of the dimensions described, including sales incentives and social solidarity. To examine frontline solar intermediaries, boundaries much be established to define what frontline solar intermediaries are and what they do in off-grid solar services.

Until recently, scholarship and industry reports overwhelmingly focused on awareness-building, adoption, and sales rather than issues arising in later stages of solar services. But PAYGo solar models rely on selling customers larger systems or new services for business growth, which involves repeated and ongoing interactions between providers and consumers. Accounting for intermediaries in after-sales maintenance and repairs is critical to the longer-term sustainability of off-grid solar and a more accurate understanding of how intermediaries may intervene in the provision of these services. Frontline solar intermediaries help people engage in these after-sales interactions – at worst, they deceive customers and, at best, they extend a customer-first approach to providing solar services.

All types of intermediaries may vary in performance, but some may be more susceptible to poor performance than others. Based on the connections an intermediary may have to an end-user and a provider, I identify four types of frontline solar intermediaries: group leaders, embedded entrepreneurs, community influencers, and networking solar agents.
I apply the typologies of intermediaries operating in off-grid solar to cases of off-grid solar distribution models to illustrate their actions in practice. Data supporting the narratives and typologies described in this chapter include interviews, field visits, focus groups, industry gray literature, and descriptive summaries from survey data. Interviews aimed to reach a broad set of perspectives from solar providers and NGOs working on off-grid solar, these were conducted in-person and on the phone. While I use company names if the information is publicly available, in general, quotations and ideas from interviewees are not directly attributed to an individual and, when used, names have been changed. Qualitative data is used here to characterize the service models that inform the consumer experience with off-grid solar providers at different stages, from awareness to product end-of-life.\footnote{Additional information on field visits is in Table A.1.}

Providers using different models commonly emphasize engaging intermediaries that are local and able to use their social network, but, in practice, some models leverage social networks primarily to grow sales, and others more for accountability. The variation in seemingly similar approaches may have implications for the efficacy of frontline solar intermediaries. Describing the similarities and differences across a set of intermediaries provides insight into how providers are deploying models effectively and opportunities for improvement.

Determining the boundaries of intermediaries can be challenging, including who is acting as an intermediary and at what point in an interaction. But helping define intermediaries in off-grid solar helps provide a “compared to what” discussion. For example, how might a solar agent with connections to a company and local users compare to salesperson in the market with no connection to the company but frequent availability at the weekly marketplace. Not all frontline actors are intermediaries and not all intermediaries act in-between service providers and end-users. In this chapter more than others, I grapple with some of the variation and messiness of experiences with off-grid solar.\footnote{In Chapter 1, I described that “Off-grid solar distribution varies from temporary vendors, small shops, to door-to-door sales. For ease of access to customers, companies also leverage existing social connections, such as chamash or lending groups, churches, and schools.” In Chapter 4, I noted that intermediaries can “provide functions within providers or between providers and government” while still intermediaries, they are outside the focus of this dissertation.} Distribution of off-grid solar includes dimensions beyond just identifying customers and making a sale, examining active frontline solar intermediaries helps identify the nature of how incentives in intermediary models and interpersonal relationships are influencing experiences with solar.

5.2 Frontline Solar Intermediaries in Ongoing Solar Services

Not all individuals associated with solar are frontline solar intermediaries. Distinguishing between on-the-ground actors helps identify those with the requisite links to both providers and consumers that allow them to act as an intermediary. Implicitly, those with links to the company may be better equipped to pass on knowledge about safeguards developed by
the private sector and to provide feedback to the company about firsthand experiences with solar.

Actions of intermediation – facilitating, configuring, and brokering – require working between multiple parties. Rather than strong, direct links between solar service providers and end-users of solar products, intermediaries operate in-between these actors. In Figure 5-1, I illustrate the role of an intermediary with bidirectional exchanges with two other parties and, in the case of off-grid solar, a weak connection remaining between provider and end-user. While scholarship (e.g. Gould and Fernandez (1989)) focuses primarily on a single group affiliation to define the boundaries of intermediary types, the typologies described in this chapter are based the possibility of multiple affiliations. Intermediaries in off-grid solar may have affiliations that provide value to each of the other parties involved – they may have both community or social embeddedness, as well as other affiliations (e.g. sector). Generally, “service providers” can be state or non-state actors, but in the private-sector led distribution and regulation of off-grid solar in Kenya, these providers are most frequently private companies, NGOs, or a hybrid (MacLean and Brass, 2015). The relative strength of embeddedness or personal identification with a group varies by intermediary model.

Figure 5-1: Diagrams illustrating direct distribution compared to an intermediary acting between providers and end-users (consumers)

Modifications illustrated in the righthand panel of Figure 5-1 illustrate that (1) there is some, but weaker, ongoing connection between the provider and the consumer (e.g., payments, call center); and (2) information flow goes both directions with the intermediary potentially able to communicate not just on behalf of the provider, but also provide feedback and information from the consumer. This suggests repeated and ongoing interactions between the frontline solar intermediary and other parties, as is likely with the broader set of services provided by off-grid solar companies. Frontline solar intermediaries have the potential to operate even in more service-oriented stages of solar distribution, such as troubleshooting or replacements.
Frontline solar intermediaries are distinguished not only by their in-between position, but also their on-the-ground presence as a resource for both users and providers. This street-level or frontline characteristic aligns with academic scholarship calling for a stronger focus on these actors as key for implementation activities (Krishna, 2011; Post et al., 2017). In Chapter 2.2.4, industry research identified in-person solar agents as a critical link for solar services, as they are the actor guiding sales and often have continued contact for after-sales needs. My focus on actors operating in-person with end-users and with links to both providers and end-users helps constrain and specify frontline solar intermediaries.

Local connections for off-grid solar that do not meet this threshold of frontline solar intermediary include local repair people and company call centers. While faced with opposite challenges – one locally connected, the other a company connection – both lack connections to both parties. Local repair people (*fundi/mafundi*) may act as a customer’s warranty or guarantee of quality for after-sales needs and are cited by academic literature as influential in the lifecycle of solar products (Cross and Murray, 2018).³ *Mafundi* are important actors for after-sales and extending the life of solar products, but are not necessarily able to solve problems sufficiently (Cross and Murray, 2018). *Mafundi* operate independently from companies, so they fail to link back to the provider to convey information about the user experience, transfer ideas, or bargain with a party aside from the end-user.

For many off-grid solar companies, the after-sales point of contact is designed to shift to a company call center and the local or regional shop. This shift is to ensure customers have accurate and adequate information and a reliable source of assistance for any challenges after the point-of-sale (interview 190719). In practice, the company agent who made the sale is often the first call when there is a problem (interview 191015). Currently, call centers and shops are not replacements for on-the-ground and personal connections (interview 191002). The success of transitioning to the call center varies by company, with some reporting stricter call center follow-up protocols to ensure customers are aware of the required information for PAYGo solar products (interview 190607). Only after a follow-up call from the company confirms the information was accurately shared with the customer, can the sale progress (interview 190619). To reinforce the importance of this consumer knowledge, some companies re-start the sales process given poor customer responses to the verification questions (interview 190607). While call centers emerged as a check on some frontline solar intermediaries, it is unclear if or how often such communication channels become a customer’s default source of ongoing service.

### 5.2.1 Indicators of Continued Consumer Engagement

Indicators of continued services for off-grid solar, such as a warranty, are present in consumer-facing materials and advertisements, but translating these concepts into actions that hold

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³The role of local repair people to make individual arrangements with customers to repair products if they fail was also mentioned in work done in India (Harrington et al., 2020) and mentioned by street vendors in Kitale, Kenya. Such vendors provide informal guarantees for products they sell, whether or not they have formal, company warranties. The role of these informal repairs arrangements compared to formal warranty channels is yet unknown.
companies accountable for good and services is less certain. This was described in Chapter 3.5, suggesting higher awareness of warranties than actual use if needed in Kenya. Often end-users rely on interpersonal interactions to learn about solar and get help with later needs. Table 5.1 illustrates that over 50% of survey respondents in Trans-Nzoia County heard about solar from a person, rather than an advertisement. Hearing about solar in-person does not necessarily mean that the person is the most trusted source of information about solar, as people do report trusting information on packaging (see Section 3.5). This mix of trusting information on packaging, but continuing to rely on people to learn about solar establishes a situation where what is presented on packaging may factor into people’s perceptions of solar products, but how to take action on that information relies on interpersonal connections.

Table 5.1: Responses to the question “How did you first hear about solar?” (N = 893), Trans-Nzoia County, Kenya (percent in parentheses)

<table>
<thead>
<tr>
<th>Heard about solar from:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>From a person (friend, family, leader, etc.)</td>
<td>465 (52%)</td>
</tr>
<tr>
<td>Radio advertisement</td>
<td>218 (24%)</td>
</tr>
<tr>
<td>Other advertisement</td>
<td>142 (16%)</td>
</tr>
<tr>
<td>TV advertisement</td>
<td>68 (8%)</td>
</tr>
</tbody>
</table>

If the dominant mode of learning about solar is through social connections, advertisements and information may not be enough to build the kind of knowledge needed to go from awareness of a warranty, to use of a warranty. It is not surprising that many in rural Kenya are aware of warranties, the concept of a warranty is commonly included in advertisements for solar as illustrated in Figures 5-2a and 5-2b. Warranties are considered one of the key pieces of information shared with customers. On a payment sheet for a distribution company operating in Western Kenya, the key information included: product name, function, warranty, battery life, and payment plan (field visit 190125). The familiarity of the 2-year warranty symbol, is common: solar advertisements are painted on entire storefronts in rural Kenya, as illustrated in Figure 5-3a, and even present on counterfeit solar products in the same manner as on genuine products, as illustrated in Figure 5-3b.

While advertisements may communicate key consumer information, advertisements alone may not build consumer knowhow. The presence of warranty information on other products, those assembled in local shops (Figure 5-2b) and counterfeits of popular brands (Figure 5-3b) suggests that the notion of including warranties on advertisements for solar is certainly permeating consumer purchases. Despite the widespread presence of warranty symbols, in focus group discussions, individuals struggled to know if or how to differentiate between a warranty indicated on a counterfeit good as compared to a genuine product (focus group 190711.k.df). One included a section on the packaging insert to fill out with product and purchase information, including the serial number, while the counterfeit has no serial number or section to provide the required details for warranty use.

Going from knowing a warranty exists to knowing how or when to use it remains a challenge in off-grid solar. Going a step beyond just the providing a warranty includes building
knowledge about how to access and execute the warranty and sufficient understanding of the terms of the warranty (Lighting Global, 2019a). Stojanovski et al. (2017, 43) highlight that despite the popularity of solar lanterns, if needed these products,

“...lack the prospect of meaningful availability of service despite a 2 year warranty...[this is] due to a lack of culture of customer engagement and feedback as well as the remote prospects of service or replacement if adopters are expected to call a support center far from where they live to initiate the warranty process.”

Both from more formal company representatives, affiliates, and partners to more informal but socially embedded relationships, frontline solar intermediaries in off-grid solar have the potential to make knowledge about consumer safeguards salient for end-users of off-grid solar.

Stemming from the quality assurance regime of Lighting Global discussed in Chapter 3, information about the technical specifications and warranties for solar products is readily available as advertisements and on packaging materials in line with “truth-in-advertising” requirements. Given many ways the concept of a warranty is presented in advertising in Kenya – from painted shops to signs and packaging – it is not surprising that consumers are aware of the concept and associate it with the 2-year symbol. But consumers may be less aware of steps beyond recognition.

As described in Chapter 3, frontline intermediaries are the links to conveying the information and protections developed in industry-led regimes of quality assurance and consumer protection to consumers of off-grid solar products and services. The role of frontline solar intermediaries spans different stages of consumer engagement with off-grid solar products and services, from awareness to disposal.
Figure 5-3: Examples of advertisements for warranties in a range of places, from billboard equivalents to counterfeit products

(a) Small shop near Kitale, Kenya painted as a Sun King advertisement, with an emphasis on the large “2 Year Warranty” sign

(b) Counterfeit (left) and genuine (right) d.light lanterns in Friday market Sibanga, Kenya: warranty is even more visible on packaging

5.2.2 Building Awareness

Awareness is the first introduction to solar, and how people become aware of solar may influence whether someone purchases a solar product and if they purchase it from a specific provider. Engaging new customers and communities with off-grid solar entails performing product demos and obtaining permission from local chiefs or other leaders in order to sell solar in that area. The on-the-ground person responsible for building these local connections to leaders, or to other influential members of a community, is often someone already operating as a solar agent in a nearby village or well-known to the community such that they are perceived as trustworthy (interview 190607). This engagement helps ensure that the sales team will be welcome to operate in that particular area. Early engagement with community leaders is an opportunity to share information about a solar provider and also offers an opportunity for product demonstrations to illustrate the use and functionality of solar. In addition to demonstrations with influential community members, companies conduct demonstrations at markets, churches, or other local venues that attract regular groups. Demonstrations include dropping lanterns or smacking pieces together to illustrate the durability of products. Representatives make pitches about cost savings compared to expenditures on kerosene or phone charging from a local duka (shop) (interview 190607). Such demonstrations are paralleled by word-of-mouth marketing.

Efforts to build awareness about solar products are rooted in social relationships, be it

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4 For projects that require buy-in from multiple community members, can be considered an additional stage of “mobilization and motivation” can encourage participation. For larger distributed generation options this may focus on encouraging collective participation in options like a microgrid. (Baruah, 2010) illustrates the role of an NGO to engage in this manner. Harrington et al. (2020) categorize this kind of NGO activity as awareness-building for microgrid adoption.
buy-in from a leader or word-of-mouth. BBOXX, a solar home system company operating in multiple East African countries, recently found that word-of-mouth is increasingly important for building product awareness, suggesting the importance of family, friends, and neighbors in the early stages of solar adoption (Bisaga, 2019). Word-of-mouth is influential as people see their friends and neighbors with solar. Additional sales stem from satisfied customers upgrading from a lantern to a solar home system with a TV or other appliances (interview 190607). For the longevity of the off-grid solar sector, word-of-mouth remains important to build connections for future sales and services.

**Figure 5-4:** Responses indicating who people report to learn about solar from (N = 893), Trans-Nozia County, Kenya

The importance of personal connections and company agents is illustrated in Figure 5-4. In this figure, I show that company solar agents are the most common person to introduce someone to solar, followed by friends, and then family. In addition to demonstrations with leaders and word-of-mouth, companies conduct other awareness campaigns and “market storming,” when agents set up demonstrations on market days to attract people with noise, music, and product displays (interview 190619). Leveraging contacts made in these awareness campaigns, solar agents extend this influence by using those contacts to present about solar to that person’s lending group (*chama*) (190124 field visit). Sales conducted in the market can also be challenging. If customers purchase a product that can be self-installed providers do not always know accurately where that customer lives for later in-person contact (services, repossession) (Barrie and Cruickshank, 2017, 434). While a company agent and a friend are most commonly selected in Figure 5-4, connections to vendors at markets, shops, and lending groups are also indicated. While leaders provide permission to operate in an area, they are not as influential as other actors in building awareness about solar.

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5 BBOXX’s research also found variation by country and over time in whether customers learn about solar from word-of-mouth or a solar agent. In Kenya, BBOXX found that in 2016, 44% of customers found out about BBOXX from word-of-mouth and 18% through agents, while in 2018 the number of customers who found out by word-of-mouth and those by agents was about even. Then again, in the first quarter of 2019, 72% of new customers were due to word-of-mouth and 19% due to company agents.

6 This trend is also identified in other contexts, such as the United States. See Graziano and Gillingham (2015) neighbor effect on rooftop solar adoption and Wolske et al. (2020) for broader discussion of peer effects on energy behaviors.

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5.2.3 Building Service

After making sales via awareness campaigns or word-of-mouth, distance becomes a substantial challenge for after-sales services. Often ongoing services rely on shops in town and call centers. When a repair or replacement is needed, customers are required to bring the part with an issue to the local shop (interview 190710). While local shops recognize that the distance to the shop can be a burden on customers, in the past when company agents were allowed to make the return on behalf of a customer, there were issues with products reliably making it back to the shop. Now, the preference is for the customer to bring products for repair directly (interview 190719). Nevertheless, agents continue to provide this link for customers because if you,

“...tell the customer to bring his product to the office. Some offices are so far away, for example, I have a customer at Teso Malaba on the border between Kenya and Uganda, now to tell that person to bring their lamp to Kakamega because of a technical problem, the fare alone will cause one to abandon the company or leave the product without paying for such an event” (interview 190719.t).

Providing reliable and useable after-sales services is a challenge where frontline solar intermediaries provide not only a link to resources and information about sales, but help overcoming long distances or high travel costs. Some also question why customers experiencing problems would want talk to someone on the phone at a call center in Nairobi, as they perceive the person in the call center to lack knowledge about the customer’s situation (field visit 190711, interview 191002). Rather, people more commonly use the call center for certain types of information, such as balance inquiries (interview 190725). While solar agents may, at times, be unreliable, they are local and can help overcome distance and cost challenges.

The importance of intermediaries in after-sales services is not limited to just accessibility of repairs or replacements, but related to information about system use and compatibility. While consumer-facing information focuses mostly on product performance, use, and warranty duration, other information and education regarding issues of safety rely on effective communication from those actors providing solar services. For example, one shop reported seven cases (within the first 7 months of 2019) of customers plugging a solar panel from one company into a battery from another, causing the system to catch fire. Customers tend of have the idea that “solar is solar” and are not aware of system compatibility issues. Even company employees believe, it is the company’s responsibility to educate customers about what they are supposed to do after a purchase, but this effort is weaker than the emphasis on sales (interview 190719). Figure 5-5 illustrates that people rely on solar company agents to help with solar products, as perhaps an unreliable agent is better than abandoning a broken product.

Second to company agents in Figure 5-5 are local electricians (or mafundi) and then shop owners. As previously mentioned, the link between a local electrician and the company may be weak or non-existent, but they may have a strong connection to the community as a community member and local business. In the bottom bar chart in Figure 5-5, responses suggest that company affiliation and experience (both years and prior personal interactions)
influence who people seek for help regarding a solar issue. Cross and Murray (2018) note that local repair people fix not only component-based systems but also the “plug-and-play” systems of PAYGo solar providers, but that a repair from a local *fundī* is not a guarantee the product will function. Further, *fundī* repairs constitute tampering, which will invalidate a company provided warranty. People rely on people for awareness and ongoing solar services, but not all go-to people for solar issues have the same connections or motivations.

**Figure 5-5:** Responses indicating who people go to for help with solar and why (*N* = 893), Trans-Nozia County, Kenya

Who do people turn to for solar services?

The data in Figures 5-4 and 5-5 reinforces the importance of frontline intermediaries in awareness-building and for after-sales assistance. But the go-to person for help with solar may not always be the same person that introduced a consumer to solar. Consistent in Figures 5-4 and 5-5 is the importance of solar agents across stages. As one type of frontline solar intermediary, agents are an important link for off-grid solar services. The reliance on agents combined with the stories of failed follow-through, circumventing the remote payment system, intentionally preventing direct communication with the company, or not providing all
the paid-for appliances, illustrates both the opportunities and risks of these frontline intermediaries (see Chapter 1 and Chapter 2.2.4). The behaviors and motivations underpinning different models rely on the characteristics of intermediaries identified in Chapter 4. I use these motivations to describe typologies and distribution models discussed in the remainder of this chapter.

Other intermediaries enter and exit the process at different stages. A notable difference between Figure 5-4 and Figure 5-5 is that the reliance on friends and family after agents for learning about solar is replaced with local electricians and shop owners when it comes to help with solar. Further, the reason for going to an intermediary for help has much more to do with their affiliation and expertise than local presence or recommendations.

Local repair people or *mafundi* may be locally available and able to repair a range of solar products (both component-based and plug-and-play), but offer no guarantee that the product will actually work again. Solar agents, while they have connections to the provider and can close the loop – distance or communication – on solar services, they too, have questionable reliability. Identifying a cost-effective and consumer-first model for off-grid solar is challenging. As one solar employee mentioned,

"...when you get out into the field, it’s like we just got to sell, that person on the last level, his job is just to sell. That’s all he knows. In terms of ethics, “Know Your Customer” that’s a regulatory requirement, so most people are fulfilling these aspects just as compliance issues and to minimize the risk to the company...It’s a challenge because until I see it down at the field level, especially with the building of that capacity and awareness and empowerment, for example, like with people who are on commission....and companies are trying, I mean, we are just out there trying to keep the lights on. But we just just need some help" (interview 190725).

Off-grid solar models that build this local capacity are still being explored. Tensions between encouraging sales and building out more customer-focused efforts are present, but doing both may be difficult in current models. In the remainder of this chapter, my effort to identify the strengths and weaknesses of different frontline solar intermediary models aims to provide insights into what small – and large – changes could help enhance that field-level capacity, awareness, and empowerment.

5.3 Typologies of Solar Intermediaries

Identifying the variation in frontline solar intermediaries provides a framework for understanding how and why frontline solar intermediaries contribute to off-grid solar services. With a range of on-the-ground intermediaries acting to build awareness about solar, sell solar products, provide after-sales services, and maintain customer relationships, there are similarities and differences in the configurations of these frontline intermediaries. As entities

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7This is also shared in story described in Chapter 1.
that work in-between the service providers and users “often with the capacity to reorder relationships between these groups” (Moss, 2009, 1481), the conceptualization of intermediaries typically assumes a somewhat direct link between each actor. The case of off-grid solar offers examples of intermediaries with links of varying strength to providers and consumers. These connections enable wider access and distribution, but also complicate knowledge transfer and the accountability behind implementing a robust quality assurance program. The relative strength of connections to each party is often overlooked in scholarship on intermediaries operating at the grassroots or frontline.

Using the links that an intermediary has to both service providers and end-users, the typologies presented here vary along an intermediary’s social connections and their underlying incentives. Often the social connections are already existing between an intermediary and community. The service provider aims to leverage these connections in their distribution of solar products. Incentives can be tied to social relationships or provided by off-grid solar companies. Existing social connections to the community are a measure of an intermediary’s embeddedness, while an intermediary’s responsiveness to the incentives provided by the service provider suggests varying levels of loyalty to the provider. Two preliminary questions help differentiate between these dimensions:

1. How does the intermediary build connections to the end-users? (A) rely on personal social network or (B) build extended connections for a broader networking providing entry into new communities;

2. Why does the intermediary remain connected to the service provider? (A) reputational incentives or (B) primarily financial incentives.  

Classifying along these two questions suggests first-level differences between intermediaries in off-grid solar. Figure 5-6 shows a two-by-two of these differences and identifies four associated typologies. Incentives indicate the extent to which a frontline intermediary is focused on commission payments or is also influenced by their status within the community. While almost all models provide some amount of financial incentive, including renumeration models that incentivize more sales or stable repayment, small amounts of cash, or branded goods that illustrate achieving a certain goal. The focus on structured financial incentives is most common for large solar agent networks behind PAYGo solar companies. Reputational benefits and status indicators from the provider are used more in group-based models rather than agents, although non-monetary benefits are cited across the board.

While all frontline solar intermediaries have some level of community connection, whether that connection was already existing or created by extending one’s social reach for the purposes of solar distribution varies. The dimensions of “personal” and “extended” in Figure 5-6 indicate this difference in social connections. Further, the incentives or motivations for

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8 An alternative to solely looking at incentives examines the influence of incentives compared to judgements of quality or the value of the service that might influence an intermediary to encourage uptake within their network, but with the cases presented here, indicators of this kind of value – such as being a customer before being a group leader – are also combined with incentives, either financial or status symbols, making it difficult to differentiate between these dimensions.
Figure 5-6: Diagram illustrating how map to variation in social connections and incentives can identify different typologies of off-grid solar intermediaries

<table>
<thead>
<tr>
<th>Incentives</th>
<th>Reputational</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social connections</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal</td>
<td>Group leader</td>
<td>Embedded entrepreneur</td>
</tr>
<tr>
<td>Extended</td>
<td>Community influencer</td>
<td>Networking solar agent</td>
</tr>
</tbody>
</table>

acting as an intermediary can be primarily financial, or primarily enhance the intermediary’s reputation within their community. While some models strive to provide multiple incentives, the divisions in Figure 5-6 indicate what type of incentive dominates, or most influences, a frontline intermediary’s behavior.

Across the combinations present in Figure 5-6, I identify four types of frontline solar intermediaries: community influencer, networking solar agent, embedded entrepreneur, and group leader. Each of these is explored next in a general description and then in more detail in a set of solar distribution narratives in the next section of this chapter. The place of each intermediary in Figure 5-6 reflects the implementation of different models to highlight variation in how intermediaries actually operate, rather than only the design of different distribution models, which may mask differences on-the-ground. After presenting the four types, they are compared based on the dimensions in the analytical frame in Chapter 4.

5.3.1 Community Influencer

A community influencer leverages their position within a community to encourage solar sales, based on prior use of products (such as giving teachers lanterns to use) or by hosting demonstrations as a local leader. This type of intermediary is often involved in building awareness (see Section 5.2.2). Community influencers often have little responsibility for sales, but they trade on their reputation within the community as a trusted entry point for a solar provider. As their incentives are not linked strongly to recurring sales, they seek to maintain their role as a trusted and respected community member. As a member of the community with existing authority, their influence is to a larger group than just their immediate social connections such as family and friends. For example, using head-teachers as community influencers for solar allows for direct engagement of students and their families in the school. Studies show some variation in trustworthiness of community influencers, for
head-teachers some solar users are willing to pay for solar in advance and some, untrusting of the teacher, are not willing to leave their payment with the teacher (Rom et al., 2017). While reputation may motivate community influencers to vouch for quality products and services – not wanting to tarnish their reputation – their existing reputation may also influence their efficacy as a point of contact within the community.

A community influencer relies on connections to larger community institutions or organizations, such as political leadership or education. There is no evidence that they then use that link for any strategic bargaining or rule-making regarding solar. They do not extend their reach beyond end-users and providers, nor do they bargain with providers for certain guarantees. Their role is focused on awareness-building given prior stature and often trustworthiness, but not on improving the long-term use or services for solar.

Their role in the community is durable, but their focus on solar is temporary. As I will describe later in this chapter, the SunnyMoney school campaign model lasts only a few weeks and demonstrations with a local chief may last only one afternoon. The example of a head-teacher is a stronger model of a community influencer intermediary than a chief, as a teacher engages parents and students without a company representative, they are the primary link. Comparing this type to the righthand side of Figure 5-1, head-teachers likely have stronger connections to end-users than the provider. More temporary community influencers, such as local leaders, may hand off the relationship more quickly to providers.

As an intermediary, community influencers provide a venue for introducing solar to a community and they facilitate initial information about solar. Their function as an intermediary is as a weak facilitator with the ability to distribute information but less incentive or capability to translate that information into knowledge or context-specific services for solar (see Table 4.4 for these different intermediary actions). A community influencer’s links to the service provider may be more informal and unidirectional, where the provider gives information to the influencer, but then collects little feedback or questions in return. Other intermediaries receive more training and education on solar products and services, which provide opportunities for troubleshooting, asking questions, and building their knowledge.

5.3.2 Networking Solar Agent

Networking solar agents are incentivized to conduct sales more than any other activity, this includes the requisite awareness-building activities, but they have a varying role in activities post-sale. As described in Section 5.2.3, agents know about sales more than other dimensions of customer satisfaction. In design, the link between agents and end-users is intended to shift to shops and call centers for after-sales needs, although this hand-off is weak in practice (see Section 5.2.3). Agents are influential in solar: Figures 5-4 and 5-5 illustrate they are involved across a consumer’s experience with off-grid solar. Figure 5-5 also illustrates the key connection that agents have to the company, with many respondents seeking help from an intermediary because of their company or brand affiliation.

Company reports of somewhat high turnover in agents suggests mixed durability, highly dependent on the agent’s interest or situation. With opportunities for company growth related to upgrading existing customers to larger systems and appliances, retaining agents with
existing customers connections may be of increasing in importance to providers. In regions of Kenya with multiple solar providers recruiting agents is a competitive process. Managers may try to “poach” agents, and agents move from one company to another to maximize their benefits or meet their goals (interview 190719). A networking agent is enterprising.

Solar agents are not employees of solar providers, rather they are commission-based affiliates. This structure suggests a more informal relationship to the provider than salaried employees such as regional managers or, in some cases, technicians. Agents leverage the flexibility in their role to extend the scale of their operations beyond immediate social ties. Here is the “networking” dimension of this intermediary type. While community influencers extend beyond close ties within their arena of influence, networking agents actively build their network to extend farther and into new territory. Informal agreements extend an agent’s reach with scouts who coordinate entry into chamas for sales or provide guidance on the geographic layout of a village or town. Additionally, agents build sub-agent networks of people working for the agent to sell in more remote locations. Sub-agents and scouts receive some amount of the commission and are instructed to give customers the contact information of the agent, not their own. While an agent’s link to the end-user may be varied, and at times mediated by layers of additional connections, they are incentivized to maintain a strong link to the provider to receive payments and attend required meetings or training sessions.

With connections to both providers and end-users, solar agents exhibit a stronger facilitation role than influencers. Training and incentives, including customer follow-up from the call center to measure an agent’s honesty about solar the terms and function of products. The role of effectively translating these terms and uses to the end-user is not always prioritized on par with the financial incentives. Accounts of agents influencing the call center follow-up by answering for the customer or telling the customer what to say suggest sales matter more than ensuring consumer education. Agents also play a broker role, with more active representation of end-users to providers. For example, when a customer experienced a faulty mobile phone from a solar provider, the agent actively took the customer to the office in town for repairs – covering the cost of transport, explaining the problem to the company, and negotiating the repair (field visit 190719).

5.3.3 Embedded Entrepreneur

The embedded entrepreneur is characterized by a concerted effort from an NGO or social enterprise to develop local entrepreneurs. Embedded entrepreneurs are encouraged to use their existing social networks to sell solar products, but maintain connections to the NGO or social enterprise that provides the solar products, training sessions, and incentives for sales. More than the other typologies, the embedded entrepreneur may draw on both reputational and financial incentives, but are categorized under “financial” in Figure 5-6 because they are involved as an entrepreneur, first and foremost, to sell solar. In this respect, they share the emphasis on sales with the networking solar agent. But unlike agents, they have more responsibility to consumers as they are operating as an independent entrepreneur.

The flagship case of the embedded entrepreneur, described in more detail in the narrative section (Section 5.4.3), is the model of Solar Sister. Solar Sister encourages women to
become solar entrepreneurs, while maintaining some connection to the organization through managers who aid with logistics and transactions. “Solar Sister Entrepreneurs” are required to invest their own funds in the enterprise by purchasing a start-up kit, which encourages the entrepreneur to have a stronger stake in the customer experience. The durability of the embedded entrepreneur may be greater than other intermediaries if they are able to make enough money to justify the time and financial investment, or they may sell solar in tandem with other work.

Entrepreneurs maintain links to the NGOs that help build their skills and link them to providers, but the training provided to entrepreneurs may provide more incentives to remain active salespeople than to provide consumer education or after-sales services. Training focuses most on entrepreneurship, sales skills, finances, and business – important to the potential success of the solar entrepreneur – but not providing a strong foundation for facilitating new consumer knowledge about solar. After initial training, it is unclear if NGOs continue to provide resources and training opportunities as new questions arise or new products are released. Entrepreneurs act as brokers by actively bridging the gap from provider to their “trust-network” to enhance access to solar products. They are frontline representation and given their financial investment, have an incentive to convey back concerns from customers that may influence the viability of their business.

Solar Sister is not the only organization encouraging independent, but locally embedded solar entrepreneurs. Other NGOs provide similar opportunities, including: identification and recruitment of last-mile female entrepreneurs, technical training, business training, and empowerment. Even with multiple training sessions, the emphasis for embedded entrepreneurs is on awareness and sales, as entrepreneurs are provided with,

“...awareness about the technology, the existence of this technology and what it can be able to do, it’s also about equipping the entrepreneurs with skills on, for example, how to overcome resistance” (interview 190610).

Often the models supporting embedded entrepreneurs, do not prefer one technology provider but rather they utilize multiple manufacturers. In rural Kenya, after an NGO trains embedded entrepreneurs, the NGO connects them to multiple distributors active in that region, allowing them to choose who to work with upon completing the training.

5.3.4 Group Leader

Like embedded entrepreneurs, group leaders are an intermediary utilized by NGOs and social enterprises alike. They represent an approach that organizes within communities to gather

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9While there is a strong focus within NGOs on female entrepreneurs, even Solar Sister has male entrepreneurs. My survey data does not support an overwhelming preference for female sales or repair people for solar, thus that dimension is not necessary for an embedded entrepreneur. In response to the statement “I prefer that the gender of the person who helps me with solar is” 67% said they have no preference, 30% said they prefer a male, and only 3% said they prefer a female. For NGOs supporting last-mile solar efforts, female entrepreneurs meet multiple goals, aside from just electricity access, including gender equality and empowerment.
people together to interact with a company or NGO representative. Generally, the financial incentives group leaders receive are minimal, thus their reputation and the value of the service to their peers is much more influential in their decision to continue providing community entry and coordination for a provider. While they have similarities to agents in their role to recruit and maintain sales, the priority is placed on embedded relationships rather than maximizing sales. They are not encouraged to network. The incentives behind each of these typologies illustrates important differences in their role in off-grid solar. As one company representative described,

“If you look at like demographics, who they are and what they do, [for agents] their job description is usually just sales only, mainly around the pay-as-you-go technology. An agent is a salesperson, they may be quite aggressive in their sales pitch, they tend to be very mobile because they need to: once they’ve sold to friends and family, they really need to go out there. Therefore, they tend to be male and usually with access to a motorbike. Otherwise, how’d you do it? Then they always know where the markets are and then they go pretty much hocking around. So, it would be a bit of a looser relationship with the eventual customer, because group leaders, they will be within that community and are strongly, strongly encouraged to only sell within their social circle” (interview 190812).

While it is advantageous if solar agents are embedded within the communities like the embedded entrepreneurs or group leaders as this helps ensure they are familiar with the area and the people, they leverage their networking to extend sales. This behavior makes a trade-off between “strongly, strongly” relying on social relationships and increased sales. Compared to group leaders, an agent may not always be the one building the in-person relationships or may not know the community well before attempting to make solar sales.

Group leaders are volunteer positions, motivated by small cash payments, branded gifts, and the reputational benefits associated with bringing quality products into the community. This enables a feeling of being a “big person” within the community (field visit 190125). Branded promotional gifts from providers – both NGOs and social enterprises – function as status symbols that are associated with tiers of sales or accomplishments. For group leaders, the interpersonal connections are key.

In the model of a large NGO, One Acre Fund, groups operate under a group liability model where they hold each other accountable for repayment and if one fails to repay, all are unable to receive financing the following year. In other models, the group provides reminders and more social pressure to repay, but they are not subject to group-wide penalties. All can take future loans for solar products (or additional products such as clean cookstoves). Across groups the face-to-face interactions build solidarity and members help one another with activities and payments. The durability of group leaders as a frontline solar intermediary varies. For groups associated with One Acre Fund, solar is an addition to agricultural products that are needed annually. This group may exist for years. Whereas group leaders engaged in single products, such as solar or other durable goods, a group leader may only
last as long as she has additional connections within her social network to form groups.\footnote{A group leader does not have to be actively purchasing the product with the other group members, she may already own the product and is promoting it within her social network.}

The field officer or group coordinator, a provider employee, provides a key and often strong link to the group leader and the whole group by participating in meetings to gather feedback and provide information. While agents and entrepreneurs also include some form of training, for the group leader model, the whole group engages in educational activities with the field officer or the group coordinator which may mitigate issues with the group leader’s ability to facilitate knowledge-building. Comparing the link between the group leader and end-user to the embedded entrepreneur and end-user, accountability in the group model is tied to the entire group (either in a liability model, or reliant on social norms) whereas the entrepreneur relies on individual relationships within their social network, but does not have the leverage of a larger group.

5.3.5 Examining Types of Frontline Solar Intermediaries Across Dimensions

Intermediaries vary across dimensions of form, function, and motivation or incentive structure. Rooted in academic scholarship, these dimensions form the analytical frame presented in Table 4.6, which aims to better differentiate among active intermediaries. In Table 5.2 the four typologies are mapped to these dimensions to illustrate similarities and differences. Other scholars such as Gould and Fernandez (1989) and Kirkels and Duysters (2010) depict differences in intermediaries based primarily on their group affiliations, but Table 5.2 illustrates that there is much more to what makes an intermediary effective than only group affiliation. The typologies presented here show that an intermediary can have multiple affiliations and these affiliations may vary in strength. This is also recognized in the variation in social connections illustrated in Figure 5-6. For example, a group leader may have the strongest affiliation to their group exemplified by the reliance on reputational incentives, but group leaders also hold an affiliation – from the perspective of the community – with the provider as they are recognized to have a stronger connection to the field officer or group coordinator.

The patterns in Table 5.2 suggest that intermediary formality and their motivation for acting as an intermediary may be related. More informal actors, community influencers and group leaders, also rely more heavily on reputational incentives. As illustrated in Figure 5-6, more informal intermediaries can still have varying strengths of social connections, with some more personal and some extended.

The actions of frontline solar intermediaries include facilitating resources or information and brokering access to resources or additional services. Configuring, where ideas, information, or resources are leveraged across different contexts, is not common in frontline solar intermediaries.\footnote{Such actions may be more common in other areas of electronics, such as e-waste collection and recycling. Tours of e-waste markets in Nairobi, suggest that the informal sector is actively taking e-waste to recycling facilities.} With respect to facilitation, all four types of intermediaries actively provide this link or conduit between the community and the provider. Those with stronger provider
Table 5.2: Dimensions of Frontline Solar Intermediaries

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Influencer</th>
<th>Agent</th>
<th>Entrepreneur</th>
<th>Group leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formality</td>
<td>informal</td>
<td>mixed</td>
<td>towards formal</td>
<td>informal</td>
</tr>
<tr>
<td>Scale</td>
<td>individual to arena of influence</td>
<td>individual with extended network</td>
<td>individual with close network</td>
<td>individual to group</td>
</tr>
<tr>
<td>Durability</td>
<td>temporary</td>
<td>mixed</td>
<td>lasting</td>
<td>mixed</td>
</tr>
<tr>
<td>Facilitate</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Configure</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Broker</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Financial</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reputational</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Connections – and the resources and incentives for good repayment – also exhibit acts of brokering. Facilitation and brokering differ, as indicated in Table 4.4, in their focus on providing relevant information (facilitation) but hand-off service to providers, versus actively participating in services by extending services from the provider to the user (brokering). Arguably, brokering may be more influential in the actions of sales and encouraging solar adoption, while facilitation is key for consumer education. Facilitation is more concerned with information and education, while brokering exhibits characteristics of intermediaries acting on behalf of customers to the provider or negotiation for access to services or products.

Each of these intermediaries can be seen across multiple off-grid solar distribution models in Kenya and in other country contexts. While the descriptions of each intermediary type, Figure 5-6, and Table 5.2 simplify across dimensions to provide comparisons, each frontline solar intermediary has some amount of complexity in their actions. This complexity provides contexts and insights into the behaviors of these different intermediaries. The following narratives of solar distribution models illustrates how each of these frontline intermediaries function to provide off-grid solar services.

5.4 Narratives of Intermediaries in Distribution of Off-Grid Solar

The following narratives illustrate how the four typologies of community influencer, networking solar agent, embedded entrepreneur, and group leader are applied in specific cases or operationalized on the ground. The purpose of this section is to apply these typologies more in-depth than the general descriptions already provided. The examples mentioned previously will be expanded upon here. The narratives described draw on some of the more widely referenced distribution models and, when possible, provider insights about how dis-
tribution works in practice. With this set of narratives, I describe some of the variation not only in the design of solar services, but in the implementation of these models. Each narrative describes a set of interactions between intermediaries, providers, and when possible, consumers.

Tracing across SunnyMoney’s engagement with schools, the widely used solar agent model, Solar Sister’s effort to build women-to-women sales networks, and the group model central to Once Acre Fund, I illustrate how engaging effective frontline intermediaries can help and hinder solar services. Not all models have the same goals, and it is important to consider not only the motivations of intermediaries, as previously discussed, but why providers pursue different strategies. For example, SunnyMoney’s function as the social enterprise of the NGO SolarAid instills within their operations an emphasis on market building and seeking outcomes other than profit. Compared to M-Kopa, which self-identifies as a finance company that uses solar to build credit for future loans (see Section 2.2.3), SunnyMoney and M-Kopa have differing internal motivations which influence how and why they engage particular intermediaries.

While focusing mostly on Kenya, two examples discussed in this section focus on models used in multiple other countries and therefore represent a common and illustrative service model. In fact, one model – SunnyMoney’s “light libraries” is linked to a school-based model originally deployed in Kenya. I include these examples to provide additional context and to illustrate the variation in frontline intermediaries in off-grid solar. Each of these narratives resonates with examples present in off-grid solar in Kenya and can be mapped to the responses in Figures 5-4 and 5-5. The strategies used to distribute solar and build connections using local intermediaries, include: solar agents and the multiple strategies that underlie this approach, the use of existing influential community members, gender-focused entrepreneurship, NGO field officers that bundle solar with other financed goods, and lean social enterprises that build on group-based models. The different ways solar services are extended to rural communities through intermediaries are exemplified in the following discussions.

5.4.1 Solar Sales Agents Used by Companies

*Networking solar agents* are one of the most common frontline intermediary types in off-grid solar in rural Kenya. They are present at market days, sell door-to-door, and leverage existing social networks and savings groups. From a provider’s perspective, the agent model is designed to achieve sales, and this focus is represented in the training and incentives provided by solar providers. As illustrated in Figure 5-4 solar agents are a common mode of learning about solar, but they are also a resource used for help after sales, as indicated in Figure 5-5 (indicated by “company agent”). Responses in Figure 5-5 suggest a strong reliance on agents for help, even though companies strive to direct such inquiries to company-run shops and call centers.¹² The after-sales responsibility for agents is unclear, with agents

¹²USAID (2017, 14) asked “how did you first hear about solar home systems?” and has far more respondents indicate neighbor or friend, rather than agent, although agent was second.
reporting they “did not feel it was their responsibility to chase up bad customers” (Barrie and Cruickshank, 2017, 434). Agents are perhaps the most dynamic frontline solar intermediary, as they respond strongly to the incentives provided by off-grid solar companies. Almost all off-grid solar companies use some version of a mobile, commission-based solar agent.

The strength of a solar agent model is their ability to access to more remote areas or areas targeted for business development. Agents tend to be effective for awareness and sales that rely heavily on word-of-mouth and door-to-door sales (Kenya Climate Innovation Center, 2017). The distribution of agents in a provider’s network aims to leverage social connections because an agent,

“...will normally come from that area, that ward. It makes it easier because our business model, the basic sales model that we use is door-to-door sales. So, it makes it easier if these guys already are familiar with the area, they know the people, it’s easier to recruit them, to explain to them, they understand the behavior” (interview 190619).

Solar agents represent the face of solar providers to customers on-the-ground and often remain a point of contact for consumers after purchase. The off-grid solar sector is “still trying to build and maintain the nimble agent networks that are the backbone of their growth strategy” (Chang, 2017). I will describe in the distribution model using community influencers, agents are often used in tandem with other intermediaries, with agents viewed as a strategy for growing sales or extending reach.

Solar agents for PAYGo solar companies are commission-based, with somewhat evolving payment models that aim for high repayment rates – meaning good quality customers – and growing a company’s customer base – large sales numbers. On-the-ground managers suggest that given the high turnover rate of agents, recruiting and retaining agents can be difficult, with some managers sharing that they “poach” sales people from other companies if they have a track-record of sales in solar, cellphones, or another similar product. While they aim for such agents to have a prior status as a “good” agent with a strong history of customer relations, some providers will still recruit those even with a poor performance history and retrain them (interview 190719). Often providers value an agent’s ability to reliably sell – to have a certain amount of business or salesperson acumen – and to be honest with customers (interview 190619). The incentives underlying agent models and their requisite behavior are critical dimensions to effectively translating the principles of self-regulation developed by the off-grid sector to solar end-users. In short, given the widespread use of agents by off-grid solar providers and consumer reliance on agents, they are a key link for enacting consumer protections.

The emphasis on sales is structured into the payment and incentive models provided to the agents. The commission agents receive drives them to sell. PAYGo providers have modified the commission structure to not only reflect initial sales but also product repayment. Like most dimensions of agent models, there are similarities and differences in how the commission payments are structured by each company. Given the possibility of defaulting customers,

13 As of 2018, M-Kopa Solar had 1,500 agents operating in five countries (M-Kopa Solar, 2018).
agents may be measured both on the number of sales they make and the quality of those sales. For example, one company provides a bonus for agents when a customer has made payments consecutively for 6 months as this is a good indicator that the customer will complete payments (interview 190619). Other models provide commission for each sale, and an end-of-month retainer payment when an agent achieves a certain number of sales, or number of certain products. But if a product is returned the commission is deducted from the agent’s next sale (interview 190719). The sales-based commissions, bonuses, and rewards for achieving certain sales or repayment goals drive the actions of most solar agents.

Agents are also provided incentives to refer additional agents. If the agent that another agent refers to a company is able to sell a certain number of units in one month, the original agent also receives a bonus of 5,000 KES (interview 190719). The incentives for agents to make referrals and build out the network of agents illustrates both the competitive nature of the Kenyan market – a need to get as many agents on-the-ground as possible – and that this model emphasizes growth in sales.

While non-monetary incentives, such as reputation, may play a role in the agent experience, it appears less utilized as a tool than financial incentives. Company staff recognize that “a salesperson won’t really give all the details” (interview 190619) and, therefore, the company utilizes the call center to develop a score for each agent based on how well the customers they bring in can answer questions about product information and terms. This score indicates “that they are telling the customer the truth. In the sense that they want to make more sales, they also are giving all the important communication to the customer” (interview 190619). The agents with the best scores are highlighted in biannual agent meetings and given opportunities to educate other agents. With many solar providers operating in Kenya, the ability for an agent to effectively communicate differences in a provider’s model can help differentiate one company from another in the market based on unique features or services (interview 190619). Not all providers track and report customer education scores: effectiveness of agent communication may not always be measured, or at least, is not given as much weight as the metrics focused on sales (interview 190607). The sales-focused structure of incentives for agents influences how they act and engage with customers.

Incentive programs such referrals and commissions suggest that while solar agents are beneficial to the provider for sales, building and retaining agent networks is difficult. The challenge is associated with many solar companies recruiting agents to distribute exclusively their products, all competing in the same geographic regions. Based on agents in financial services, using agent networks to distribute proprietary products – which is the dominant model in off-grid solar – results in the duplication of agent networks that are essentially all doing the same work, in the same areas, but limited by which products they can individually sell (McCaffrey and Linares Villuendas, 2018, 4). The counterargument is that while proprietary distribution networks may be more costly, they enhance consumer relationships, data collection, and customer loyalty (Dalberg Advisors et al., 2018, 103). The agent model, while by far the most common in off-grid solar, continues to be a work in-progress.

Given their prevalence, for both early and later stages of solar use, agents play an important role in education and closing the loop for quality assurance and consumer protection.
Agents, like other frontline solar intermediaries, help build trust (Zollmann et al., 2017) and ensure transparency (interview 190719). The need for customers to be provided with accurate information, in particular regarding payment terms, by agents and that agents take the time to ensure comprehension (and that call centers follow-up to ensure this occurred) is a component of GOGLA’s consumer protection code (Global Off-Grid Lighting Association, 2019a). As a common go-to for sales and help, an agent’s discretion regarding protections influences how effectively the sector’s growing regime of self-regulation is implemented.

The accuracy and transparency of information throughout a consumer’s experience with solar, but especially in sales, can help companies distinguish themselves from other solar providers. For example, BBOXX has a different warranty model than most other companies and this is a part of the way they differentiate themselves as a company. Accurately making this point about different in warranty models relies on the solar agents. Or, M-Kopa operates with three primary company values: *maendeleo* (progress), *umiliki* (ownership), and *uwazi* (clarity or transparency) (M-Kopa Solar, 2020). Training solar agents aims to ensure they uphold these company values in their interactions with customers. In other models, if a customer does not sufficiently understand the terms, the sale will be rejected and the process will start over to ensure customer awareness of the terms and product information (interview 190607). The agent’s interest in providing accurate and transparent information is related to the underlying incentives — a mix of their ability to make as many sales as possible and their loyalty to the company.

At this point, it is clear that agents are motivated by renumeration for sales. But other dimensions also influence their relationship to providers and their customers, including reputation that will promote future sales and opportunities. The next two sections (5.4.1 and 5.4.1) describe what activities are prioritized from the perspective of providers and from an agent. From the providers, training offers a way to educate agents on the information they are to share with customers, this can involve both in-person training sessions, shadowing other agents, and ongoing mobile-based training modules. But ultimately, the information flow is much more unidirectional (from the company to the agent) than bidirectional. This misses the chance to gain feedback and encourage a sense of importance to the company. This gap is directly tied to the loyalty some agents may have to the customer, rather than a company. As members of the community, agents may face similar constraints regarding solar use and affordability, and they may experience similar frustrations about certain terms, such as remote lock-out, in solar contracts.

**From the Provider: Training & Communication with Agents**

One of the areas companies have already improved on – and are continuing to build – is agent training and education. From the provider’s perspective, it is difficult to manage a network of agents with high turnover rates. Embedded within the proposed model in Figure 5-1 and the argument that agents help convey the private sector-led safeguard regime to consumers, is an assumption that agents know the information they are to convey. The curricula of company training programs suggest what of this information is prioritized for agents. While educating consumers via agents may be important, companies have to contend
with the issue that agents may not last that long.\textsuperscript{14} Training agents that may not last a long period of time is expensive. Broadly, companies want to make sure customers understand: how long will a system provide light given the number of lights and appliances (runtime), and variation with multiple settings; plugging and unplugging the battery; battery storage to ensure safety; and what lights indicate the unit is charging (interview 190619). The focus of agent training tends to be on product specifications, installation practices, and PAYGo payment terms. Depending on the size of the provider, some offer mobile phone modules that can be completed remotely by agents to augment any in-person training and provide scalable opportunities for ongoing agent training (interview 190607).\textsuperscript{15} What agents should or must know prioritizes short-term gains: sales, technical information, and repayment.

In addition to financial incentives, such as commissions and bonuses, the training sessions help companies ensure that agents provide transparency and enhance trust in the company and solar systems. The shop or regional manager plays an important role in training and establishing local expectations for agents. For example, one shared that “when recruiting, you don’t get a good person, it is your responsibility to make that person to be a good salesperson” (interview 190719). The process of training agents, includes both in-person sessions (e.g., a 5-hour training session) and field visits to “show how it is supposed to be done” (interview 190719). Providing opportunities to shadow existing agents also shows the realities of the job, potentially reducing churn as agents know what they are getting into. Industry reports provide some indication that better trained salespeople are more productive (Hystra, 2013). In addition to training sessions that follow a company curriculum, new agents are frequently paired with a more experienced agent for a period of shadowing and on-the-ground learning.

Strategies are used within sales regions to coordinate information, encourage learning, and troubleshoot challenges. Weekly or monthly meetings at the local shop or with the regional manager provide opportunities for ongoing training, to answer questions, and to troubleshoot problems (interview 190607, interview 190719). Less frequently, such as three-month increments, some companies hold larger meetings that may include all agents that have achieved certain sales numbers in the region (interview 190719). Some also leverage mobile chats, like WhatsApp groups, for on-the-spot questions regarding specific problems and issues that need timely responses (interview 190607). Across group meetings, peer-to-peer shadowing and mentorship, and options like WhatsApp, providers are striving to offer different levels of information and guidance to ensure agents have sufficient, and up-to-date, knowledge.

The communication channels providers use to communicate with their agents, provide feedback, and engage them in further training can potentially offer a bidirectional flow of information. This would enable companies to learn more about what is working and what needs improvement. This bidirectional information flow seems relatively weak, paralleling experience in the mobile money sector. Wellen and van Dijk (2018, 266) note that,

\begin{quote}
“One would expect Safaricom to use agents for client feedback. However,
\end{quote}

\textsuperscript{14}Churn for solar sales agents may be 40-80% (Hystra, 2013).
\textsuperscript{15}See Chapter 3 for discussion of standardized information on packaging and understanding of key terms such as runtime.
during the discussions it became clear that the agent–Safaricom meetings mainly regard how turnover can be increased, solving practical issues, and avoiding fraud, not on how customers consider the service....agents were unsure if such opinions [about satisfaction with Safaricom] were known by Safaricom as that company does not focus on agents to understand customers.”

The regular meetings with regional managers and supervisors are not only sessions for additional training and troubleshooting, but also an opportunity to describe challenges. Providers do not seem to effectively use these more informal opportunities to get feedback on the agent and consumer experience. Like companies rely on the call center to verify information told to the customer, they also rely on the data logged by the operators in the call center to provide feedback, rather than the agents. Varying by company, some deploy targeted research projects that gather feedback or test new service options (interview 190619). The training provided by companies to agents suggests that the flow of information between the provider and agent is somewhat unidirectional, failing to incorporate the experiences of agents into business improvements or enhanced agent training curricula to improve consumer knowledge.

From an Agent: Loyalty to the Customer

Reflecting the challenges at the provider-level – how much to invest in the training and relationship with potentially short-term agents – this section recounts the story of one solar agent in Kakamega. Her loyalty is to her customers in pursuit of maintaining current and future sales. While sales are her primary motivation, her role as an agent is multifaceted. Narratives from industry reports, those already shared in Chapter 1 and Section 2.2.4, often emphasize agent failures, of which there are many stories. Sharon’s account highlights that agent dissatisfaction with the agent or off-grid solar sales model is not as important to her as the opportunity to earn commission from sales. While she suggests frustration with the inflexible nature of an agent’s contract, her focus is on sales made today and tomorrow.

Sharon is an agent in Kakamega and has worked for at least three solar companies as a solar agent since 2015.16 While she has only worked for one company at a time, her stories suggest her loyalty is, first, to her ability to progress from an agent to other positions in the local office, and second, to her customers.

After a short tuk-tuk ride toward the edge of town, Sharon walked us around a small shopping area with many of her customers. While she did not have prior relationships with these customers, the market area is a convenient stop on her way to and from the solar shop in town, which provides multiple opportunities to follow-up with any customer concerns. While some of the buildings nearby had access to electricity from the grid, the shops that line the edge of the street selling fruit, vegetables, fish, beans, and other goods are informal structures without grid connections. Figure 5-7a and 5-7b illustrate the use of some of these solar products and the varying needs within the marketplace, with a multifunction lantern in Figure 5-7a providing light, charging, and radio, while Figure 5-7b is a system with a larger

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16 Agent’s name has been changed.
light (the complete system not pictured, would have multiple overhead lights) and phone charging.

As Sharon has shifted from one company to another, she maintains her relationship to these vendors. When she switched to sell solar products from a different company, so too they shifted their new solar purchases to this company. One customer had a lantern from the previous company, and a new smartphone from the current one. Sharon said that if they were to have a problem – even with a system she sold from the previous company – she would help them get it fixed. She said, “I will not get paid [for this] but I help because I want to maintain a relationship with them, even if I do not get paid. And I even visit them because I know one day, they will direct customers to me and the money will come back.”

There are limitations to this too, not all solar companies last, she shared working with companies that folded, rebranded to disassociate from previous issues, or left the region. In those cases, there was little she could do to help customers get repairs from the company.

**Figure 5-7:** Examples of solar used by small shops in Kakamega, Kenya

![Image of fruit vendor with Sun King BOOM, which provides both lighting, phone charging, and radio.](image1)

![Image of shop (butcher) with a solar home system, which provides overhead lights and charging.](image2)

Sharon has a solar training certificate; her solar knowledge exceeds the company-provided training. She completed the T2 training at Strathmore University in Nairobi and returned back to Kakamega and started working for a solar company as an agent. While she noted that not all shops even know what the training and Energy and Petroleum and Regulatory
Authority (EPRA) licenses mean, she is eager to progress with more training (T3 level) because eventually she would like to have her own shop, not work as a company agent. Depending on their product portfolio and the complexity of the “plug-and-play” systems some companies rely on the customers or agents for installation, and others have designated technicians for installation. The system pictured in Figure 5-7b can be installed without a technician. Currently, the company Sharon works for does not have technicians, so despite her training she remains a solar agent.

Sharon reflected frustration with some of the repayment terms provided to customers, frustrated not with nonpayment behavior, but with company terms that seem unfair. She told the story of a company operating in the area – although not the one she works for – that cuts off service after just one day of nonpayment or that if a product is returned or repossessed, the deposit is not always returned to the customer. As a commission-based agent, not formal employee, Sharon shared the challenge of having her agent account closed after a period of poor sales due to unforeseen challenges, such as sickness. When an agent’s account is closed, she said they may move companies or just abandon the endeavor. She takes issue with repairs sent off to Nairobi, rather than repaired locally because people continue to pay while a product is away for repair yet they are not receiving any of the benefits. Sharon described that the link between agents sharing such experiences, and companies acting on their information, is weak.

Sales drive Sharon’s activities, although she acts not only for today’s sales but long-term relationships. Here, Sharon may differ from some other agents, such as the examples described earlier of deceit or poor customer service. She describes a situation of some fluidity and talk between agents at different companies. So, if someone asks about solar from a specific company, but she is not the agent for that company, she will try to show them similar products but will also call her friend who does sell those products and make the connection. Building local relationships not just for customers, but for referrals and awareness-building is important to her agent operations. Thus far, this account of solar agents helps describe the strength of the relationship between an agent and the two parties they sit between, providers and consumers. From an agent’s perspective, their loyalty is stronger to the customer but they stay connected to the company for commissions.

Network-building with Sub-Agents & Informal Scouts

The other dimension of the agent typology is networking. Sharon exemplifies this through her connections to other agents and relationships across companies. Often network-building for agents is an intentional business effort. For many agents, coordinating large numbers of sales, requires more than one person. Solar agents build out informal networks of sub-agents who sell products on their behalf and they receive a portion of the commission. Such sub-agents do not have a direct relationship to the provider and receive no direct company training, rather they are connected to the agent. If a sub-agent is particularly effective at sales, the agent may recommend them to the company to be an agent on their own. This referral is beneficial to the sub-agent to earn more commissions and the agent who may receive a referral bonus. Some agents manage as many as 30 sub-agents who sell on
their behalf, but direct customers to the agent for any after-sales needs (interview 190719.t). Networks of informal relationships enhance the sales process by assisting in the identification and coordination of new sales, or reaching areas farther afield.

Agents use “scouts” to help identify and establish first connections with customers. These scouts extend an agent’s network by telling their friends and neighbors about the solar provider, and then the scouts organize a group meeting so the agent can engage with multiple potential customers at once. To incentivize or reward help scouts receive around 500 KES for making these referrals. Based the areas surrounding Kisumu, near Lake Victoria in Kenya, even in the areas within a short distance from urban or town solar shops, basic challenges, such as finding the correct houses, are addressed with guidance from these on-the-ground scouts (field visit 190124). Aside from small payments, these informal, local connections may receive branded items like t-shirts or calendars.

The reliance on informal connections suggests a layering of intermediaries in the off-grid solar agent model, with both on-the-ground company representatives and more informal entry points into communities, such as sub-agents and scouts. This use of connections for entry into communities will also be illustrated in other models, such as SunnyMoney which uses both teachers and agents.

Solar agents are the most common frontline solar intermediary. While there are the formal arrangements between providers and agents, agents extend their reach with informal scouts and sub-agents to build a wider network. Agents illustrate the impact of a sales-driven approach to off-grid solar, but also provide a sense of opportunity as they have a strong on-the-ground presence, are responsive to the incentives provided by off-grid solar companies, and have the potential to form strong links with consumers.

5.4.2 SunnyMoney and Engaging with Schools

Existing community resources, institutions, and organizations are used by solar providers to build credibility and to reach target populations. SunnyMoney’s “light libraries” and “school campaigns” highlight the instrumental role of building awareness through influential members of the community. This case utilizes schools as an entry for solar products, not only to promote solar, but to specifically promote solar to help children study and succeed in school.\(^\text{17}\) As described in the community influencer description, head-teachers illustrate a case of this type of intermediary.

SunnyMoney, as a social enterprise spin-out of the NGO SolarAid, marries lighting access with other development goals, such as education. The bridging, or blurring, of solar companies and non-profit organizations can influence the priorities of solar companies and how they incorporate intermediaries into their model (see MacLean and Brass (2015)). SunnyMoney brings solar to markets that might not be served by traditional companies not by bringing a solution to communities, but by offering a choice of solar (interview 190404). SunnyMoney started about 10 years ago (SolarAid was started in 2006) in Kenya and Tanzania to catalyze

\(^{17}\)63% of SunnyMoney lanterns are at least partially used for studying (Harrison et al., 2016, 15).
the market for solar, which at that time was a relatively small market. The link between SolarAid and SunnyMoney allows them to,

“...do things that conventional businesses can’t. We take the time to travel to remote rural communities, educate people about the benefits of solar, instill trust and build demand. All of which costs time and money. We help get lights to the people that need them most – and if they are unable to afford them – then we think of new and innovative ways to help them get on the energy ladder” (SolarAid, 2019a).

Since their early work in Kenya, SunnyMoney has exited the market as the private sector is now independently active in Kenya. Companies report that the market is Kenya is competitive, and rather than strategically identifying comparative advantages and working together “it’s still the rat race, [with the prevailing model that] I just need to produce and sell more, quicker than you” (interview 190725). Organizations like SolarAid and SunnyMoney are trying to figure out how to reach those who may benefit the most from basic lighting from solar.

SunnyMoney and SolarAid – like other NGOs such as One Acre Fund – use pilots to test out new models, changes to existing models, or ways to make their approaches more effective. In 2013, SunnyMoney conducted a pilot of a solar light library in Senegal, a model that is now being explored in Zambia and Malawi. With funding from Lighting Africa and the World Bank, this project was in partnership with the government and leveraged existing schools. After establishing the school program, ongoing management (including sales and after-sales) was transferred to the school and community members. More than other programs, this effort was aimed at affordability of solar lanterns by allowing the smallest lanterns to be borrowed at less than $0.01. At each school in the pilot, the head-teacher was required to commit to the program with the lanterns for use only by students as property of the school. This program aimed to reduce perceptions of financing risk and reach populations less likely to afford solar via other channels. In design, the program aimed to address key barriers to off-grid solar, including: of lack of awareness, lack of trust, and affordability (Sunny Money, 2014). With access through the school, as well as a replacement program for faulty lanterns, this pilot aimed to overcome not only initial but ongoing barriers.

Community members and existing organizations are used by SunnyMoney in their regular distribution model as well, still centered on schools. But the typical SunnyMoney model focuses on sales of lanterns than on rentals. Using pre-existing channels such as schools help build buy-in for off-grid solar, with sales numbers suggesting substantial effectiveness. Unlike other providers such as M-Kopa, BBOXX, or Mobisol, SunnyMoney focuses on small (or pico) solar lanterns to jumpstart the market for solar and provide basic access to lighting. Using schools is the first stage of SunnyMoney’s model and their experiment with the light libraries program resulted in enhanced awareness and familiarity with the technology to build local trust in solar (Sunny Money, 2013). After the introduction of the library, SunnyMoney introduced their more common channel “school campaigns” that they have used in Tanzania.

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18This parallels the start of other efforts to build the Kenyan market, such as Lighting Africa in 2007.
Kenya, Zambia, and Malawi (Sunny Money, 2014). In Kenya, SunnyMoney sold over 234,600 solar lanterns from 2011-2013 in five counties in Western Kenya using the school campaign model (SolarAid, 2014). The Light Library program enhanced adoption even more: there was a 35% uptake of lanterns during the campaign in schools with a library, compared to 15% uptake in schools without a library. SunnyMoney’s effort to work through schools illustrates demonstrable results to build awareness and make solar sales.

For both the libraries and school campaigns, the teachers are a key local intermediary, an example of the community influencer frontline solar intermediary. These teachers agreed to manage the library and were a main avenue for discussing experiences with solar and the benefits of solar. Each school was given a set of solar lights for the teachers to use (free of charge) to ground their explanations to students and parents in prior experience with solar. The head-teacher acts as the main conduit of information from SunnyMoney to the school community on the benefits of how solar and lanterns work (facilitation). In this model, it is the responsibility of the head-teacher to set up meetings with students, parents, and the broader community to build awareness and interest in solar lanterns (Sunny Money, 2014). The influence of these intermediaries extends beyond a teacher’s immediate social ties to the students and their families.

Head-teachers in the school campaign model are a respected and local community member, which helps overcome the biggest barrier in developing solar markets: trust (Moore, 2015). Teachers are on-the-ground contacts or “local influencers,” who help manage the customer relationship (USAID, 2017, 21). At the outset of a school campaign, which is designed to last 3-4 weeks, SunnyMoney holds meetings with groups of school-heads to introduce them to the program, including the benefits, process, schedule, and incentives. Teachers receive a financial incentive to work with SunnyMoney based on a small number of hours per week (SolarAid, 2019b). The design of SunnyMoney’s model explicitly includes teachers as a temporary intermediary, with the hopes that future engagement will transfer to SunnyMoney agents or shops. After using the school campaign to build awareness and trust, agents help reach additional consumers and sell system larger than lanterns. Adding solar agents in combination with other forms of distribution can significantly increase adoption of PAYGo solar (Barrie and Cruickshank, 2017). From internal research, SunnyMoney found that even some of the agents are motivated to sell solar for altruistic or reputational benefits, in addition to financial benefits (Moore, 2015). If solar sales are their primary job, solar agents may rely far more on the financial incentives as it is their income, while for teachers their role in school campaigns supplements their existing income. So, reputational incentives – a teacher’s status and standing within the community – are equally, if not more, influential for community influencers.

Reported challenges with damage and repairs suggest that this model is most successful in building trust and awareness, but has less structured accountability for repairs. The library program reported that within 9 months, 5% of solar lanterns were reported broken and that this varied by manufacturer and lantern type (Sunny Money, 2014). The library model retained a stock of lanterns held by the government as replacements for the pilot program, but a long-term strategy to account for after-sales services to these rural and remote schools
was left incomplete (Sunny Money, 2014). Cross and Murray (2018) examine one case of a SunnyMoney customer who just kept his broken lantern at home awaiting more information from the headteacher or agent. In response to the question “what do you do with a battery when it stops working,” 26% of respondents in Trans-Nzoia said they keep it at home. The tendency to retain failed solar products is not unique to the SunnyMoney model, even staff working in solar shops reported keeping broken solar products at home (field visit 190716).

The SunnyMoney model and the incentives provided to teachers align best to build early interest and adoption of solar products. The temporary nature of community influencers as frontline solar intermediaries in school campaigns suggests they are only intended to address these early stages of awareness and sales. While this model shows the strength of community influencers in the early stages of solar distribution, it also shows a layering of intermediaries over time. In the current SunnyMoney model, the customer relationship shifts from teachers to agents or shop managers.\textsuperscript{19}

\section*{5.4.3 Women-to-Women Networks}

Aligned with the \textit{embedded entrepreneur} frontline solar intermediary, women-to-women sales models have received special recognition in off-grid solar. Evidence from the off-grid solar industry suggests that, given training, female solar agents generate more sales and revenue than male counterparts (GOGLA and Vivid Economics, 2019). Examples of women-to-women sales efforts span geographic regions, from Solar Sister operating in multiple companies to Simpa Networks in India and Bidhaa Sasa in Kenya (Power for All, 2018; ICRW, 2018).\textsuperscript{20}

While female entrepreneur models have similarities to solar agents, women-to-women sales efforts often place more emphasis on building entrepreneurial skills and sales using direct personal ties.

Solar Sister is perhaps the most widely referenced model of women-to-women sales of solar. The social enterprise started in 2010 in Uganda with 10 “Solar Sister Entrepreneurs” and now operates with over 3,000 entrepreneurs across Uganda, Tanzania, and Nigeria. Most frequently described as an “Avon-lady” model (MacLean and Brass, 2015; Heuër, 2017), Solar Sister is not a manufacturer of solar products, but rather a micro-franchise business model where “Solar Sister Entrepreneurs” sell clean energy products (lighting and cooking) to their local networks (Asher et al., 2015). The products sold by Solar Sister are manufactured by other companies, such as Barefoot Power, d.light, and Greenlight Planet (Sun King). Each

\textsuperscript{19}See Figure A-3 in Appendix

\textsuperscript{20}The model used by Simpa Networks – a solar home system company operating in Uttar Pradesh, India since 2014 – is a commission-based model using “Village-level Entrepreneurs” to make local sales. As a company Simpa Networks is interested in engaging women as entrepreneurs and as customers. The previous experience with Self-Help Groups arm women with a credit history making financing opportunities for Simpa’s products more viable. As agents or entrepreneurs, Simpa identifies women with existing relationships to the community, such as ASHA workers or women with previous sales experience. Village-level entrepreneurs receive some materials on marketing and developing awareness, but after developing a lead the customer process is transferred to the sales team (interview notes 180801). Power for All (2018) mentions that as of 2018, Simpa Networks aimed to train over 5,000 women village-level entrepreneurs and grow the number of women customers to over 36,000 (interviewee mentioned 30-40% of customer base).
entrepreneur buys solar products from Solar Sister and then sells them to friends, family, and neighbors. Solar Sister leverages the trust-building between women and the role of women in household energy production and consumption (Schiller, 2015).

Examples of embedded entrepreneurs have similarities to other intermediary types, such as the community connections of community influencers or the enterprising nature of networking solar agents. This model explicitly encourages each entrepreneur to start and operate their own small business, diverging from the agent model (Asher et al., 2015). Within accounts of Solar Sister some emphasize commission-based sales, while others suggest that Solar Sister Entrepreneurs purchase a start-up kit and then invest profit into additional purchases in a “micro-consignment” model (Heuër, 2017). The required investment from entrepreneurs has the potential to hold the local entrepreneur accountable to the experience of their network with the products sold. With personally invested resources, an entrepreneur has interest in providing products and services that meet the needs of those using these solar products.

Like agents, Solar Sister Entrepreneurs establish a network for sales, but in this case, it is based on the trust within an existing social network (Schiller, 2015). These existing social connections enhance the process of building trust in solar products and improve the collection of formal and informal feedback (Heuër, 2017). Compared to a networking solar agent who is actively extending their network, an entrepreneur of this type relies on their personal embeddedness within a community to make one-on-one sales.

At an organizational-level Solar Sister leverages its relationship with NGO partners to identify potential entrepreneurs that are well-connected and already active in their community. Such NGOs include organizations like the Mothers’ Union of Uganda which encourages women to become entrepreneurs (Heuër, 2017). Solar Sister is a social enterprise (like Sunny-Money) as a hybrid between a business and non-profit (revenue from both sales and grants) (TaroWorks, 2017). Beyond partner NGOs for recruitment, Solar Sister has regional staff called Business Development Associates who also recruit entrepreneurs through savings and credit co-operatives (SACCOs) and more informal savings groups who can help them iden-

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21 While a dominant narrative associated with the Solar Sister model is the women-to-women sales approach, Soria et al. (2016) identify that there are both male and female Solar Sister Entrepreneurs in Tanzania, although the motivation for men to participate as entrepreneurs is lower than for women.

22 Asher et al. (2015, 4-44) describes the model as “Solar Sister gives women the opportunity to own micro-businesses by providing training and startup capital—a “business in a bag” containing solar lanterns (numerous different models have been distributed) and marketing and training materials. SSEs sell the lanterns to people in their social networks, earning per-sale commissions that contribute to household income while simultaneously bringing energy and light to areas that need it.” Heuër (2017, 188) also describes this as a “business in a bag” model but describes that “buying one or two lights at first, and reinvesting that profit into buying more solar products until they can purchase in bulk.” If an entrepreneur has to purchase lanterns outright and then makes a profit on lanterns they had to buy, versus receives commission on sales from Solar Sister, the incentives may be slightly different. A commission-based model is more akin to an agent model, than owning a business. Solar Sister has started collecting more real-time data that focuses less on recruitment numbers and more on repeat sales to encourage development of businesses, measured by “level of engagement” (TaroWorks, 2017).

23 Many of the grants are tied to the number of entrepreneurs that Solar Sister has active (TaroWorks, 2017).
tify potential entrepreneurs with some existing capital (Soria et al., 2016). In this sense the extension of impact to new social circles done by scouts paired with agents is reflected in this model too. But unlike the scouts who do not interact directly with the company except through agents, entrepreneurs identified through SACCOs become a Solar Sister Entrepreneur, directly in contact with the company. The entrepreneur does the building of local ties, not a sub-connection.

The “trust network” that entrepreneurs have is one of the primary reasons people buy from Solar Sister. This is followed by more product-oriented reasons for purchasing, such as quality, warranty, convenience, and pricing (Miller Center for Social Entrepreneurship, 2017). Successful embedded entrepreneurs have entrepreneurial attributes associated with the ability to sell consistently. Such attributes include, intrinsic motivation, communications skills and ability/willingness to travel are significant predictors of a solar sister entrepreneur’s ability to consistently sell solar products (Asher et al., 2015, 4-51). Solar Sister identifies entrepreneurs with “entrepreneurship and interpersonal qualities” (Soria et al., 2016, 4) including trustworthiness, problem-solving abilities, quick learning, and creativity. The entrepreneurs are key to the Solar Sister model, “While having good credit policies and choosing high-quality, low-cost lantern models is important, the sustainability of Solar Sister’s approach hinges on its ability to recruit, train, and maintain SSEs [Solar Sister Entrepreneurs]” (Asher et al., 2015, 5-56). The reputation of Solar Sister Entrepreneurs is reported to be positive, with clients recognizing that they “are hard workers and well-respected in the community” (Soria et al., 2016, 8).

Earning additional income is a primary motivator for embedded entrepreneurs. Most entrepreneurs cite income and personal benefits as the primary reason for working with Solar Sister and they spend this income on household needs, school fees, or save (ICRW and Solar Sister, 2016; Soria et al., 2016). The motivations underpinning embedded entrepreneurs, like Solar Sister Entrepreneurs, stem from both financial and reputational incentives. As indicated by the reliance on financial benefits, Figure 5-6 associates financial incentives as more dominant in the behavior of embedded entrepreneurs than reputational ones, although reputation is certainly important as they are selling to their community. Each entrepreneur may earn only a modest amount, making an average annual commission of $55 from sales of less than 20 lanterns (Asher et al., 2015). Thus, while added income is the primary incentive, developing respect within the community is certainly at play as well.

Like the agents or SunnyMoney teachers, embedded entrepreneurs are also weaker in after-sales services than initial sales. Entrepreneurs are supposed to be trained in customer care and product repairs (Heuër, 2017), but skill development for the entrepreneurs focuses on sales, business skills, networking and communication. There is a limited focus on “customer care” with no mention of building the skills required for repairs (Soria et al., 2016, 11). Across the frontline solar intermediaries discussed thus far, it is clear that providing consumer information on labels is the more dominant model of consumer education, than

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24 Each entrepreneur buys the lanterns and then re-sells them and the local staff (BDAs) who recruit and manage the entrepreneurs are incentivized to keep entrepreneurs active rather than have one-off sales.

25 Solar Sister has encouraged more “Sisterhood Meetings” which provide additional opportunities for training and mentoring (TaroWorks, 2017).
exerting substantial effort on educating intermediaries beyond sales tactics and relevant sales information.

5.4.4 Developing Group Leaders

For many solar users, especially for lanterns and smaller plug-and-play systems, the affiliation of the on-the-ground intermediary is not always from a solar company, but a partner or distributor. NGOs, such as One Acre Fund, incorporate solar distribution into their services. Like SolarAid, solar products contribute to broader NGO developments goals and work in part to build or facilitate the market (Hong, 2015). One Acre Fund is an, “agricultural service provider and we deliver not just agricultural inputs, but other products like solar, clean jikos, which are the clean cooking stoves, reusable sanitary pads and are moving into nutrition. Then we deliver all these in walking distance and we couple it with training because we understand that some of our clients are buying this for the first time....In Kenya, we see consistently that the product that gets people coming back all the time is our solar products” (interview 190726).

One Acre Fund aims to reach small-shareholder farmers and has become one of the largest distributors of solar products given their work with over 800,000 farmers.26 Some households that receive solar through One Acre Fund consider the solar product a One Acre Fund product, rather from the manufacturer. Others associate companies with the color of a solar product (e.g. yellow, red/orange) more so than the distributor (focus group 190711.k.bt).

As solar products in this case are lumped into the general loan for One Acre Fund, specialized training on the payments for solar are not needed as is the case for a PAYGo solar model, as it follows the terms of the other goods included (interview 190607). The One Acre Fund financing model relies on three primary principles to best reflect the lumpy farming cashflow: repayments to reflect cashflow, de-linking repayments from only harvest income, and group solidarity. The repayment model here allows for a 10 to 11-month repayment period for farming inputs (with solar bundled in) after paying a minimum threshold prior to delivery. This allows for payments at different times and in different increments. Groups of 5 to 15 members meet weekly or biweekly and a One Acre Fund field officer collects payments at each meeting (One Acre Fund, 2015a). In each group, one member is designated as the “group leader” to help arrange meetings and group farming activities.

As a frontline solar intermediary, group leaders are widespread in Kenya. One Acre Fund has over 20,000 group leaders who operate in a voluntary manner to coordinate meetings.

26In their 2018 Annual Report One Acre Fund reported distributing 190,000 solar lanterns (One Acre Fund, 2018). Products are co-branded between One Acre Fund and Sun King. Early studies by One Acre Fund used Barefoot Solar (2011), followed later by Greenlight Planet (2013) (One Acre Fund, 2013). One Acre Fund distributes products from other solar companies such as BioLite, and likewise, Greenlight Planet has a range of distribution including, One Acre Fund (Rwanda, Kenya, Tanzania, Burundi), Fullerton India, Bandhan Microfinance India, Total (Haiti, Cambodia, Myanmar, Nigeria, Tanzania, Zambia), Sunny Money (Kenya, Uganda, Malawi, Zambia, Tanzania), Wilkins Engineering (Ghana), ZamSolar (Zambia), Global Cycle Solutions (Tanzania), Orange (Kenya) and Oolu Solar (Senegal) (Greenlight Planet, 2015).
(One Acre Fund, 2016). The model is intended to function such that “formal and informal feedback” is collected by group leaders and One Acre Fund field officers, who are full-time employees that coordinate groups. This feedback is then conveyed back to managers in the office. Group leaders may receive branded thank you gifts, such as t-shirts or calendars (field visit 190125, field visit 190711). The incentives for the group leader parallels the informal scouts used by networking solar agents.

Groups started by One Acre Fund members may span beyond solely agricultural purchasing to promote more general savings groups. Similarly, it is likely that a member of a One Acre Fund group is also a part of another savings group. Beyond financial benefits, members report that this group also provides “a platform for face-to-face interaction and building of close interpersonal ties....members also share their personal experiences, ask for advice, and have the opportunity to relax and chat. Sometimes, friends in the group will cover each other’s contribution during weeks they have no money” (One Acre Fund, 2015c). This description of the group function parallels that of Grantham and Baruah (2017), in Section 4.2.2, where solidarity and providing expertise or advice enhances trust.

For One Acre Fund, the group’s function extends beyond solidarity and trust to group liability. The group “quality” is an important factor in achieving their 99% repayment rate; this includes ensuring regular group meetings and strong group cohesion (One Acre Fund, 2015a). In a trial of larger group sizes, of up to twenty members rather than the more common limit of twelve, One Acre Fund found increased fraud, less group cohesion, and lower repayment rates. In this large group trial, group leaders were incentivized to increase the number of people in a group, but this resulted in adding fake group members or adding members without full buy-in from the rest of the group (One Acre Fund, 2015b). In this pilot of larger groups, with less accountability, we see some parallels to the negative stories of agents – deceit or lack of honesty about products – when the incentive is much more financial and less reputational.27 The function of the group leader is a local contact to coordinate her peers and facilitate information about and access to these loan bundles. While trained to some extent, it is the field officer who provides the group with more complex information.

5.4.5 Lean Startups Using Group Connections

Groups are also commonly used by social enterprises striving to enhance accountability in models targeting remote communities. Small social enterprise distributors that operate regionally in Kenya – such as Bidhaa Sasa in Western Kenya or Zawadisha in Taita-Taveta County – provide financed solar and other products. These models leverage existing social

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27 Applied to microfinance more broadly, group liability models have been largely considered successful for extending credit, and evidence from South Africa suggests peer groups are able to hold each other accountable for repayments (Bryan et al., 2015) although are limited in their ability to judge creditworthiness. Even in individual-liability loans, individuals in India participated more frequent (weekly; increased social interactions) repayment groups increases willingness to pool risk and decreases defaults (Feigenberg et al., 2013). The group liability model employed by One Acre Fund holds the entire group liable for each member’s repayments. While Kodongo and Kendi (2013) find that individuals in Kenya may prefer individual rather than group liability, socially embedded financing has a long history of group-based services (Vershinina et al., 2018) influencing the role of social ties in key services.
groups but do not all require stringent group liability like One Acre Fund. In general, the advantage of working with groups is that it is easier “convert” customers more quickly. As one solar company employee described that,

“...from what we’ve seen, the conversion for an individual takes much longer than the conversion within a group. Now, with groups you’ll find that if one person has understood, they will normally pick that person to explain a bit more [to the group] because they’ve worked with these people. It’s easier for other people to pick it from their own. Even the agents, you’ll find that most cases these agents are in certain chamas, so it becomes easier” (interview 190619).

Operating through groups allows for more reliable sales (selling to the whole group), although there is the risk that if the group leader is not interested in solar, then no one will buy. Here this illustrates the group leader’s gatekeeping role.28

Leveraging group connections also provides each group member with a network of peers for troubleshooting and asking follow-up questions. This reflects the face-to-face peer interactions also associated with One Acre Fund groups. Figure 5-4 indicates that that group leaders and other members of chamas may be more influential in building awareness than teachers, elders, and chiefs or leaders, but less than agents and the close friend and family networks. Groups report helping each other identify how to adjust usage patterns given new technologies, such understanding battery charging and solar use (field visit 190125). Reputational benefits may be stronger in this type, even without financial payments there is a benefit for group leaders of being considered a “big person” in the community (field visit 190125).

Solar startups use a variety of group models in Kenya, primarily varying in their level of formality. Some chamas are formally registered with the government and small distribution companies like Zawadisha work with these formal groups. Other distributors like Bidhaa Sasa use a range of groups, from registered chamas to colleagues in a school or neighbors and friends that come together in a group for the duration of a product loan (interview 190812). While some providers use groups to enhance repayment accountability, not all require a group liability model that penalizes all group members if one fails to repay. Since products like solar can be repossessed, unlike agricultural inputs that are consumable, there may be gains by allowing someone to buy again in the future. The liability model may reduce risk since often small distribution companies do not require “guarantees, [and] we want the women to feel that we are being a little bit easier on them, so if the group is registered, they guarantee each other in the group” (interview 190628). The number of groups that a group leader can coordinate at one time may be constrained to ensure that there is not too much cluster risk, where a leader is an effective salesperson, but not attentive to loan repayment (interview 190812). Incentives for group leaders include small cash payments (both for recruitment and for on-time repayment), but also gifts like t-shirts and calendars as branded goods function as “status symbols” (interview 190812).

28Gould and Fernandez (1989) identify gatekeeper as one type of intermediary.
Other dimensions of social relationships are also present in these group-based models to encourage collective learning. Group leaders are not only trained by staff, but also use a peer-to-peer learning model. Further, group leaders are often required by companies to have been a client beforehand, and thus have some experience with the process and products. These group leaders stand behind the quality of the products and interactions with the service provider representatives. Often, each group leader has a primary company point of contact, a group coordinator or field officer, who is a full-time employee and responsible for recruitment, product delivery, collecting payments, and responding to follow-up concerns or needs (ICRW, 2018). Group leaders have some similarities of close group connections to the more informal actors used by agents, like scouts, but have a strong and ongoing connection to the provider through these regional employees, officers or coordinators. This is most similar to the Solar Sister “Business Development Associates” who coordinate the entrepreneurs in a region. Like community influencers and embedded entrepreneurs, group leaders rely – as described earlier “strongly, strongly” – on their existing social network. While some effort to train leaders does occur, the intention behind the group leader model is not that they become independent entrepreneurs or commission-based agents who may more frequently be a go-to for after sales questions. Rather, many after-sales questions are directed to the company staff who are connected to the group and group leader.

5.5 Considering Actors with Stronger Company Links

After reviewing the four typologies indicated in Figure 5-6 applied to these models of solar distribution, it is evident that much more of their role is allocated towards sales than ongoing and after-sales services. If this is the case, how can the gap be filled for after-sales services in this sector-provided safeguard regime? Examples of on-the-ground actors with stronger connections to providers offer some reassurance of filling this gap: local shop managers and regional field officers. These local actors oversee the implementation of off-grid solar, while maintaining connections with the consumers in the area.

Frontline solar intermediaries as illustrated in Figure 5-1 sit in-between providers and end-users. While the four cases described already often have stronger connections to end-users and their communities with weaker connections to the providers, these final two intermediaries (not included in Figure 5-6) have much stronger connections to the companies, as they are full-time employees. The cases of shop manager and field officer represent intermediaries one-level removed from end-users as they are often responsible for coordinating the intermediaries previously described. But nevertheless, end-users may turn to these resources if their first go-to is unable to solve their problem, does not know the answer, or is no longer working for the provider. In a field visit in Vihiga, when asked what happens if a group manager does not know the answer to a group member’s question, either the group leader or that member directly go to the local full-time staff (field visit 190125). Managing a much larger number of influencers, agents, group leaders, or entrepreneurs, managers and officers have more authority to make decisions about repairs or replacements and are not beholden to the mixed incentives of commissions or small rewards.

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Shop managers and field officers are more comparable to one another than to the previous four intermediaries described, as each is an employee and responsible for managing – or being the point of contact – for some of the other intermediaries described. Such actors do not fit the same two-by-two table as illustrated in Figure 5-6 because they are not relied upon by providers for their social connections, rather they must excel at managing the services in a larger geographic region. In their position as an officer or manager, these intermediaries are seeking the best on-the-ground models for the influencers, agents, entrepreneurs, and group leaders and provide advice and training to implement such efforts.

As mentioned in the agent description or with group leaders, these company staff hold regular meetings to provide additional training, troubleshoot, or ask questions. They are positioned to collect, aggregate, and report experiences back to company headquarters, while they are also the source of more complex information for end-users. But as described with agents, distance and access may remain a problem: getting to the shop to speak with the manager, or convincing someone to give their phone number. Here there may be advantages in the field officer model, as they not only interact with the group leaders, but the groups themselves; they have a stronger direct link. As described below, shop managers are the weaker of these two intermediaries, as they have fewer local connections and are more akin to the direct sales model in Figure 5-1.

5.5.1 Local Shop Managers

Direct sales models use local shops to provide access to off-grid solar and, for companies like Greenlight Planet, local shops are a large part of their on the ground support for PAYGo agents. The model that Greenlight Planet calls “Easy Buy Direct” relies on 65 shops throughout Kenya, each with a shop manager who coordinates the agents that operate in that region. Shops, such as M-Kopa retail locations, serve as regional hubs for inventory and management staff. Examples in Figure 5-8a and 5-8b illustrate the role that these shops have in coordinating inventory and deliveries, and that they are often the meeting point for intermediaries such as agents. In addition to coordinating agents, these retail shops provide direct sales options for those customers with the ability to reach the town center. Shops are often the most reliable source of information and after-sales services. As described in Section 5.2.3, companies prefer when customers bring components in need of repairs directly back to shops rather than going through agents. Not all solar distribution models rely on retail locations, those relying on field officers rather than shop managers often have less robust shops that primarily focus on inventory and regional staff meetings, not consumer-facing services.

Whereas more remote sales rely on agent networks, shop managers may provide more reliable sources of information. As employees of the company, shop managers have more incentives to provide accurate information and make quality sales that build the company’s overall sales in the area, not just provide an individual financial benefit. At times, shops may be more reliable at providing the receipts needed for warranties and information for after-sales services (field visit 190711). Shop managers and their services also vary in quality. My experience purchasing solar products in Kitale and Eldoret suggest that shops do not always provide the receipts necessary for later use of a warranty, or all the information that may
be required to register a product after purchase using a USSD number (field visit 190716).\textsuperscript{29} While the shop managers represent an important avenue of information, they have more limited direct connections to customers and rely on agents or other frontline intermediaries for distant sales and the active awareness-building efforts such as door-to-door sales or market storming.

### 5.5.2 Field Officers

Called \textit{field officers} by One Acre Fund, this intermediary type is also called group coordinator in other distribution models. Just as the social interactions of the group encourage accountability, so too does a reliable and strong relationship with field officers. Unlike the group leaders, field officers are full-time staff. One Acre Fund, for example, is continually innovating with the field officer model – recognizing the instrumental but challenging role played by the field officers. In 2014, One Acre Fund did a field officer survey which suggested that both strong and weak (poorly performing) field officers spend most of their time doing field visits and walking, but that 30\% of field officers were not present in the final repayment period and 41\% did not consistently hold their member meetings (One Acre Fund, 2014b).

\textsuperscript{29}In Kitale, one d.light S3 was purchased at Total and a written warranty card was provided. In Eldoret, a d.light A2 was purchased from a shop that did not provide any warranty information or receipt, later the lantern was registered using a USSD code at the d.light regional service center but information such as shop number has to be looked up. A second d.light S3 was purchased at Total in Eldoret and a completely different warranty receipt was provided then was provided the Total in Kitale. Just as d.light products are distributed at Total stations, M-Kopa systems are also sold at some Safaricom locations.
Communities described a gap in service for solar products when a field officer changes locations or leaves One Acre Fund (focus group 190711.k.bt). Figure 5-9 illustrates the key role the field officer (FO) plays in the warranty process for solar products. It is the field officer, not the group leader, responsible for providing receipts, warranty information, and making returns.

Figure 5-9: Image of One Acre Fund solar distribution from Field Officer (from One Acre Fund distribution materials, personal image from household Kitale, Kenya)

The relationship between the field officer and group leader is recognized as a critical link for distribution, training, and repayment. In 2014, One Acre Fund started a pilot to better equip field officers to train group leaders on relationships and team building, and community organizing more broadly, including how to help motivate others (One Acre Fund, 2014b). Whereas a shop manager is associated with the regional shop, often in town, field officers are mobile. As indicated by the term “field” officer, they are often in the field with consistent responsibilities to visit the groups they manage, oversee product delivery, and any replacements. Rather than rely on the group leaders, some customers directly call staff to help with repairs (interview 190812). For some models, these field staff even bring
training to the field and coordinate the best examples of peer-to-peer knowledge sharing. For example, one small distributor trains group leaders quarterly, and it is the responsibility of this coordinator or officer to identify a convenient location, provide some tea and food, and then,

“...training would often be around new products that get introduced. [And] It will be around, how do I manage my groups? Because that’s what often they struggle with...how do I make sure people pay back? And what we really encourage there is peer-to-peer learning....good group coordinators talk to their best leaders and say can you say something on that topic?...And then she would share a few of her or her secrets in terms of I always go to their house, or I make sure I call them a week before, or we make sure we sit together; whatever it may be” (interview 190812).

Unlike shops, the field officer provides some solutions to overcome physical distance between shops or offices and rural solar users, and enhances the provider-consumer relationship with frequent and consistent interactions with field officers.

5.6 Revisiting Typologies Across Stages of Solar Services

The typologies and distribution narratives illustrate that not all intermediaries are equally incentivized or equipped to be reliable or available resources at every stage of solar use. The different stages of off-grid solar distribution highlight the importance of frontline intermediaries in solar products and services from facilitating information about off-grid solar to a more limited role in brokering the process of repairs and replacements or questions about payments. The existing incentives for both providers and the frontline solar intermediaries are focused mostly on sales and repayment rather than education and long-term services. Figure 5-10 illustrates the mapping of the four primary intermediaries plus the two with stronger company links to the different stages of solar services. This figure mirrors the trend that intermediaries are strongest for awareness and sales, with some engagement from the shop managers and field officers in after-sales activities.

Given the range of services increasingly provided by off-grid solar companies, from cash-payment small lanterns to loans for other household needs, intermediaries play important roles in a user’s experience with both solar products and the service provider. To understand how the safeguards described in Chapter 3 are implemented it is necessary to examine how frontline solar intermediaries act at these multiple stages of the consumer experience with off-grid solar. This is relevant for issues of consumer protection because while initial expectations, terms, and knowledge about protections may be built during the sales experience, the actual use of those protections is likely needed if they experience issues of product quality (repairs, replacements) or payment challenges (mobile or in-person payment systems). Mapping existing frontlines solar intermediaries across these stages identifies the capacity imbalance on-the-ground: far more intermediaries focus on awareness and sales than later
Figure 5-10: Stages of User Engagement with Frontline Intermediaries for Off-Grid Solar. The dotted lines in this figure identify the extent that intermediary operates across stages and if they are active throughout the whole process, or just the beginning or end.

5.7 Discussion

Distribution efforts for off-grid solar rely on frontline solar intermediaries to build customer relationships, especially in the areas of awareness and sales. Sunny Money’s model uses schools and head-teachers to distribute solar and then make connections to agents or shops. NGOs, like One Acre Fund, provide solar as a part of their other services with field officers responsible for educating and answering questions about solar. While an “ideal” agent would fit into the financial incentive and personal social connections box in Figure 5-6, in practice, the use of scouts and sub-agent networks suggests a much stronger reliance on using others to gain entry into communities extending beyond an agent’s personal social network. In the case of sub-agent networks, there is no guarantee that a customer brought in by a sub-agent will even interact with the company affiliated agent.

Companies are just beginning to explore end-of-life services, such as recycling and disposal. Recently, the solar industry started working to address this final stage of e-waste, with a working group in the Global Off-Grid Lighting Association and companies like Mobisol and d.light promoting their own versions of recycling programs (Global Off-Grid Lighting Association, 2019c). On-the-ground staff report that while returning broken products to the local or regional shop for disposal is possible, it does not happen in practice (interview 190719).
The connections that solar agent has to their customers exhibits a layering of social connections that places the agent, and therefore the service provider, potentially more disconnected from the end-user. This contrasts with the emphasis in group leader or entrepreneur models on strongly encouraging a frontline intermediary’s actions to stay within their social network. Additionally, for group leaders follow up from a field officer or group coordinator at the local-level reinforces this provider-consumer connection. Within each of these typologies of group leader, community influencer, embedded entrepreneur, and networking solar agent there is some layering of connections and relationships; agents using sub-networks, community influencers making connections that are then handed-off to agents or shops, or continued interaction from both group leaders and coordinators.

The intermediary function of configuring (see Chapter 4, “arbitrage of ideas, information, resources, and connections from one context to another to add value and improve practices”) is not present in the frontline intermediary models of influencers, agents, entrepreneurs, or group leaders. The local staff – represented by the shop manager and field officer types – link these influencers, agents, entrepreneurs, and group leaders back to the companies. As a company employee they represent the strongest case of being able to learn from the on-the-ground experiences of other intermediaries via meetings or training sessions and, in turn, use this knowledge and experience to identify modifications to distribution models, suggested improvements to technology designs, or changes to the goods provided. Managers and officers also exhibit much stronger forms of brokering services as they are the strongest link to the company. Whereas, the other intermediary models are likely better at facilitating information and education, as exemplified by the importance of peer-to-peer education efforts in both the agent and group leader models.

The modes of conveying increasingly complex ideas about consumer protections (from payments to data privacy) remains a challenge for providers. Frontline solar intermediaries, such as community influencers, in off-grid solar struggle to effectively reprocess information to ensure relevance for the community, as many community influencers are learning about solar at the same time as other members of the community. The group leader model mitigates this by requiring that a group leader have prior experience as a customer. Frontline solar intermediaries paired with stronger accountability mechanisms, such as the call center for solar agents or direct user accountability for entrepreneurs, have more incentives to ensure information is processed into knowledge, but even these accountability mechanisms have ways of being circumvented. Solar agents, in particular, make a strategic calculation about short-term financial gains and long-term customer relationships when deciding how much effort they put into knowledge-building and active brokering (such as bargaining for or representation in discussions of repairs or replacements). Like the agents with a strong link back to providers, the relationship between a group leader and the field officer is a consistent link for brokerage activities. The group format and underlying strong social ties provide opportunities for collective knowledge-building allowing for the group leader to leverage the experiences across the group to provide formal and informal feedback to the provider.

Frontline solar intermediaries operate with a layering of relationships to connect end-users to solar providers. The formality and duration of connections may help or hinder how
others – community members, solar users – learn from intermediaries in off-grid solar. The PAYGo solar model requires repeated interactions with frontline solar intermediaries to ensure payments are collected and problems are solved, these repeated interactions necessitate reliable interactions with and transparent communication from frontline solar intermediaries.

The next two chapters, Chapters 6 and 7, examine what features of frontline solar intermediaries influence trust and the impact of intermediaries on consumer knowledge of solar use and associated safeguards. Building on the typologies and narratives described in this chapter, the following chapters illustrate which areas within these models may benefit from future attention and re-design, or should be promoted as effective aspects of the consumer-intermediary relationship.
Chapter 6
Dimensions Influencing Trust in Frontline Solar Intermediaries

“...the general public’s acceptance of new technology depends to a large extent on the perceived trustworthiness and legitimacy of the suppliers of said technology” (Aklin et al., 2018, 468).

“By using head teachers to recommend these unfamiliar and alien technologies we were also able to overcome perhaps the most important barrier to market: trust. It was a revelation that spurred us on to sell one million lights in only a few years” (Moore, 2015).

6.1 Introduction: Importance of Trust for Off-Grid Solar Services
Consumers in Kenya have varying experiences with off-grid solar, as illustrated in Chapter 1 these experiences are often tied to what happens after they purchase solar, from uncertain after-sales contacts to local electricians unable to determine the problem to processes with poor accountability for repairs or replacements. Examples in Chapter 2 that highlight the critical role solar agents play in building effective communication channels to consumers. In Chapter 5, examples of solar agents putting forth extra effort to provide service to their customers illustrate action based on the hope of future gains. These experiences layer atop trends in the sector of increasing PAYGo sales and future growth of off-grid solar centered on selling more appliances and new services to existing customers. In this chapter, differences in frontline intermediary models are explored empirically by comparing the influence of different factors associated with intermediaries on trust in those actors.

In my experience with Sharon, the solar agent in Kakamega (see Chapter 5.4.1), her customers were not comparing solar providers on a set of predetermined measures, rather
they traded on the reputation of companies and the recommendations Sharon provided. Therefore, we see customers following Sharon for new solar products and services, buying a lantern from her previous company, and a smartphone from her new company. Sharon extends the trust she has with her customer to the solar provider when she goes with the customer to the company repair center, linking her trust in the company’s guarantee to repair or replace an item to the customer.¹

Frontline intermediaries are used to convey trust in solar providers to end users with no, or limited, prior experience with solar. The two quotations above, the first from academia and then second from the NGO SolarAid, suggest the importance of trust and the instrumental role frontline intermediaries have in building trust in off-grid solar.² Trust in solar products and services is a recognized barrier to solar adoption, using frontline solar intermediaries may help overcome this lack of trust to promote off-grid solar growth. Trust is often earned, or broken, over repeated interactions and such interactions are only heightened with PAYGo financing and future opportunities to up or cross-sell customers.

Company efforts to distinguish themselves using information on packaging do resonate with consumers: people trust information on packaging. Evidence suggests that there is limited action translating said information into action for after-sales needs (see Chapter 3.5). Examples of solar agents responsive to post-sales challenges shows that intermediaries can play an active role in longer-term services by taking customers to local shops in-person (see Section 5.3.2) or by committing to help customers today in order to earn referrals in the future (see Section 5.4.1). Such actions help overcome barriers to awareness, distance, or the cost of going to the provider for help. Intermediaries enable “transactions between other actors lacking access to or trust in one another” (Marsden, 1982, 202). Trust in frontline solar intermediaries influences multiple stages of off-grid solar services, with the strongest incentives from providers to build trustworthy relationships that support awareness and sales. After-sales experiences with intermediaries suggest that frontline intermediaries can enhance trust through responsive service or diminish trust with dishonesty or nonresponse to customer issues.

Scholars recognize a strong link between brand and reputation, and between reputation and perceived quality. Further, a brand’s ability to establish prestige, or the ability to communicate “superiority to the purchaser and relevant social groups of the purchaser” (Brucks et al., 2000, 361), aids in decision-making when objective quality may be difficult to evaluate. Building consumer knowledge, as is often the role of off-grid solar intermediaries, can enhance trust in a service provider (Eisingerich and Bell, 2008) and after-sales support can

¹This mirrors some of the transferring of trust described by Baruah (2010), but this case focuses on transferring trust at an individual-level across purchases, while Baruah (2010) focuses on organizations, a local NGO, acting to transfer trust between projects.

²More broadly industry research identifies intermediaries as “effective in gaining trust for the brand” (Dalberg Advisors et al., 2018, 94).Dalberg Advisors et al. (2018, 94) outline additional cases not described in Chapter 5 but that support the critical role of frontline intermediaries in off-grid solar. These additional examples include: Greenlight Planet’s village entrepreneur network, community ambassadors, and generally recognized importance of direct marketing, demonstrations by peers, and community leader referrals. Dalberg Advisors et al. (2018) also describe utilizing already trusted brands to increase credibility and trust, this is not explored in this research but a fruitful avenue for future work.

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help maintain trust (The Climate Group and Goldman Sachs, 2014). The examples that we have seen thus far illustrate that trust in service providers is developed in part by frontline solar intermediaries that help build or rebuild trust in solar services in rural Kenya.\(^3\)

This chapter expands on the literature described in Section 4.2.2 to layout the complexities of trust, both theoretically as a concept and in measurement. Examples from prior scholarship suggest that trust in an intermediary can enhance trust in associated services and technologies. For example, the Solar Sister entrepreneurs, described in Chapter 5, are able to increase awareness, trust, and ownership in off-grid solar (Heuër, 2017). I examine what dimensions – or attributes – influence trust in the frontline solar intermediaries people go to for help and describe the ways that trust is operationalized as dimensions of social capital and reputation. I use a conjoint survey experiment which asks people to choose between two profiles, each with different characteristics of intermediaries. This method allows me to, first, examine trust in a multidimensional manner by examining a set of attributes each with sub-variation, and second, best approximate real decisions in a survey experiment which inherently relies on reported not actual choices (stated-preferences). Before discussing findings, I describe the conjoint survey experiment in greater detail, across design, implementation, and analysis.

From this conjoint experiment, I find that the emphasis from providers on local ties does, indeed, matter for trust. This supports prior literature strongly linking trust and social capital. Beyond this, my findings show patterns relevant to the ongoing changes in the sector and opportunities for future partnerships and innovations. First, there is more trust in the government as sector-affiliation than in politicians. While Chapter 3 unpacks the challenges of implementing policies regarding solar quality, my results in this chapter suggest that people still trust in help from those affiliated with the government more than other sectors, and distrust those with links to politicians more than links to the provider or an NGO. This supports other research finding that people tend to associate civil servants with the public interest more than politicians (Brass, 2016, 198). Second, while the bulk of training for solar intermediaries is from internal company training efforts (described in Section 5.4.1) and technical training for solar licensure (see Section 3.3.3), these findings show more trust in intermediaries that provide training and are affiliated with an NGO. Stronger partnerships across sectors in off-grid solar will continue to enhance trust. The findings in this chapter suggest opportunities for building trust in frontline solar intermediaries beyond current intermediaries in solar distribution models.

### 6.1.1 Importance of Trust in Frontline Solar Intermediary Models

Trust is central to frontline solar intermediary models. Across intermediary models the strategic way providers incentivize or structure interactions aims to build trust between the provider and consumer. Industry leaders suggest that existing social ties and relationships help frontline solar intermediaries build this trust in solar. Solar Sister encourages embedded

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\(^3\)Trust in service providers, and the use of intermediaries to build that trust is not only associated with off-grid solar, but broadly applicable to electricity and other services (Lins, 2014).
entrepreneurs to sell to their “trust network” and SunnyMoney’s community influencers specifically aim to overcome the hurdle of trust. The need for frontline solar intermediaries to build trust with consumers as new technologies and services are developed and implemented is recognized in both scholarship (Moss, 2009) and industry research (Dalberg Advisors et al., 2018). While intermediaries are not the only source of trust, they help create initial trust by often leveraging prior interactions or reputations, and have the potential to build consumer knowledge and provide the type of responsive service that underpins longer-term trust in solar providers.

The importance of intermediaries in building trust is well-known and documented in scholarship and, frequently, in our daily lives. Simply, many people we meet, we trust because we meet through others acting as “intermediaries in trust” (Hardin, 2002). Intermediaries may act in economic situations as “guarantors of someone’s trustworthiness....Outside of that [commercial] world, they may still be important for their knowledge of the reputations of people and organizations with whom we might want to deal” (Hardin, 2002, 140). The models used by solar providers explored in the previous chapter, Chapter 5, directly use this role of guarantor, in particular in the group model associated with large NGOs like One Acre Fund and lean start-ups like Bidhaa Sasa. For example, the groups led by a group leader are not static, but rather they use initial experiences with group members to make changes. Leaders and group members use prior experiences with their peers to decide if other members are indeed trustworthy and if they can act in this guarantor role. As one provider described,

“...often what happens is that the group morphs, so the group on average is about six people, four of them may be buying something else again, and then other two maybe are not interested, or they fell out with the group. For example, if they didn’t make the payments regularly, even though, eventually they paid, maybe they’re like we don’t really want her any more in the group, and then they kind of get kicked out. That sort of dynamic” (interview 190812).

This illustrates that these models depend on the trust dynamic within a group. The notion that intermediaries play an instrumental role in extending trust applies to off-grid solar. Frontline solar intermediaries have the potential to extend their trust in solar products and providers to their friends, family, and community-members. As described in Chapter 5, this can occur directly, or often in a somewhat layered manner where frontline solar intermediaries continue to build social connections (e.g. scouts, sub-agent networks, group leaders to group members, and using first community influencers and then solar agents) that help intermediaries extend into new geographic and social arenas.

As trust contributes to building effective solar services – and underpins growth of the sector – it is also amorphous and difficult to specify, here, I examine the factors that influence trust and apply those to off-grid solar in Kenya. After revisiting the key elements of trust

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4Moss (2009, 1491-2) describes that the “impact of intermediaries is not very tangible, as it relates primarily to changing attitudes, building trust, networking stakeholders, influencing policy priorities, or bridging discourses. The influence of intermediaries on resource use is, therefore, mostly indirect: for instance, creating conditions favourable for technology take-up, rather than installing or using the technology themselves.”

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from academic scholarship, in particular the dimensions of reputation and social capital, I unpack these into testable attributes in a conjoint survey experiment. The goal of this experiment is to inform both our understanding of trust in intermediaries assisting service providers and also possible ways to enhance trust in intermediaries. Trust in intermediaries enables them to extend trust between the other two parties involved, in this case, off-grid solar providers and consumers. As providers continue to identify ways to build brand awareness, a better sense of what underpins this trust can spark new innovations in intermediary models. Increased trust in off-grid solar providers can help build a stronger solar sector in Kenya.

6.2 Revisiting the Literature on Trust and Intermediaries in Solar

Few studies explicitly link adoption or use of distributed renewable energy technologies and trust, but that is beginning to change. Recently, scholars examined trust and solar microgrids (Aklin et al., 2018). Additionally, trust and electric utilities has recently been explored to show that pro-environmental messaging may enhance trust in utilities, a sector with reportedly low trust (Przepiorka and Horne, 2018). As referenced in the start of this chapter, Aklin et al. (2018, 468) posit that the “public’s acceptance of new technology depends to a large extent on the perceived trustworthiness and legitimacy of the suppliers of said technology.” Further the authors suggest that policies and markets that help differentiate high quality products may enhance trust in off-grid solar.

In the context of distributed renewable energy, initial studies suggest mixed results about the influence of trust in providers on adoption. Aklin et al. (2018) examine the trustworthiness of other households and the trustworthiness of businesses or service provider, with the hypothesis that increased trust is associated with a higher likelihood of solar microgrid adoption. While the authors find that neither measure of trust significantly explains adoption decisions, they interpret this to indicate that respondents do not see abuse or non-cooperative behavior as threats to adoption. For a microgrid scenario this indicates that the provider successfully prevents electricity theft and the use of unauthorized devices (Aklin et al., 2018, 45), but they do not find evidence to support that trust in either the provider or the community has a direct, positive relationship to adoption. This null finding indicates the importance of competing hypotheses, such as affordability and the need to better understand the ways that trust in services forms and how it influences decisions.

Utilizing policies and markets to help enhance trust in off-grid solar suggests that there are multiple dimensions or understandings of trust at play in off-grid solar. Different forms of trust, interpersonal trust or political trust (Bauer and Freitag, 2017), may rely on different approaches to build or reinforce that trust. Often reviews on how to measure trust examine these different dimensions of trust, recognizing differences in trust, trustworthiness, and motivations for trust (Levi, 2015). In line with “cognitive” trust (Levi, 2015), a commonly used specification of trust is that “a truster A that trusts (judges the trustworthiness of) a trustee B with regard to some behavior X in context Y at time t....time t clarifies that trust...
may change, that is, a truster may adapt his expectations over time” (Bauer and Freitag, 2017, 2). But given the premise of A trusts B or A judges the trustworthiness of B, what underpins the trustworthiness of someone, or the willingness for someone to engage in the relational, vulnerable act of trust?5

While people are motivated to trust by a range of factors, instrumental motivations are likely most relevant for off-grid solar services, as such services are predicated on exchange. Instrumental motivations for trust are based on a risk calculation: the payoff of trusting may be greater than the risk (Levi, 2015). In off-grid solar, the payoff of receiving a high-quality solar product, or in some cases any solar product, may outweigh the consideration of uncertain after-sales service or the possibility of having no solar at all. Trusting in an intermediary to help provide off-grid solar may be worth the risk. The typologies of off-grid solar intermediaries exhibit other motivations for building trust, including social benefits related to personal identity, self-esteem, or social status. The group leader intermediary is able to build an identity as a “big person” for bringing solar to the community, a personal benefit that may underpin intermediary behavior and encourage trustworthy actions. Reputation can be both instrumental – enhancing future exchanges and cooperation – and social (Levi, 2015). Building a reputation in off-grid solar can be associated with measures of quality such as Lighting Global (see Chapter 3.3.1) or can be extended by intermediaries that provide introductions to and ongoing assistance with solar. In turn, the reputation of the frontline solar intermediary matters for the solar provider.

Management scholarship provides some guidance on how to better understand the relationship between trust and service provision, and in particular, the dimensions of service that may help build trust. Dimensions of the provider-consumer relationship may include characteristics related to the delivery of the service, such as competence or reliability, and others that are more personal characteristics, such as empathy or perceived similarity between the provider and consumer (Coulter and Coulter, 2002). Again, there is a multidimensionality to trust related on the one hand to the quality of the service and on the other hand to interpersonal relationships. Risk again plays a role: customers may be uncertain of the outcomes of intangible services, although over time, this risk may be reduced as consumers become more knowledgeable about and familiar with the provider (Coulter and Coulter, 2002). Building a trusted service provider reflects the consumer protection code underway in off-grid solar by ensuring customers have a sense of being safe in their dealings, honesty, and credibility (Coulter and Coulter, 2002; Parasuraman et al., 1985). As introduced in Chapter 2, trust is a key element of effectiveness for both intermediaries and service providers.

Trust functions in a multilevel manner, which underpins the notion that intermediaries who are trusted can then build or extend that trust to the consumer-provider relationship. For this work, these relationships are presented in Figure 6-1, which illustrates the role of

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5Levi (2015, 664) describes that, “[f]or most scholars, trust is relational, involving at least one individual making oneself vulnerable to another individual, set of individuals, or an institution that possesses the potential to do harm or betray. Trust implies a judgment of risk in conditions of uncertainty. Moreover, trust is seldom unconditional; it is given over specific domains.” This notion of trust reflects the accounts of risk and uncertainty described in Chapters 1, 2, and 5 as rural individuals rely on the intermediaries to do what they say they will do, despite uncertainty of the process of returns or repairs.
**Figure 6-1:** Illustration of the mediation role of trust in intermediaries on trust in provider and ultimately off-grid solar company performance. This chapter focuses just relationship A: what influences trust in intermediaries in off-grid solar, as illustrated by four dimensions: sector affiliation, social connections, expertise, and external bargaining links.

*individual* intermediaries acting to promote *organizational* outcomes (hence the multilevel operation of trust). The interplay between individual-level trust and organizational-level trust relies on “individual boundary spanners” (Zaheer et al., 1998, 143), or what I call intermediaries. In management scholarship these intermediaries act between their counterparts in other organizations to build trust between organizations (Zaheer et al., 1998), while in this work they bridge between consumers lacking access or knowledge and providers more in line with public policy (Krishna, 2011) and more recent scholarship on sociotechnical transitions (Moss, 2009). Nevertheless, management scholars explicitly make this link between interpersonal trust and organizational trust and find that interorganizational trust built by intermediaries does have a positive relationship with performance. Using this interdisciplinary lens on trust, it is possible that prior research on trust in distributed renewable energy (e.g. (Aklin et al., 2018)) has oversimplified a complex transfer for trust from individuals to providers.

Across the literature on trust, some disciplines focus more on trust facilitating economic transactions while others examine trust in the construction of social order, institutions, and cooperation. Broadly, a transactional approach is dominated by economists, while outcomes from social order or daily interactions are studied by sociologists. Trust is increasingly studied across areas of scholarship from organizational change to coordination to good governance (Levi, 2015). In this research, trust is both understood as an important facilitator of off-grid solar services – a more transactional focus – but also that consumers in Kenya put their trust in the private sector to act in the consumer’s interest even with limited direct government action – an element of how trust plays into governance.

The models being deployed by off-grid solar providers aim to build trust in providers and transactions by leveraging intermediaries to expand networks and reach potential customers. The trust generated by social capital illustrates the intensely social nature of these efforts to use intermediaries to engage in rural transactions. The use of trust or other social norms that contribute to social capital can help facilitate cooperative action (Putnam, 1994). The issue faced by off-grid solar providers is that,
“...the average radius of trust of cooperative groups tends to be small....What is needed in these cases is to increase the radius of trust...between groups that typically have had little to do with one another....The more realistic ways of building social capital through policy lie not at the macro, but at the micro level....One of the most successful instances of the building and exploitation of social capital is in the area of microfinance....This is where social capital comes in, since social networks are extremely effective at disseminating precisely the kind of information that determines creditworthiness” (Fukuyama, 2002, 32-33).

This reference to microfinance is an example of relatively recent efforts in the Global South to utilize the social capital embedded in rotating credit associations. As Putnam (1994, 169) describes, that participating in mutual aid efforts, like a rotating credit association, also work to build social capital. Like other entrepreneurs and enterprises before them, off-grid solar providers are leveraging the social networks, norms, and trust that form social capital to facilitate economic transactions.

Parallel to the emphasis in microfinance on deploying trust in pursuit of financial inclusion and credit, so too in off-grid solar is the notion of a “trust radius” influential in distribution models and the role of intermediaries such as group leaders. The principles of social capital used to expand the radius of trust can be seen by the “layering” of connections between agents and their scouts or by the group leaders and members acting to determine worthy participation in group buying efforts. Just as some of the consumer protection challenges of financed off-grid solar mirror those of microfinance, so too do the strategies of leveraging social capital for transactions.

Evident in the broad use of trust across disciplines and to promote a range of outcomes, trust is both critical and difficult to define and measure. Trust is complex as it “is both an outcome and an antecedent of relationships. It forms a basis for relationships, and thus generates social capital. It may be based on institutions, and it may be built from relationships, and then it arises from social capital” (Nooteboom, 2007, 29). Or as Putnam (1995, 664-5) describes “|b|y ‘social capital,’ I mean features of social life – networks, norms, and trust – that enable participants to act together more effectively to pursue shared objectives.” Trust both helps build social capital, and relies on social capital.

As described earlier (see Chapter 4.2.2) social capital is often associated with trust that can help facilitate economic transactions. In transactions for off-grid solar, providers design distribution models where intermediaries act within their “...personal relations and structures (or ‘networks’) of such relations in generating trust and discouraging malfeasance” (Granovetter, 1985, 490). These networks of relationships are what Granovetter considers embeddedness in the domain of economic sociology. Explored earlier in typologies such as embedded entrepreneurs, embeddedness is tightly linked to social capital and is the premise that behavior and institutions are constrained by social relationships (Granovetter, 1985). But what influences trust in frontline solar intermediaries may not stop just at social capital or the embedded relationships that influence off-grid solar purchases and ongoing use.

Described in scholarship on intermediaries and in management literature on service provision, trust is also built by the sharing of information and building of knowledge. Chapter 2
describes the role intermediaries play in “information sharing” and Chapter 4.2.2 emphasizes that expertise underpinning knowledge-building also builds trust in a provider. As management scholars highlight, dimensions of service delivery influence ongoing trust in providers. As actors that can potentially transfer trust between consumers and providers that do not know one another, intermediaries act as the face or frontline representation of providers. Different disciplines highlight dimensions of what may influence consumer trust in frontline solar intermediaries, in the next section, I divide trust into sub-dimensions of reputation and social capital that have the potential to influence trust in frontline solar intermediaries.

6.2.1 Dimensions of Trust: Social Capital and Reputation

As with many of the factors influencing trust, it can be difficult to draw boundaries between different dimensions. Across areas of scholarship, I classify these dimensions as those related to social capital and those related to reputation.

- **Social Capital**: Attributes of intermediaries based on their personal relationship, often within-group or identity-based that may contribute to “embedded” transactions and experiences with off-grid solar. The networks and norms that underpin social capital may enhance coordination.\(^6\)

- **Reputation**: Attributes of intermediaries based on prior interactions or information about them spread by word-of-mouth. Relying on reputational measures can influence how intermediaries act by providing a set of non-financial incentives (as described in Chapter 5) and can provide individuals with information about an intermediary’s reliability if they have no prior, personal interactions to determine trustworthiness.\(^7\)

Figure 6-1 illustrates the four concepts explored in this chapter: sector affiliation, expertise, embeddedness, and bargaining connections. As I indicate in the figure, I hypothesize that each of these influences trust in frontline solar intermediaries. The remainder of this section describes why each of these may play a role in the trustworthiness of intermediaries and possible variation within each attribute.

The dimensions of reputation and embeddedness described above mirror the dimensions used to describe the four typologies in Chapter 5 and here provide a framing for the four attributes tested in this conjoint survey experiment about trust in intermediaries. The

\(^6\)Intermediaries sit at the center of a debate regarding the influence of social capital on innovation as dense, closed but cohesive networks versus ties that individuals or organizations may have to bridge gaps in expertise, knowledge, or experiences (what Burt (2004) calls “boundary-spanning” structural holes) (Obstfeld, 2005). The influence of intermediaries with strong ties to individuals/groups or weak ties to others (see Granovetter (1973) for the strength of weak ties). Both strong and weak ties may be at play in off-grid solar distribution models, as intermediaries first sell directly to their personal ties, their “trust-networks” while also working to expand and build networks based on the “layering” of connections described in Chapter 5. These layered connections are likely weaker, but able to span across groups and distances.

\(^7\)Granovetter (1985, 490) discusses the importance of reputation for embedded transactions and exchanges, as information from others or one’s prior experiences with someone can enhance trust by providing more detailed information and can encourage people to act in a trustworthy manner over continuing interactions.
influence of social capital and reputation on trust are distinguished here as embeddedness and bargaining connections are dimensions of social capital, and sector affiliation and expertise are dimensions of intermediary reputation.

**Embeddedness.** Building trust via intermediaries may interact with other conditions influencing trust based on personal relationships and existing institutions. Where institutions are weak, trust is more likely to stem from personal relationships (Nooteboom, 2007). Granovetter (1985, 490) argues that embeddedness plays a larger role in protecting against malfeasance or poor behavior than institutions or some form of generalized morality. Of the four attributes examined here, embeddedness has been described most frequently in connection with trust, in particular to facilitate transactions and coordinate activities such as purchasing solar. Embeddedness has already been highlighted in typologies such as the embedded entrepreneur who relies on their existing social connections for making solar sales. The concept of embeddedness can be applied to organizations (Child, 2016), state-society relations (Evans, 1996) or institutions (Viterna and Robertson, 2015), but here is operationalized as the social connections an intermediary has to a consumer. I adopt the use of embeddedness most common in the literature on intermediaries and off-grid solar, embeddedness is associated with stronger, close ties. Easley and Kleinberg (2010) consider embeddedness to mean the number of common neighbors two endpoints (which could be individual, groups, etc.) have in common. Thus, embeddedness by definition has variation in strength, one may be more or less embedded within a network. Embedded connections may enhance trust or make trusting easier, but also carry with them the potential for social sanctions given a wrongdoing, as both parties have mutual contacts.

**Bargaining Connections.** A key function of an intermediary is to link those lacking trust or familiarity in one another. The concept of a bargaining connection is based on the description from Krishna (2011, 106) that naya netas – intermediaries operating in India to provide access to key services – have “two sets of trustworthy bargains. On the one hand, they strike bargains with their fellow villagers needing access to welfare benefits, and on the other hand, they strike deals with the service providers.” In the realm of social capital, these connections represent weaker ties, allowing intermediaries to span beyond their immediate ties and bridge “structural holes” to facilitate interactions that would otherwise not occur. In such cases, intermediaries often function as gatekeepers by acting as the connection for those within their group or those they have prior relationships with to an external connection (Gould and Fernandez, 1989; Fernandez and Gould, 1994; Easley and Kleinberg, 2010). In the context of off-grid solar, intermediaries often establish these connections to solar providers, but have the potential to establish connections with others who might have influence, resources, or additional information about solar.

**Sector Affiliation.** Sector affiliation is one of the most common stratifications in academic literature on intermediaries. Studies stratify intermediaries by sector, emphasizing the important role of government-affiliated intermediaries (Kivimaa, 2014) or NGOs as intermediaries (Baruah, 2010; Grantham and Baruah, 2017). Aklin et al. (2018) test different frames of off-grid energy as an alternative to grid extension in India and find differing levels of trust in government compared to private sector providers (“people overwhelmingly prefer
the government to run infrastructures over the private sector” (Aklin et al., 2018, 470)). NGOs are recognized as capable of building community trust by continued, repeated visits with communities and engagement across stakeholder groups on energy projects (Baruah, 2010). Increasingly, there is a recognition that “nonprofit organizations undergird the practice of market-based social enterprise...by producing systems of trust and accountability” (Child, 2016, 225), such systems include those emphasized in Chapter 3 like labeling or certification regimes. Evidence from Chapter 5 in Figure 5-5 illustrates the importance of affiliation: affiliation with a solar company or brand is the most commonly cited reason for choosing an intermediary for help with solar. To suggest a difference to survey respondents between sector affiliation (a more general relationship) and a bargaining connection (a more instrumental relationship), in this data collection a bargaining connection is described as a more personal relationship (*uhusiano wa kibinafisi*) that may help disseminate or provide information about solar.

**Expertise.** Often overlooked in scholarship from sociology, but emphasized in management and public policy scholarship is how the expertise of an intermediary may influence the trustworthiness. In regulatory processes, Lee (2011) identifies expertise as a key attribute of intermediaries, with particular emphasis on their ability to reduce uncertainty by identifying and effectively translating necessary information. With the growth of pay-as-you-go financing options, in off-grid solar the expertise of intermediaries may span beyond product information or proof-of-functionality provided by product demonstrations, but may require more knowhow regarding financing or longer-term system operations. With respect to service quality, management scholars find that consumer knowledge is a significant predictor of consumer trust and building such knowledge includes, “inform[ing] customers about service-related concepts and explain[ing] the pros and cons of service products they recommend to their customers” (Eisingerich and Bell, 2008, 257).\(^8\) Variation in what expertise intermediaries are able to provide consumers may influence consumers’ trust in a provider. For off-grid solar, intermediaries may be responsible for activities ranging from just providing basic information (equivalent to what one might find on a box or flyer) to detailed information on PAYGo and financing models. The dimension of expertise also links to the key role intermediaries play in building a stronger consumer protection regime for off-grid solar as they often provide or suggest potential resources to end-users.

### 6.2.2 Hypotheses

Each of the four attributes proposed as influential in the trustworthiness of intermediaries is operationalized at three levels or sub-dimensions. In Table 6.1, I provide the variation tested in this conjoint survey experiment. While specific to off-grid solar, such as the variation in expertise across information, training, and financing, the trends identified here may be applicable to intermediaries acting in service provision more generally.

Based on the intermediary models used in off-grid solar, I expect all four attributes to

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\(^8\)De Silva et al. (2018) explicitly examine the role of intermediaries in knowledge-based practices in innovation within an organization.
Table 6.1: Operationalizing Trust in Intermediaries into Multiple Dimensions

<table>
<thead>
<tr>
<th>Concept</th>
<th>Attribute</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embeddedness</td>
<td>Your relationship with this person</td>
<td>Outsider (not from community)</td>
</tr>
<tr>
<td>Bargaining</td>
<td>External linkages</td>
<td>Connections to local politicians</td>
</tr>
<tr>
<td>Sector</td>
<td>Sector affiliation</td>
<td>Private sector</td>
</tr>
<tr>
<td>Expertise</td>
<td>Activities (they provide)</td>
<td>Provide information</td>
</tr>
</tbody>
</table>

have a relationship with trust in a frontline solar intermediary. With the most of the off-grid solar models described in Chapter 5 relying on some local engagement, from community leaders to building networks with scouts and sub-agents, I hypothesize social capital will have a strong, positive relationship with trust. In particular, embeddedness of intermediaries will have a positive effect on trust in intermediaries. In Table 6.1 this is illustrated by the first attribute and sub-variation across outsider (not embedded), elder (from community, prior relationship), and family (most embedded).

\[ H_1: \text{Intermediaries that are a family member or a community elder will be more trusted.} \]

While there are multiple intermediaries operating in the off-grid solar sector, the focus of this dissertation is on frontline actors that operate between end-users and providers. I hypothesize that intermediaries with this connection to providers will be more trusted. Examples of bargaining connections include the actions of agents and entrepreneurs in Chapter 5 that extend beyond just facilitating service but brokering transactions – actively participating in the provision of service by engaging with the provider on behalf of or in conjunction with the end-user. In such cases, as with an agent who is not a formal employee, these bargaining connections are differentiated from the next attribute, affiliation, as often, frontline solar intermediaries operate more independently or informally as gatekeepers between local community members and a solar provider, rather than fully affiliated with a solar company.

\[ H_2: \text{Intermediaries with external links to the service provider will be more trusted.} \]

Examples such as One Acre Fund’s distribution of solar lanterns in Chapter 5 or the substantial emphasis in scholarship on NGOs able to navigate as effective intermediaries suggest that an intermediary affiliated with an NGO may be more trusted than other sectors. It is uncertain if the emphasis Aklin et al. (2018) find on trust in government to provide infrastructure services spans country contexts outside of India, but if it holds, it suggests that there may be more trust in government.

\[ H_3: \text{Intermediaries with affiliations to NGOs or the government will be more trusted than the private sector.} \]
Finally, the last attribute explored here is the expertise of the intermediary. Intermediaries can be viewed as responsible for minimally providing information relevant to solar or in more responsive situations, providing information in a manner meaningful to consumers about the purchase and use of solar. As the main source of face-to-face interactions, frontline solar intermediaries also have the potential to provide more than just information, they can train end-users on how to troubleshoot their system and work to overcome issues with safety and compatibility of systems (see Section 5.2.3). With the growing emphasis on PAYGo financing for solar in Kenya, intermediaries often are responsible for providing the terms and conditions to end-users, reinforcing their role in effective consumer protections. Providing basic system information and financing options mirror the training provided by companies described in Section 5.4.1 and likely form the baseline of what people expect intermediaries to provide.

$H_4$: Intermediaries that provide expertise in financing will be more trusted.

### 6.3 Conjoint Design & Multidimensional Choices

I use a conjoint design which allows for jointly testing these attributes and their sub-variation, called levels, on consumer trust in frontline solar intermediaries. As previously described, the attributes included are used by providers to overcome barriers to trust. Results from this experiment can help illustrate if these attributes are strongly associated with trust, and if there are dimensions of intermediaries that may enhance trust beyond the existing models. Trust is associated with both social capital and reputation, this conjoint survey experiment aims to understand the influence of different dimensions of social capital and reputation on trust in an intermediary for solar. In this section, I will explain why conjoint experiments may be helpful to test outcomes such as trust, which are multidimensional, and I will walk through the steps of designing and implementing this conjoint survey experiment.

Conjoint surveys started in the 1970s in marketing and product design research, but are increasingly applied to a range of issues and used by multiple disciplines (Rao, 2014). The use of conjoint surveys spans scholarship from political preferences (Hainmueller et al., 2014) to public health (Janssen et al., 2018) to energy policy (Friebe et al., 2013). While the applications of conjoint experiments have varied over time, the basic tenets have remained the same: ask respondents to either rate or choose between hypothetical profiles that combine a set of attributes and determine the relative influence of each attribute on the rating or choice (Hainmueller et al., 2014). Conjoint designs are particularly useful in comparison to other methods to understand multidimensional preferences (Horiuchi et al., 2018). During the process of a conjoint experiment choices made by respondents are based on variation in a set of attributes associated with each alternative in the choice set. In this case, the choice is based on the respondent’s trust in an intermediary.

In the process of a conjoint experiment, the options that underpin the choices or ratings are called a choice set, comprised of a set of alternatives.\(^9\) The levels of each attribute vary

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\(^9\)Hainmueller et al. (2014) also call the choice set a “task.”
**Figure 6-2:** Illustration of what a choice set looked like to respondents, with the two alternatives: A and B with variation in the levels of each attribute. In response to the question “which of the two would you trust more to help you get solar services?” respondents selected between profile (or alternative) A and B. This choice is used as the dependent variable, with the levels for each attribute as the key alternative-specific independent variables.

Across these alternatives, in this case, there are two alternatives each representing a different intermediary: Profile A and Profile B. Figure 6-2 illustrates what these choices looked like to respondents, although text was in Kiswahili rather than English. Figure 6-2 shows a paired, choice-based conjoint design, which evidence suggests better approximates real-world behavior than other survey options (Hainmueller et al., 2015). This approach allows for testing of the joint effect of different attributes on an overall judgment (Rao, 2014).

Choice-based conjoint experiments are increasingly used to study issues of service provision and distributive politics. Auerbach and Thachil (2018) use a conjoint survey experiment to study preferences for brokers in India. While brokers are a sub-set of intermediaries and studied in an urban slum context, this study by Auerbach and Thachil (2018) is the closest in kind to the research in this chapter, but there remain substantial differences between the conjoint experiment in this chapter and that of Auerbach and Thachil (2018). Primary differences between the two conjoin experiments include, the authors’ focus on dimensions of

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Appendix A.0.6 includes an image of the Qualtrics Offline App illustrating exactly what respondents saw as the survey instrument. A choice-based conjoint is also understood as a discrete choice experiment, as the instrument asked respondents to choose between two profiles rather than rate or rank profiles. Appendix A.0.6 also provides survey materials including attributes and levels in Kiswahili as presented to respondents.
ethnicity, partisanship, education (proxy for capability), and occupation (proxy for bureaucratic connectivity), whereas I focus on more malleable characteristics that can inform the design of intermediary models. The last two attributes in Auerbach and Thachil (2018) are similar in concept to the expertise and bargaining attributes used in my study, although operationalized quite differently. This study finds that lobbying capability (level of education) is more influential on broker selection than many group characteristics such as ethnicity or caste.\footnote{Auerbach and Thachil (2018) is a much larger study in scope and sample size than the conjoint survey experience conducted for this chapter, nevertheless it serves as a useful comparison for this and future work on intermediaries. (Krishna, 2011) also highlights the important of education for intermediaries, the naya neta\s studied in Rajasthan and Andhra Pradesh, although finds more of a basic threshold of education rather than such a strong influence of higher education, such as college, as Auerbach and Thachil (2018) find in their study of slum leaders as brokers.}

Previous applications of conjoint experiments to political problems and energy policies illustrate the use of this method to measure dimensions beyond just choice. Oliveros and Schuster (2018) test attributes of politicians on voter choice and test attributes of bureaucrats on perceptions of corruption and clientelism. This example provides the basis for operationalizing dependent variables beyond choice in the question which asks the respondent to select between profiles. Oliveros and Schuster (2018) examine dependent variables of corruption, political services, and work motivation all by asking questions aimed at measuring those attributes. For the conjoint experiment in this chapter, respondents were asked: which of the two would you trust more to help you get solar services? This question was designed to measure trust in the person respondents would go to for help getting solar services.

Like illustrated with data from Trans-Nzoia County in Chapter 5, respondents in this conjoint survey experiment also identified the importance of friends, family, and solar agents in building awareness about solar.\footnote{In Table 6.2, the “Other” category for awareness includes store and market and advertisement includes both radio and TV advertisements. The “Other” category for purchases includes family, friends, and market.} The emphasis on building awareness through social channels supports the characterization described in Chapter 5, although the respondents in this survey report relying on solar agents less for awareness, with agents as third, whereas in Chapter 5 data from Trans-Nzoia indicated solar agent was most common then followed by friend and family. Across both surveys these three channels for awareness are most commonly referenced. Table 6.2 illustrates who respondents may consider as the person they might turn to for help with solar.

6.3.1 Benefits and Limitations of Conjoint Survey Experiments

Compared to more traditional survey methods conjoint surveys can be used to estimate “the effects of causal components on respondents’ stated preferences without bias” (Hainmueller et al., 2014, 3). Conjoint surveys can jointly measure the influence of attributes on the choice of interest, which better measures multidimensional preferences and reflects a choice-based on “packages as a whole” (Horiuchi et al., 2018) which more closely approximates real choice settings.
Table 6.2: Summary Statistics for Questions Associated with Intermediary Roles for Awareness & Sales (N = 373), counts with percent provided in parentheses

<table>
<thead>
<tr>
<th>Awareness</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Friend</td>
<td>151 (40%)</td>
</tr>
<tr>
<td>Family</td>
<td>78 (21%)</td>
</tr>
<tr>
<td>Company agent</td>
<td>63 (17%)</td>
</tr>
<tr>
<td>Advertisement</td>
<td>49 (13%)</td>
</tr>
<tr>
<td>Other</td>
<td>32 (9%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Purchase</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Store</td>
<td>166 (45%)</td>
</tr>
<tr>
<td>Company agent</td>
<td>100 (27%)</td>
</tr>
<tr>
<td>Other</td>
<td>57 (15%)</td>
</tr>
<tr>
<td>Lending Group (Sacco, chama, etc.)</td>
<td>50 (13%)</td>
</tr>
</tbody>
</table>

The primary challenge faced by conjoint survey experiments is they are stated-preference surveys that do not actually capture real-world behavior, the choices between alternatives is limited to the hypothetical world of the survey experiment. This contrasts with revealed-preference data, which is observed data that represents a choice or decision actually made and in making that choice or decision reveal their preferences (Train, 2009).

Table 6.3: Benefits and Limitations to Conjoint Experiments

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conjoint experiment</td>
<td>Understand influence of multiple dimensions on a choice (more akin to reality)</td>
</tr>
<tr>
<td></td>
<td>Stated-preferences, unsure how respondents would actually act when faced with this choice</td>
</tr>
<tr>
<td>More traditional survey</td>
<td>Easier to administer, more straightforward questions</td>
</tr>
<tr>
<td></td>
<td>More difficult to understand relative influence of different dimensions on choices or behaviors</td>
</tr>
<tr>
<td>Revealed Preferences</td>
<td>Reflect decisions or behaviors that actually occurred</td>
</tr>
<tr>
<td></td>
<td>Difficult to obtain or, at times, nonexistent; research may want to examine alternatives that do not currently exist</td>
</tr>
</tbody>
</table>

One of the benefits of conjoint analysis is that each respondent in the sample can answer more than one choice set of hypothetical profiles. As illustrated in Figure 6-2, respondents in this survey responded to five rounds or five different choice sets with two profiles (A
and B). Asking respondents to respond to multiple choice sets increases the sample size without adding substantial cost to data collection. While more time is spent with each respondent, that is less costly than identifying new respondents. Additionally, using multiple attributes allows for testing of multiple hypothesis in one study, also more cost effective than alternatives (Hainmueller et al., 2014). While cost effective for practical purposes, responding to repeated tasks has the potential to introduce bias into the responses. Such biases include: carryover effects, profile order effects, randomization, attribute order effects, and atypical profiles (Hainmueller et al., 2014). Relevant diagnostics for this research are presented in Appendix A.0.7.

6.3.2 Data Collection

Data was collected in July 2019 in Yatta sub-county in Machakos County in Kenya with the Busara Center for Behavioral Economics. Busara assisted with preliminary field testing and data collection (including identifying enumerators), but I remained responsible for instrument design, Qualtrics management, and daily data quality checks during data collection. Yatta sub-county was selected by filtering out sub-counties in Machakos that have many households connected to the electricity grid (to increase the chances of people with solar) and then selecting sub-counties that would be feasible logistically. Within Yatta, three wards were selected given their likelihood to have solar users (Ndalani, Kithimani, and Matuu). As this survey focuses on understanding the experience of solar users, all respondents had some type of solar product in their home. In order to identify respondents with experience with solar products, community mobilizers were identified through referral to the Busara Center staff in each ward to identify potential respondents with solar or areas with high solar use. In the recruitment phase, the starting point in each village identified to have solar was random and then households with off-grid solar or those connected electricity grid and with off-grid solar were identified as potential participants. This was largely done using a snowball sampling technique: mobilizers asked for referrals for people with solar systems and recruited respondents based on their knowledge of the local communities.

At the recruitment phase, there were 487 potential respondents, from this a total a sample of 374 respondents were ultimately surveyed. During data collection, screening questions ensured that respondents had solar in their home, had a working knowledge of Kiswahili in order to respond to the choices included in the conjoint experiment, and have some involvement in household budgeting choices given that solar may compete with other items in a household’s budget.

---

13 Early conversations with the Busara Center indicated they prefer not to have foreign researchers at the point-of-collection as prior studies indicate bias in responses given a “white foreigner” effect that may alter responses (Cilliers et al., 2015).

14 The other conjoint survey conducted at the same time was about solar upgrades and therefore wanted to build on the experience of those with solar products in their household.

15 Other examples of conjoint experiments utilize images to overcome literacy barriers, for this experiment, the attributes did not lend themselves easily to images and therefore we relied on text. This is a limitation of the study, as a working knowledge of Kiswahili may bias our sample towards more educated, possibly
Design Limitations & Future Improvements

The instrument used in this study asked respondents to select between two profiles in response to the question “which of the two would you trust more to help you get solar services?” and while enumerators were trained to emphasize that this question is about which person the respondent would trust more, not just which to they prefer, this survey instrument did not measure if respondents behave differently in response to a question regarding trust compared to a question about their general preference or choice. An improved design would ask a portion of the sample about trust (question asked in current survey instrument), and the remainder would be asked “which of the two would you choose to help you get solar services?” This would allow for a better understanding of how effectively the instrument measured trust and can be pursued in future research. Prior scholarship suggests that including the key dependent variable in the question posed to respondents does influence the choices respondents make between profiles. Oliveros and Schuster (2018) use three questions in the same study to measure corruption, political services, and work motivation finding differences in the influence of attributes on each. This study illustrates a challenge of using trust as a dependent measure: it may be used as a proxy for many other concepts. Oliveros and Schuster (2018) use trust in a person to manage project funds transparently as an indirect proxy for lack of corruption.

This conjoint instrument asked people “who would they go to for help” aiming to understand preferences for intermediaries involved in after-sales services rather than who they would go to just to buy solar. Again, this study would benefit from a comparison of the two to see if they vary in the attributes that influence trust. As illustrated in Figures 5-4 and 5-5 there is some variation in who people go to for different stages of solar use, and therefore the attributes that influence trust in intermediaries at those stages may also vary.

An additional limitation of this instrument design is differentiating between trust in someone for solar services versus trust in someone more generally. Similar to differentiating between trust and choice, this study did not capture if trust in an intermediary for solar is any different than trust in a different intermediary or other person more generally. Future work may address this problem by examining attributes over different forms of trust (e.g. interpersonal or institutional) or attributes across the same form of trust applied to different issues, such as solar, food products, transportation or other goods and services.

Finally, this conjoint survey experiment used three screening questions (described in Section 6.3.2) that may differentiate this sample from the population. The three screening questions aimed to capture respondents that would be able to sufficiently answer questions about their solar use and participate in the conjoint survey experiment: presence of solar in the household, experience with household budgeting decisions, and working knowledge of Kiswahili. These screening questions may introduce bias into the sample compared to the general population in Machakos. Based on education statistics, 2007 data from Machakos County finds the primary school completion rate for boys to be over 80% and for girls just under 80% (EPDC, 2007), in my sample about 75% have completed primary school younger, respondents.
or achieved a higher level of education. While all included in this sample are literate, the literacy rate in Machakos is quite high, reported at 97-100% for both males and females (Kenya National Bureau of Statistics and ICF International, 2016). While findings from this survey should only be cautiously applied to other sub-populations, especially those that do not have solar in their households, the statistics on education and literacy suggest similarity to the broader population in the county.

6.3.3 Model Selection & Descriptive Statistics

In total, 373 respondents completed five choice sets each (resulting in a sample of 1865 choices, and 3730 alternatives/profiles). In Figure 6-2, these choices correspond to if the person selected “Choice A” that is coded 1 and then for the same choice “Choice B” is coded as 0. This binary choice is the dependent variable used in this analysis.

\[ y_{njt} = \begin{cases} 
  J = 1 & \text{if individual } n \text{ selected profile in round } t \\
  J = 0 & \text{if individual } n \text{ did not select profile in round } t 
\end{cases} \]

Table 6.4 illustrates the variation across attribute levels and choices. The raw counts presented suggest likely directionality associated with each level: outsider, politician, and government stand out as levels with much larger differences than the others.

<table>
<thead>
<tr>
<th>Attribute Levels</th>
<th>Total (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Embeddedness</strong></td>
<td>Elder</td>
</tr>
<tr>
<td>Choice = yes</td>
<td>680</td>
</tr>
<tr>
<td>Choice = no</td>
<td>563</td>
</tr>
<tr>
<td>Difference</td>
<td>117</td>
</tr>
<tr>
<td><strong>Bargaining</strong></td>
<td>NGO</td>
</tr>
<tr>
<td>Choice = yes</td>
<td>678</td>
</tr>
<tr>
<td>Choice = no</td>
<td>606</td>
</tr>
<tr>
<td>Difference</td>
<td>72</td>
</tr>
<tr>
<td><strong>Sector</strong></td>
<td>Company</td>
</tr>
<tr>
<td>Choice = yes</td>
<td>592</td>
</tr>
<tr>
<td>Choice = no</td>
<td>673</td>
</tr>
<tr>
<td>Difference</td>
<td>-81</td>
</tr>
<tr>
<td><strong>Expertise</strong></td>
<td>Financing</td>
</tr>
<tr>
<td>Choice = yes</td>
<td>650</td>
</tr>
<tr>
<td>Choice = no</td>
<td>644</td>
</tr>
<tr>
<td>Difference</td>
<td>6</td>
</tr>
</tbody>
</table>

As the four attributes are nominal (unordered categorical) variables, chi-squared tests be-
between pairs of attributes finds no association in the population between any of the attributes. Using a conventional p-value of \( \alpha = 0.05 \), the null hypothesis for relationships between each of these categorical attributes is that there is no association between each pair of attributes. For the two attributes aiming to measure social capital, embeddedness and bargaining, I fail to reject the null hypotheses at \( \alpha = 0.05 \) \((\chi^2(4, N = 3,730) = 1.1888 = p = 0.880))\). For the two attributes aiming to measure reputation, sector and expertise, I also fail to reject the null hypotheses at \( \alpha = 0.05 \) \((\chi^2(4, N = 3,730) = 6.1787 = p = 0.186))\). The relationship between these two is the strongest of all the attributes, with the lowest p-value of all the chi-squared tests. Examining the relationship of embeddedness to the two attributes aiming to measure reputation, I fail to reject the null hypothesis for embeddedness and sector \((\chi^2(4, N = 3,730) = 2.9261 = p = 0.570))\) and for embeddedness and expertise \((\chi^2(4, N = 3,730) = 2.7263 = p = 0.605))\). The association between bargaining and the two measures of reputation also fails to reject the null hypothesis at \( \alpha = 0.05 \), bargaining and sector \((\chi^2(4, N = 3,730) = 3.1790 = p = 0.528))\) and bargaining and expertise \((\chi^2(4, N = 3,730) = 2.6327 = p = 0.724))\). As none of the relationships between attributes reject the null hypothesis of no association in the population, I am not concerned with multicollinearity of attributes in my analysis.

To analyze conjoint survey experiment data, scholars and disciplines use different approaches. For this analysis, I use a McFadden’s choice model, a conditional choice model allowing for both individual-specific and alternative-specific variables (StataCorp LLC, 2019). The difference between each of these variable types is that,

- alternative-specific variables are the attributes that comprise the profiles presented in each choice set or task and will vary by each choice; and

- individual-specific variables include socio-demographics or other variables that describe the respondent and therefore vary by respondent, but are constant across all choices made by that respondent.

This allows for a panel data specification, common when each respondent makes more than one choice in a data set. While data set is referred to as panel data given the repeated observations for each individual, it does not have a temporal dimension as common in more typical panel data. Repeated choices from one respondent are accounted for with clustered standard errors at the individual-level. For this analysis, a McFadden’s choice model is a specific case of a conditional logistic regression that accounts for multiple choices over choice set \( t \) (Train, 2009, 51). McFadden’s choice model accounts for the variation in the choice alternatives, not just differences in the individual respondents (Hauber et al., 2016). Not all choice models use conjoint experiment data, choice models can be used on observed rather than stated-preference data. For conjoint experiments, the multiple observations for each respondent suggest this is an appropriate use of a choice model with panel specifications.

Based on Train (2009, 51), the model is specified as follows. The utility that decision-maker (or respondent) \( n \), obtains from alternative \( j \), in choice set \( t \) is specified as:

\[
U_{njt} = V_{njt} + \varepsilon_{njt}, \forall j, t \tag{6.1}
\]
\( \varepsilon_{njt} \) is a distributed extreme value (Gumbel-type) independent over \( n, j, \) and importantly, \( t. \) In this model \( V_{njt} \) is considered the deterministic component and \( \varepsilon_{njt} \) the random component of the utility function presented above (Rao, 2014, 155).

\[
V_{njt} = \beta'_j x_{njt} + \beta'_z z_n
\]  

(6.2)

Where \( x_{njt} \) is a vector of variables describing alternative \( j \) as faced by respondent \( n \) in choice set \( t \) (alternative-specific variables) and \( z_n \) is a vector of individual-specific control variables.

The choice probability is:

\[
P_{nit} = \frac{e^{V_{nit}}}{\sum_j e^{V_{njt}}}
\]  

(6.3)

Logit models can be used for choice-based conjoint data, for both choices greater than two (multinomial logit) and binary data, as is used in this analysis (logit) (Rao, 2014).\(^{16}\) Other disciplines, such as political science, use ordinary least squares to estimate a linear probability model for choice-based conjoint data (Hainmueller et al., 2014; Hainmueller and Hopkins, 2015), while other examples use hierarchical Bayesian methods for respondent-level part-worth utilities (Friebe et al., 2013; Rao, 2014).

### 6.3.4 Covariates and Controls

Using prior research on solar and guidance on measuring trust, covariates were included in the survey to capture demographic and socio-economic variables that may be related to a respondent’s trust in intermediaries. Studies on household energy choices frequently examine covariates including: income, energy expenditures, electricity access, head of household gender, age, household size, age, and education (Alem et al., 2016; Aklin et al., 2018). Controls such as education, gender, and income are also associated with variation in trust levels. Additional controls more specific to trust include social networks, governance and civic engagement, religion, identity, well-being, and personal security (OECD, 2017). As described earlier, in Section 6.2, management scholars identify a relationship between trust and familiarity or length of relationship with providers (Coulter and Coulter, 2002). In this survey these key variables related to trust were operationalized as prior use of solar, participation in lending groups, mother tongue (ethnic group), as well as variables already introduced such as where respondents purchased solar and how they heard about solar (see Table 6.2). But few individual-specific variables were statistically significant or resulted in improved model fit, Table 6.5 presents only those included in the final model.

As many of the variables collected were binary, ordinal, or nominal rather than continuous typical measures of correlation or linear association are not possible, therefore a series of polychoric correlations were calculated for continuous, binary, and ordinal variables. Chi-squared tests were used to test the association between nominal variables. Controls variables were selected with to have limited multicollinearity, for example, household size and number of school children had a correlation coefficient of 0.74 and were, therefore, not included in the

\(^{16}\)From Gelman and Hill (2007, 80) the function \( \logit^{-1}(x) = \frac{x}{1+e^x} \)
Table 6.5: Household demographics for respondents (N = 373), counts with percent provided in parentheses

<table>
<thead>
<tr>
<th>First solar</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes = 1</td>
<td>298</td>
</tr>
<tr>
<td>No = 0</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household size</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>min</td>
<td>1</td>
</tr>
<tr>
<td>max</td>
<td>15</td>
</tr>
<tr>
<td>mean (sd)</td>
<td>4.80 ± 2.15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Has electricity (KPLC)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes = 1</td>
<td>50</td>
</tr>
<tr>
<td>No = 0</td>
<td>323</td>
</tr>
</tbody>
</table>

model together. Similarly, for head of household gender and respondent gender, which had a polychoric correlation coefficient of 0.93 (although neither had a statistically significant effect when included in the model). Table 6.5 provides descriptive statistics on the control variables included and Table 6.6 provides the polychoric correlations for variables included in the model (not including nominal variables). Other variables with expected relationship to trust, such as *chama* participation or ethnic group were not statistically significant.

Table 6.6: Polychoric correlations for continuous, binary, and ordinal variables included in models (not appropriate for nominal variables)

<table>
<thead>
<tr>
<th>choice (DV)</th>
<th>First solar</th>
<th>HH size</th>
<th>Has electricity</th>
<th>Mo. Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>choice (DV)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First solar</td>
<td>1.604e-07</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH size</td>
<td>1.092e-12</td>
<td>-0.04950672</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Has electricity</td>
<td>2.085e-07</td>
<td>-0.04103112</td>
<td>-0.02612823</td>
<td>1</td>
</tr>
<tr>
<td>Mo. income</td>
<td>1.246e-07</td>
<td>0.2293858</td>
<td>-0.017617</td>
<td>0.27723168</td>
</tr>
</tbody>
</table>

6.4 Findings

Table 6.7 shows the results for four conditional choice models, illustrating key influences on trust in frontline solar intermediaries. Results show mixed support for the hypotheses presented in Section 6.2.2. The first model, indicated as Model 1: Base, is a main effects model with just the alternative-specific variables included as independent variables. The trends shown in this first model hold in significance, direction, and are similar in magnitude in the subsequent models as well. The second model, Model 2: Dummies, introduces dummy variables for village and enumerator, both variables are commonly used as control variables.
in survey data (see Rosenzweig (2018) as an example). The third model, Model 3: Controls, introduces first solar (is this current solar in the household their first solar, proxy for familiarity with solar), household size (number of people living in house), and connection to grid electricity (KPLC). As illustrated in Table 6.5, the sample is not balanced across groups with electricity access or those with more familiarity with solar. The inclusion of these control variables in Model 3 was determined by a Wald test of coefficients post-estimation, as likelihood ratio tests based on clustered standard errors are likely invalid because observations are no longer independent (UCLA: Statistical Consulting Group, 2020). Wald test results for Model 3 suggest that we can reject the null hypothesis that the coefficients for the three control variables are jointly zero in the population ($H_0 = \beta_{FirstSolar} = 0$ and $\beta_{HasElectricity} = 0$ and $\beta_{HHSize} = 0$ ($\chi^2(3, N = 3,730) = 14.99 = p = 0.0018$)). Including the control variables have little impact on the magnitude, direction, or significance of the alternative-specific attributes, but these additional variables improve the model fit as suggested by the Wald tests. Table 6.7 shows that for Models 1-3 the direction and magnitude of the coefficients remain consistent across models with additional control variables. The consistency of magnitude and direction of attribute coefficients across models suggests confidence in the modeled relationship between the four attributes of interest and choice in intermediary. Additional robustness checks for profile order and carryover effects are in Appendix A.0.7 and these tests also suggest relatively consistent magnitude and direction for the four attributes. Finally, the fourth model includes an interaction between affiliation and expertise. While the significance of $\beta_{TrainingsxNGO}$ only meets the threshold of $\alpha = 0.1$, the results are substantively compelling and discussed more later in this section.

The main effects models in Table 6.7 (Models 1 - 3) show some support for the hypotheses presented in Section 6.2.2 and some surprising relationships as well. Hypothesis 1 proposed that within the attribute embeddedness, those that are more embedded (family or elder) will be more trusted than an outsider. This is supported across all models; outsider is less trusted than either family or elder (reference case). Using the final main effects model, Model 3, the probability of trusting an outsider is 0.26, while the probability of trusting an elder is 0.39 (holding all other variables constant). The probability of trusting an outsider is 0.13 less than an elder. This finding supports the strong connection between embedded relationships and trust, but the difference between an elder and a family member is not statistically significant suggesting a stronger influence of insider versus outsider.

Hypothesis 2 proposed a strong, positive relationship between trust in an intermediary and a link to the service provider. Results in Model 3 support for this hypothesis at $\alpha = 0.01$, the probability of trusting someone with bargaining connections to the service provider is 0.45, 6% greater than someone with connections to an NGO, holding all other variables constant. This supports the data in Figure 5-5 that suggests brand or company is influential in who people go to for help with solar. The unexpected result from this attribute is that

\[
P(choice = 1 | outsider = 1) = \frac{\exp(\beta_0 + \beta_{Outsider})}{1 + \exp(\beta_0 + \beta_{Outsider})} = \frac{\exp(-0.46 + -0.58)}{1 + \exp(-0.46 + -0.58)} = 0.39
\]

17 Improved model fit with village and enumerator: $\chi^2(28, N = 3,730) = 3191.26 = p = 0.0000$. Often these dummy variables are termed “fixed effects” but I elected not to use that language to prevent confusing these control variables with estimating constant slope, group-level variation (see Gelman and Hill (2007, 245-246) for a discussion of this inconsistent terminology).

18 $P(choice = 1 | outsider = 1) = \frac{\exp(\beta_0 + \beta_{Outsider})}{1 + \exp(\beta_0 + \beta_{Outsider})}$
the probability of trusting someone with bargaining connections to politicians is much less than other external linkages. The mistrust of an outsider is comparable to the mistrust of those with linkages to politicians. From the two variables designed to capture the influence of social capital on trust in frontline solar intermediaries, there is support for the two initial hypotheses but the results also show the strong negative relationship between trust and politicians, even in a sector with relatively limited action from politicians.

Hypothesis 3 draws on the literature and long-standing involvement of NGOs in services in Kenya and proposed a positive association between trust and affiliation with NGOs or the government compared to the private sector. Results consistent across main effects models in Table 6.7 indicate that there is much more trust in intermediaries affiliated with the government, and actually the difference between the private sector or companies and NGOs is not significant. Based on Model 3, the probability of trusting someone affiliated with the government is 0.52 compared with the baseline of company affiliation, of 0.39 holding all other variables constant. The main effects models, show no support for hypothesis 4, respondents did not trust an intermediary that provided one form of expertise compared to another: all three levels of expertise have no statistically significant difference.

The interaction effect of $\beta_{\text{Training} \times \text{NGO}}$ was not initially anticipated in this this study, but Model 4 is included in Table 6.7 for as it suggests a potentially interesting future area of research. No other interaction effects were statistically significant, and Training $\times$ NGO is only significant at $\alpha = 0.1$. Result from a post-estimation Wald test suggest that we cannot reject the null hypothesis that all levels of the interaction term are jointly zero in the population ($H_0 = \beta_{\text{Information} \times \text{Government}} = 0$ and $\beta_{\text{Information} \times \text{NGO}} = 0$ and $\beta_{\text{Training} \times \text{Government}} = 0$ and $\beta_{\text{Training} \times \text{NGO}} = 0$ ($\chi^2(4, N = 3,730) = 5.12 = p = 0.275$)). Model 4 is not the most parsimonious model, but suggests an interesting finding to explore in future work: trust in frontline solar intermediaries affiliated with NGOs varies by the expertise they provide. As the final main effects model (Model 3) did not find a statistically significant difference between affiliation with a company and an NGO, comparing the effect of the interaction between companies and NGOs may suggest differences in trust. Holding the other attributes constant at elder and connections to NGOs, the probability of trusting companies that provide training is 0.37 while the probability of trusting NGOs that provide training is 0.42, a 5% difference. While Model 3 provides the most parsimonious model to describe the influence of embeddedness, bargaining connections, sector affiliation, and expertise on trust in an intermediary, Model 4 is worth exploring in future research.

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19 $P(\text{choice} = 1|\text{government} = 1) = \frac{\exp(\hat{\beta}_0 + \hat{\beta}_\text{government})}{1 + \exp(\hat{\beta}_0 + \hat{\beta}_\text{government})} = \frac{\exp(-0.46 + 0.51)}{1 + \exp(-0.46 + 0.51)} = 0.52$

20 While these models have clustered standard errors, so McFadden’s $R^2$ estimates are likely invalid they are included here for illustrative purposes using the formula: Pseudo $R^2 = 1 - \frac{\ln(L_{\text{full}})}{\ln(L_{\text{intercept}})}$ with $\ln(L_{\text{intercept}}) = -1291.8$ and the model estimates in Table 6.7. Pseudo $R^2$ Model 1 = 0.068, Pseudo $R^2$ Model 2 = 0.099, Pseudo $R^2$ Model 3 = 0.104, Pseudo $R^2$ Model 4 = 0.105.

182
6.4.1 Comparing to Ranked Attributes

In addition to the conjoint choice experiment, each respondent was asked to rank the four overall attributes: sector affiliation, embeddedness, bargaining linkages, and the activities or expertise intermediaries provide. While respondent answers suggest strong distrust of outsiders and those with connections or linkages to politicians, both classified as dimensions of social capital, expertise a dimension of reputation, was ranked highest by almost 48% of respondents. This comparison illustrates some of the pros and cons of conjoint experiments and other survey approaches.

In the main effects model, respondents did not trust intermediaries providing one type of expertise more than another, but as indicated in Figure 6-3 many respondents reported that expertise as a general attribute is important to why they trust someone. On the other hand, the results from the conjoint experiment indicate that even if respondents report that an attribute, such as expertise is most important, when paired with another dimension influencing the same choice, such as being an outsider or having connections to politicians, they may weight other attributes more in the moment when they make their decision about who they trust more.

Figure 6-3: Ranks of four attributes: embeddedness, bargaining connections, sector affiliation, and expertise; completed by respondents after they finished all five choice sets. Respondents were asked: “Of the attributes we just discussed in the previous choices, please rank them from most important in why you trust someone to help you get solar services to least important in why you trust someone to help you get solar services, with 1 indicating most important and 4 being the least important.”
6.5 Discussion

Findings from this conjoint survey experiment support prior descriptions of trust and also highlight the importance of examining dimensions of trust stemming from multiple disciplinary perspectives. For off-grid solar, dimensions highlighted by both sociology and management influence trust in frontline solar intermediaries. For practitioners, as illustrated by the quotation from SolarAid in the beginning of this chapter, trust stems from more than just initial social capital, but may be enhanced by strategic partnerships or collaborations.

Social capital is frequently described by both political scientists and management scholars as intertwined with trust – both a cause and an effect of trust.21 I find a strong negative association with outsider but more trust in insiders from the community – this supports the importance of embedded social relationships for solar services in Kenya. While the lack of trust in outsiders is strong, the difference between intermediaries who are elders and family members is not statistically significant suggesting the difference between insider and outsider is much stronger than differences within one’s group. The personal connections of group leaders and embedded entrepreneurs (see Figure 5-6) suggest this strong link between an embedded intermediary and trust. The difference in trust between insiders and outsiders also suggests some caution in the variety of models used. As proposed by the typology in 5-6, intermediaries such as head-teachers – one case of a community influencer – often use a more extended network than their close, personal connections. Where insider status is uncertain frontline solar intermediaries may be trusted by some, but not by all.

Findings in Table 6.7 suggest that it matters who within government is associated with frontline solar intermediaries. Prior scholarship finds more trust in government to provide electricity services than the private sector (Aklin et al., 2018), but my findings suggest a more nuanced view of trust in government institutions in Kenya. Both bargaining connections to politicians and government affiliation are statistically significant and similar in magnitude, but with opposite directions. Respondents trust intermediaries affiliated with government more than they trust those affiliated with companies or NGOs. On the other hand, respondents trust intermediaries with bargaining connections to politicians less than those with connections NGOs or service providers. Mirroring the variety of experiences people have with solar providers, the opposite directions for government and politicians suggests that people experience different aspects of the government in different ways as well, with implications for trust. The difference between general government affiliation and connections to politicians aligns with findings that suggest politicians in Kenya do not have the interests of people in mind, while civil servants act – to some extent – with more public interest (Brass, 2016, 198). Brass (2016) finds much more support for Kenyan and international NGOs, which is not supported here, and surprising given the strong distribution of off-grid solar from NGOs, including One Acre Fund.22

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21 See Putnam (1995) and Nooteboom (2007) and my discussion in Section 6.2 of this chapter.

22 The distrust of those with bargaining connections to politicians suggests that potentially distributive politics for off-grid solar function differently than for electricity or other services. Prior scholars emphasize the politicization of electrification (Min, 2015) and the role of intermediaries in developing these bargaining connections for other services (Krishna, 2011).
Even without strong action from government to implement or enforce off-grid solar quality standards, as discussed in Chapter 3, the trust in affiliation with the government mirrors other research illustrating historical optimism about government and trust in a range of government institutions (Wolf et al., 2004). Historically, responses in the Afrobarometer survey suggest strong trust in multiple political institutions – from the Presidency to Parliament and local elders (Wolf et al., 2004). My findings also suggest some potential changes in political trust in Kenya, respondents in this conjoint experiment did not trust politicians as much as others. Changes in political trust in Kenya may mirror more recent trends in devolution of services and responsibilities to county governments in Kenya (USAID, 2019).

6.5.1 Sector Matters in Surprising Ways

The results from sector affiliation also suggest that people do not strongly differentiate between NGOs and private companies. This blurring of sectors (see MacLean and Brass (2015) and Section 2.2.3) and what solar providers offer to consumers is supported as there is no significant difference in trust in intermediaries affiliated with NGOs compared to those affiliated with the private sector. The split in trust across the three levels of expertise – one was not trusted more than another – also supports that the increasingly wide range of activities solar providers offer is resulting in consumers concerned with many different aspects of solar services. What consumers believe they must or should know about solar is not consistent across respondents as they seek varying types of expertise from frontline solar intermediaries. The comparison between the ranked attributes in Figure 6-3 and the results in Table 6.7 highlights that expertise is influential on consumer trust generally and consumers rely on intermediaries for a range of expertise, but one form of expertise is not currently more trusted than another.

Alongside the increasing specialization in the off-grid solar sector, there are opportunities for cross-sector partnerships that reinforce existing patterns of consumer trust. As described in Chapter 2, vertically integrated off-grid solar companies tried to do everything from manufacturing to financing, but that is changing. Model 4, which tests if trust in an intermediary affiliated with a particular sector varies by expertise, shows that NGOs may be able to provide trusted training more than others. An NGO actively working on energy access in Kenya supported this idea in Kenya, sharing that,

“...with time we’ve seen that the private sector has developed and so we are less and less being involved in the actual technology development. So initially, [this NGO] was seen as, you know, a place where we had engineers and people who are very much focused on developing the technology, but now we are playing a much more facilitative role and looking at how do we help people to harness that transformational power of clean energy” (interview 190610).

The results from this conjoint experiment support the observation that the role of NGOs is evolving in off-grid solar. Increasingly, NGOs leverage their strategic ability to provide trusted training in tandem with the activities from solar companies and government agencies.
6.5.2 Building Trust in Off-Grid Solar

The importance of trust in frontline solar intermediaries is already recognized by solar providers, provider accounts suggest trust built by these intermediaries enhances adoption of solar. But often trust is described in somewhat general terms associated more strongly with embeddedness and social capital than other sources of trust. This experiment suggests that frontline solar intermediaries – and the providers designing distribution models – should consider multiple sources of trust.

Intermediaries are often effective when they can strike bargains across parties, acting as brokers (see Table 4.4) but trust is not even across intermediaries with connections to different sources of influence. The attribute of external linkages, representing bargaining capacity, illustrates that as proposed in this research, intermediaries are most trusted when they have these links to service providers. This suggests that extensive layering (described in Chapter 5, with particular relevance to solar agents), where sub-agent networks reduce the connection to service providers, has the potential to negatively influence consumer trust in intermediaries. While links to the service provider are more trusted, links to politicians are less trusted suggesting that service providers must be aware of political risk in frontline solar intermediary models. More research is needed to understand the complexity of mistrust in frontline solar intermediaries with connections to politicians and if this mistrust is broader than off-grid solar, or specific to intermediaries acting in this sector.

Providers in Kenya can turn to the successful example of Bangladesh to understand both the political risks of off-grid solar programs and effective government interventions and partnerships for off-grid solar diffusion. While Kenya’s solar development has often been private-sector led, Bangladesh suggests an alternative model with stronger government involvement in solar investments and programs (Khandker et al., 2014). Stronger government action supporting off-grid solar in Kenya is just emerging with the Kenya Off-Grid Solar Access Project and given the stronger trust in government affiliated intermediaries, there is potential to leverage new partnerships and collaborations with civil servants to enhance trust in off-grid solar models.

Within Kenya, most government activity in solar has focused on developing a licensing program for solar technicians and on establishing technical quality standards. But the influence of government training programs appears to have limited influence on trust in solar. In her description of what it is like to be an agent in Kakamega, Sharon – the agent in Chapter 5.4.1 – described that few solar shops know of or act upon the technician licenses granted by the Energy and Petroleum Regulatory Authority and Figure 3-4 indicates the limited penetration of certified technicians to rural areas in Kenya. Regulatory agencies may enhance future trust in training programs by pursuing partnerships with local NGOs rather than establishing independent training programs, such partnerships may tap into trust in both government and NGOs. Ultimately the stronger trust in frontline solar intermediaries affiliated with the government but with the ability bargain with service providers, suggests that enhancing existing models by leveraging the relative strength of different sectors may enhance trust in frontline intermediaries which will, in turn, support adoption, consumer-education, and the longer-term sustainability of off-grid solar services.
Earlier in this chapter (see Section 6.2.1), the dimension of expertise emphasized the importance of consumer knowledge to trust and the next chapter explores the extent to which different intermediaries are able to build this consumer knowledge. Scholars recognize the key role of intermediaries in taking information and reframing it in a manner that supports knowledge creation that may spur action (Lee, 2011). The next chapter provides a baseline of consumer knowledge about off-grid solar in Trans-Nzoia County and examines if that knowledge varies by intermediary type.
Table 6.7: McFadden's Choice Models, "which of the two would you trust more to help you get solar services?" Dependent Variable: choice (0 = No/1 = Yes), coefficients in logit

<table>
<thead>
<tr>
<th>Model</th>
<th>Model 1: Base</th>
<th>Model 2: Dummies</th>
<th>Model 3: Controls</th>
<th>Model 4: Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Embeddedness</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Reference</td>
<td>Elder</td>
<td>NGO</td>
<td>NGO</td>
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<tr>
<td></td>
<td>Family</td>
<td>-0.0739 (-0.85)</td>
<td>-0.0826 (-0.92)</td>
<td>-0.0880 (-0.99)</td>
</tr>
<tr>
<td></td>
<td>Outsider</td>
<td>-0.540*** (-5.75)</td>
<td>-0.569*** (-5.82)</td>
<td>-0.578*** (-5.87)</td>
</tr>
<tr>
<td></td>
<td>Bargaining</td>
<td></td>
<td></td>
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<td></td>
<td>Reference</td>
<td>NGO</td>
<td>NGO</td>
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<tr>
<td></td>
<td>Politicians</td>
<td>-0.547*** (-6.30)</td>
<td>-0.579*** (-6.40)</td>
<td>-0.578*** (-6.37)</td>
</tr>
<tr>
<td></td>
<td>Service provider</td>
<td>0.211* (2.42)</td>
<td>0.237** (2.61)</td>
<td>0.236** (2.59)</td>
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<td></td>
<td>Affiliation</td>
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<tr>
<td></td>
<td>Reference</td>
<td>Company</td>
<td>NGO</td>
<td>NGO</td>
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<tr>
<td></td>
<td>Government</td>
<td>0.479*** (5.28)</td>
<td>0.507*** (5.41)</td>
<td>0.515*** (5.48)</td>
</tr>
<tr>
<td></td>
<td>NGO</td>
<td>-0.00373 (-0.04)</td>
<td>0.0131 (0.15)</td>
<td>0.0149 (0.17)</td>
</tr>
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<td></td>
<td>Expertise</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Reference</td>
<td>Financing</td>
<td>NGO</td>
<td>NGO</td>
</tr>
<tr>
<td></td>
<td>Information</td>
<td>-0.0777 (-0.85)</td>
<td>-0.0925 (-0.96)</td>
<td>-0.0861 (-0.89)</td>
</tr>
<tr>
<td></td>
<td>Training</td>
<td>0.0421 (0.44)</td>
<td>0.0555 (0.57)</td>
<td>0.0574 (0.58)</td>
</tr>
<tr>
<td></td>
<td>Affiliation x Expertise</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Information × Government</td>
<td>0.232 (1.16)</td>
<td></td>
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<tr>
<td></td>
<td>Information × NGO</td>
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<td></td>
<td>Training × Expertise</td>
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<td>NGO × Government</td>
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<td></td>
<td>Government × Government</td>
<td>0.0033 (0.04)</td>
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<td></td>
<td>Government × NGO</td>
<td>0.479 (2.82)</td>
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<td>NGO × NGO</td>
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Chapter 7

Building Knowledge about Consumer Safeguards with Frontline Solar Intermediaries

7.1 Introduction

Building stronger consumer knowledge strengthens protections for the off-grid solar sector and encourages accountability more broadly. Building trust in a new technology to enhance adoption requires providing adequate information about new technology (Scott, 2017), but Section 3.5, illustrates that information alone does not translate to actionable knowledge beyond adoption: people may be aware of warranties and still not use them when a solar product breaks-down.

Information alone is rarely enough. In Kenya, other scholarship found limited influence of information on individual or collective action (Lieberman et al., 2014). The effectiveness of information is often associated with additional activities, such as training sessions that may enhance the use and maintenance of solar systems (Baldwin et al., 2015), targeted education campaigns through schools and existing self-help groups (International Energy Agency, 2017b), or building on-the-ground capacity for help and repairs (Joshi et al., 2019).\textsuperscript{1} Frontline intermediaries may be able to provide this ongoing engagement as local resources that can answer questions and provide connections back to the solar distributors and manufacturers.

Off-grid solar providers recognize the gap in consumer knowledge and are actively trying

\textsuperscript{1}If the individual incentives are strong enough, information provision may build awareness of programs and encourage individuals to act on that information. Banerjee et al. (2018) finds that mailing flyers about government programs, does affect program participation with the opportunity for information to equalize unequal implementation of government programs. In this case, it is unclear if information on government welfare programs is directly comparable to consumer protections information, such as warranties, as it requires more than just enrolling in a program but an understanding of technology performance, warranty length, and repair or replacement policies. Decades of inaction on energy efficiency despite labeling efforts suggests that the effect of information may not be uniform across programs or topics (Newell and Siikamiikki, 2014; Waechter et al., 2015).
addressed issues associated with PAYGo solar knowledge – but it is a work in progress. As more providers use PAYGo financing options, knowledge about increasingly complex solar services is beginning to take hold. As one provider described in response to the question: do you find that the pay-as-you-go model is relatively clear to customers?

“No, [laughter], yes and no. I think with time we are getting there because the fact that most of the other companies are also moving to the pay-as-you-go model makes it much easier. But there’s still a lot of awareness of pay-as-you-go and education that needs to [happen] – especially if you still have both options. So, you could pay-as-you-go or you could just buy cash up front or it’s a higher purchase, so the fact that there’s still a couple of different models is still a bit confusing so we need to create more awareness. But I would say we’re getting somewhere, if I compare with a year ago....One key thing is the customer education at all touch points, from the agent, to the call center, to the technician, to the shop...it’s more of education at all levels that we are pushing” (interview 190619).

This quotation illustrates that intermediaries are one prong of a consumer education strategy. Education efforts are improving, especially as multiple companies address common challenges with evolving, and increasingly complex, off-grid solar services.

Examining consumer experiences in after-sales services and engagement with customers on consumer safeguards suggests areas of potential improvement in off-grid solar services. Responsive solar services often stem from the frontline solar intermediary, often a solar agent. On-the-ground interactions with intermediaries may provide customers help when needed, or may leave them trying to contact the company on their own or resort to asking a local electrician. Building on the different types of frontline solar intermediaries examined in Chapter 5, this chapter examines if different intermediaries influence consumer knowledge as one dimension of the consumer experience and critical for implementing consumer safeguard regimes from the non-state organizations and government agencies, such as the Kenya Bureau of Standards.

International and domestic policies and programs that support quality assurance and consumer protections require certain information to be included in product labeling and such efforts appear to have encouraged familiarity with warranties in rural Kenya. Labeling and performance requirements are big steps forward in developing awareness about product quality and building consumer confidence. In Figure 5-3a, it is evident that solar companies are making an effort to expose consumers to these quality assurance efforts, especially the 2-year product warranty. While labeling and advertisements may increase recognition of a warranty symbol or familiarity with the concept, it is less clear if labeling efforts are translating to knowledge that can inform how to actually use safeguard frameworks.

Frontline solar intermediaries, such as solar agents or entrepreneurs, extend the training they receive from providers to end users through their in person interactions. Agent training from providers, for example, aims to provide solar agents with knowledge about how to use their solar system, how long the battery will last on different settings, storage, safety, and payment terms. Companies like Sun King provide solar home system users with a detailed
installation guide that illustrates how the different system components should be placed, spaced, and attached. Often, it is the agent or a technician that does this installation or for larger systems, not the end user. Nevertheless, as described in Chapter 5, consumer knowledge about solar systems can be critical for safety and product performance.

But not all solar users keep or use the user manuals that come with products to guide installation and use of their solar products. In my survey of Trans-Nzoia County, of those with solar in the sample, 82% reported that their solar came with a user manual, and of those with a manual, 63% reported using their manual. This equates to about half of those with solar using their manual, and the other half never engaging with this source of information. With inconsistent use of items like manuals, the education provided by frontline solar intermediaries is even more important.

Training curricula for solar agents and on-the-ground company representatives are proprietary and it is difficult to know exactly what and how these intermediaries are trained. While licenses from the Energy and Petroleum Regulatory Authority (EPRA) follow an established technical training curriculum, the overlap between this curriculum and company or NGO training curricula is uncertain. Sharon, the agent in Kakamega, reported that certifications from EPRA licenses are not very influential in the hiring or training of agents. Rather, it is on local company staff – the shop managers or regional coordinators – to train local intermediaries. Or in some cases, NGO-company partnerships provide opportunities for NGOs to train local entrepreneurs. Evidence from Chapter 6 suggests that NGOs may play a role in enhancing trust in frontline intermediaries with training programs. With the case of NGO trained entrepreneurs, it is unclear if they have a continued point-of-contact after the training, at least for agents and group leaders there is some continued training and engagement. This ongoing engagement is strongest for agent networks that leverage regional agent meetings, platforms such as WhatsApp for immediate questions, and retraining efforts (either in-person or via mobile apps).

How consumers learn about the complex dimensions of solar access and use, such as quality and consumer rights, is not fully explored in the existing literature on off-grid solar technologies and services. To go from information provision to behavior change, there are different conditions or experiences that may influence whether information is used to take action or make a change. Such conditions typically begin with understanding or comprehension of information and eventually require people to believe that action will have an impact (personally or encourage others to act) (Lieberman et al., 2014). Gaps may exist at various stages in the process of going from comprehension to action. This chapter begins to chart out that process for off-grid solar, establishing a baseline of knowledge associated with off-grid solar.

Intermediaries may act at multiple stages in the process of information provision and overlooking their role in this process may provide an inaccurate picture of where action occurs. Even frontline intermediaries may respond to the information from providers, not only

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2 One consideration was if manuals are in languages people understand, in the market I saw solar lanterns with Hindi on them rather than Kiswahili and also saw full manuals with both English and Kiswahili – so there was some variation in language. Nevertheless, 89% of survey respondents state that they think a solar manual will be in a language they understand.
individual consumers or citizens act on provider information. Scholarship on intermediaries recognizes that often intermediaries take more generic information and identify the essential or most relevant content and, if needed, repackage information in the most coherent manner for those that need to act on it (what Lee (2011) calls “coding” and “linking”). This specific intermediary role is considered a “knowledge broker” – one who mediates knowledge between two groups to make complex knowledge relevant (Boari and Riboldazzi, 2014). Often intermediaries acting as knowledge brokers are gatekeepers; they take information available to them from providers and make it more salient to local perspectives or needs.

The ability of knowledge brokers to make information more salient to the local community reflects the rationale companies use for recruiting agents local to the sales regions, as they “they know the people...they understand the behavior” (interview 190619, see Section 5.4.1). At times, agents can selectively share information to further their personal gain, rather than broader goals of honesty and transparency, but company incentive structures are beginning to recognize the need to explicitly encourage truthfulness. In the process of going from information to behavior change, frontline solar intermediaries can make information relevant to enhance opportunities for action and accountability.

Literature on knowledge brokers emphasizes understanding, often qualitatively, what these intermediaries may do in certain situations, but continued work is needed to examine how the characteristics of knowledge brokers apply beyond single case studies and across broader contexts. Scholarship on information interventions examined in field experiments and randomized control trials (Lieberman et al., 2014; Banerjee et al., 2018) is beginning to explore the nuances of what it means to go from information to behavior change or action. In this chapter, I sit somewhere between the two, while using survey data it is not an experiment or RCT, I use this quantitative data to examine the variation in frontline solar intermediaries acting as knowledge brokers in off-grid solar.

Existing data on consumer knowledge about off-grid solar is difficult to come by, few are actively measuring what people know about solar (and measuring knowledge about solar is, in and of itself, quite difficult). As a service provided primarily by companies, data on consumer behavior, intermediary models, and training programs is often considered a part of their competitive advantage. Results indicate that knowledge about off-grid solar is, for some measures, quite good. For example, almost all respondents (95%) knew that if you stopped paying for your solar it would be locked or repossessed and 90% knew that a warranty can be used for repair or replacements. On the other hand, only 32% know that electricity from solar home systems is direct current (or DC), underscoring the importance of building knowledge about safety and compatibility for off-grid solar components and appliances. Finally, only 21% reported knowing the government agency responsible for ensuring consumers are protected from fraudulent companies, this indicates, that accountability for failed systems or inaccurate information about solar may be weak.

Solar agents – while not as socially embedded as other intermediary types – function as a critical knowledge broker for off-grid solar. Second, to agents are mafundi (electricians/repair people). In Chapter 5 I discussed local electricians as a key resource for solar but that they lack the connection to service providers for intermediation. Consumers do value this link
between agent and company: 54% of those who would go to an agent care that they are affiliated with a company, compared to the majority of those who would go to an electrician do not care about their affiliation (73.8%). Comparing those who people learn about solar from (awareness) and those they go to for help, agents are present in both categories while electricians emerge as an important actor for ongoing assistance. Overall both have a positive association with consumer knowledge, but do not fill the same role as intermediaries: agents are valued for that connection to companies.

7.2 Effective Information from Knowledge Brokers

The use of intermediaries to make information into salient, actionable knowledge is applicable to areas and contexts beyond off-grid solar in rural Kenya, but this case provides an example of how different intermediaries may act to enhance the adoption, use, and consumer experience with new technologies and services. Like the notion of intermediaries more broadly, brokers are studied across contexts, from information provision to key services. The concept of a knowledge broker is most frequently discussed applied to intermediaries acting in innovation systems or to promote innovation within organizations. In Chapter 4, the role of a broker (as compared to facilitator or configurer) is an intermediary involved in “active negotiation, bargaining, or representation that bridges a gap in social connection or interaction to provide access to resources, goods, or services” (see Table 4.2). Knowledge brokers actively mediate access to, and the flow of, information between actors (Boari and Riboldazzi, 2014), and often, repackage or identify the most relevant information at the in-between stage.

Unlike other forms of brokerage, knowledge brokerage has not been examined within the context of local services in this broad body of literature. More often knowledge brokers are examined as organizations (Boari and Riboldazzi, 2014) and focus on the science-policy interface (Ward et al., 2009). Intermediaries acting to transfer knowledge have the potential to engage in a process of mutual learning based on dialogue, reflection, and the co-construction of new, potentially more relevant, knowledge (Wolfe, 2006). Knowledge brokers can engage in acts of linking and exchange, capacity building, and shifting information into practice (Ward et al., 2009). Transferring what is often examined at an organizational-level to individual frontline solar intermediaries requires examining service provider training curricula to identify what kind of knowledge brokerage, if any, do they encourage; and how the ongoing interactions between frontline solar intermediaries and consumers may encourage or inhibit different forms of knowledge creation.

Applying the concept of knowledge brokerage to off-grid solar highlights the importance

\[ ^3 \text{Scholarship on knowledge brokers specifically acting in areas of development, suggests that researchers have a unique role as research brokers in improving policy an practice to support evidence-based “pro-poor” decision-making (Fisher and Vogel, 2008). Cvitanovic et al. (2015) differentiate different forms of exchange between researchers and policy-makers as: co-production, embedding, knowledge broker, and boundary organizations. Here, knowledge brokers facilitate the exchange of knowledge as an individual primarily within one group (e.g. researchers, or in my case, solar users) and build networks and relationships with external actors that facilitate knowledge exchange.} \]
of considering what individuals do with information and how intermediaries in this sector engage at different stages of information use and processing. In Figure 7-1, I build on prior work that examines information use and intermediaries: information to action from and the role of intermediaries acting to synthesize information (from Lieberman et al. (2014) and the discussion of interest intermediaries and information in Lee (2011)). I propose that not all knowledge brokers are necessarily acting to achieve the same goals. The current focus in off-grid solar is on comprehension of information above other outcomes such as salience, connection to resources, and building broader value. One example of this emphasis on end-user comprehension of information rather than other stages in Figure 7-1, is that company call centers conduct follow-up calls with customers that verify the ability to recall information provided by solar agents.⁴

Transparency, in particular for public policy goals, has been studied for decades. Applied to key services, such as public health or in this case basic electricity access, the “action cycle” of transparency includes four stages: value and salience to users, users act on information, providers sensitive to users’ actions, and providers respond constructively; and so, the cycle continues iterating along these four stages (Kosack and Fung, 2014, 71). The series of questions in Figure 7-1 fall within the first two stages of providing salient and valuable information resulting in action. The second two stages of this action cycle require a “constructive response by providers who are sensitive to the users’ actions” (Kosack and Fung, 2014, 73). These latter two stages of the action cycle suggest that providers are required to care about consumer actions, or care for some other reason associated with organizational goals (e.g. solar providers linked to NGOs or – possibly – social enterprises with social goals beyond profit). While this chapter focuses on these first two stages, limitations or gaps in the latter two stages of the cycle may help explain why, for example, there is little actual use of warranties for solar in Kenya.

How or if, intermediaries can act to make information relevant, may help overcome some of the challenges associated with behavior change. The increase in sharing of information from organizations across sectors – in particular government and companies – falls under broader goals for enhanced transparency. Enhanced information transparency about solar, in theory, may enable solar users to hold providers and government agencies accountable for quality, reliability, and recourse (if needed) for off-grid solar services. But like many of the discussions about information access, or disclosure, information interventions alone have inconsistent effects (Lieberman et al., 2014; Kosack and Fung, 2014). Potentially, effective frontline solar intermediaries can enhance transparency efforts to achieve behavior change, data-backed decision-making, or accountability.

From the perspective of solar providers, transparency is central to enhancing the provider-consumer relationship for repayment and future sales and providing transparent information is a key responsibility of frontline solar intermediaries. Frontline solar intermediaries are not only responsible for information about the solar system itself, but increasingly about

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⁴Follow-up calls do not aim to identify areas of insufficient consumer awareness, such as compatibility issues, that are associated with consumers plugging in incompatible components resulting in safety hazards (e.g., fires see Section 5.2.3) or ensure a customer’s ability to file a complaint or take action on a warranty if needed.
Figure 7-1: Bridging the flow of knowledge to action from Lieberman et al. (2014) with the information-focused actions of intermediaries from Lee (2011), with the addition of four goals of knowledge brokerage: comprehension, salience, resources, and value. Below the information on coding and linking, I provide more generalized actions for intermediaries at each stage of coding and linking.

When Might Information Generate Citizen Action? (Lieberman et al. [2014])

- Does citizen understand information?
- Is the information new?
- Does citizen now prioritize the issue area?
- Does citizen now feel responsibility to act?
- Is the citizen now aware of what actions to take?
- Does citizen now have skills for taking action?
- Does the citizen now have a sense of efficacy to think his/her actions will have an impact?
- Does citizen believe his/her actions will have an impact?

Knowledge Brokers

Comprehension

1. Coding: make information systematic and comprehensible (Lee 2011)
   - Particularly salient when intermediary has more technical capacity to filter, analyze, and understand information (Lee 2011)
   - Requires understanding of norms, community, behaviors to help make people care about or finding meaning in the information provided (local connections)
   - Explain technical considerations in a manner that resonates or is salient to end-users

Saliency

Resource

Value

2. Linking: validate information for practical use (Lee 2011)
   - "Information does not automatically turn into something with immediate use value. It should be situated within and validated through actual practices to be trustworthy from the recipient’s perspective if it is to be made usable" (Lee 2011, 143)
   - Shift in focus to more action-oriented activities
   - Leverages the trust build with individuals and communities to provide hands-on examples, training, or capacity building
     - Reputation, social capital
   - Acts to encourage peer-to-peer engagement and accountability (collective)

Action
financing and even other services being offered by solar providers. As described in Chapter 2, burring the boundaries between solar and financial services is associated with new issues of transparency, data privacy, and equity.

### 7.2.1 What should consumers know about off-grid solar?

Efforts like Lighting Global’s Quality Assurance measures or, specific to Kenya the Kenya Bureau of Standards (KEBS) quality label, indicate basic measures of performance for consumers. Prior evidence from this research suggests that such quality indicators are not as important to consumers in Kenya as other dimensions of solar, such as company (see Figure 3-3), but the KEBS quality label may be more important to Kenyans users than international certifications. Nevertheless, such certifications often guide company information disclosure or labeling efforts they extends to multiple countries and often form the basis for country-level standards (interview 190725). Based on efforts to enhance transparency and promote quality standards for solar, labels like the example in Figure 3-6 illustrate some of the key pieces of information consumers should know from product labels and education from frontline solar intermediaries.

Honesty of frontline solar intermediaries was not directly measured for this research, but I focus on a comparable measure of consumer knowledge: are intermediaries conveying critical information to consumers such that they can recall the correct answer? From a standards perspective, labeling and information requirements from efforts like Lighting Global aim to enhance transparency about solar product information, such as lumens, runtime, and warranty duration. Across the four goals outlined in Figure 7-1, I propose a range of measures in Table 7.1 to reflect consumer knowledge about off-grid solar aligned with the goals of providing useful, actionable knowledge. Not all the measures indicated in Table 7.1 are included in this chapter’s analysis, as this work primarily focuses on role of intermediaries in information coding, in particular a baseline of information comprehension.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Description</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comprehension</strong></td>
<td>ability to recall information related to solar use and safeguards</td>
<td>terms &amp; conditions; technical specifications</td>
</tr>
<tr>
<td><strong>Salience</strong></td>
<td>illustrates knowledge about why information is important</td>
<td>possible actions to take; personal impact</td>
</tr>
<tr>
<td><strong>Resources</strong></td>
<td>knows resources for assistance or recourse</td>
<td>provider representatives; responsible governing agencies</td>
</tr>
<tr>
<td><strong>Value</strong></td>
<td>can explain the steps to take action</td>
<td>why action matters; who benefits</td>
</tr>
</tbody>
</table>

The belief in the ability to get help with solar is quite positive in rural Kenya: 85% of respondents suggest they have access to people to help solve problems with solar. Trends
indicated in Table 7.2, suggest access to people to help problem-solve across intermediary types, with more of those relying on agents and electricians than others. Of those with solar in this sample, 60% reported *not* having a problem with solar and of those with a problem a majority (61%) reported that it was fixed. Across different types of solar, those with pico-solar lanterns and solar home systems both reported about 30% of problems were left unresolved, while multifunction lanterns was about 50%. Other industry data suggests that the proportion of unresolved issues may be greater than this sample suggests (Harrison et al., 2020). Actions in response to problems with solar are listed in Table 7.3, which shows the strong reliance on company representatives, call centers, and local electricians. While 29% of those with a problem did call the call center – as companies would prefer – a similar number continued to rely on local agents and the same number did nothing to solve their problem. When faced with a problem with their solar system, it is uncertain how much action consumers take in response to that problem. The trends in Table 7.3 suggest potentially weak links in the action sequence for off-grid solar, as not everyone who experiences a problem with solar then takes action to remedy that problem.\footnote{As the data in Table 7.3 was a “select all that apply” option, some respondents selected more than one action if they had a problem with solar, while 52 respondents reported never doing anything (4 reported doing nothing and something else hence the 56 in the table), 119 respondents reported taking one action, 25 reported taking 2, only 5 reported taking 3 actions, and a single respondent said they took 4 actions.}

Table 7.2: Two-way table with intermediary type (help) and if people believe they have access to people to help solve problems with solar, N (percent)

<table>
<thead>
<tr>
<th>intermediary type</th>
<th>have access to people to solve solar problems</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>entrepreneur</td>
<td>14.0 (28%)</td>
<td>36.0 (72.0%)</td>
</tr>
<tr>
<td>electrician</td>
<td>25.0 (13.89%)</td>
<td>155.0 (86.11%)</td>
</tr>
<tr>
<td>solar agent</td>
<td>55.0 (10.52%)</td>
<td>468.0 (89.48%)</td>
</tr>
<tr>
<td>other social ties</td>
<td>29.0 (30.21%)</td>
<td>67.0 (69.79%)</td>
</tr>
<tr>
<td>other</td>
<td>8.0 (18.18%)</td>
<td>36.0 (81.82%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>131.0 (14.67%)</strong></td>
<td><strong>762.0 (85.33%)</strong></td>
</tr>
</tbody>
</table>

Pearson chi²(4) = 33.3439 Pr = 0.000

The role of frontline solar intermediaries, such as solar agents, as knowledge brokers reinforces their role as key a component of the safeguard regime underway for off-grid solar users. As described in Chapter 2, what GOGLA –the off-grid solar industry group – termed the “agent challenge” indicates that the behavior of agents and their ability to communicate with end-users throughout the sales process is key to effective consumer protections (Global Off-Grid Lighting Association, 2019a, 11) (see Section 2.2.4). The importance of consumer protections does not stop at sales, rather the key role of frontline solar intermediaries extends into problem-solving and after-sales services. The remainder of this chapter examines if intermediary type has an effect on consumer knowledge about solar.
Table 7.3: Responses to the question “If you had a problem with you solar, what did you do?” (N = 202; although select all that apply allowed for multiple responses), Trans-Nzoia County, Kenya (percent in parentheses)

<table>
<thead>
<tr>
<th>Action</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call company call center</td>
<td>59  (29%)</td>
</tr>
<tr>
<td>Returned to store</td>
<td>17  (8%)</td>
</tr>
<tr>
<td>Returned to local agent/representative</td>
<td>56  (28%)</td>
</tr>
<tr>
<td>Asked local electrician</td>
<td>30  (15%)</td>
</tr>
<tr>
<td>Asked friend or family</td>
<td>21  (10%)</td>
</tr>
<tr>
<td>Nothing</td>
<td>56  (28%)</td>
</tr>
</tbody>
</table>

7.3 Survey Instrument & Design

The data collected to understand the effect of intermediaries on consumer knowledge and perceptions of solar was designed to measure key distribution and information channels and multiple measures of knowledge and solar use. Working with Pearson Research Consulting and Strathmore Energy Research Centre, this survey data was collected in Trans-Nzoia County in July of 2019. The survey was structured to include: informed consent, an introduction to solar, familiarity with solar, trust, frontline interactions, responsibility for quality and safeguards, consumer education, payments and pricing, social groups, electricity access, economic indicators, and household demographics. Data was collected using the Qualtrics offline app, which enabled enumerators to collect data digitally and upload responses using mobile data.

7.3.1 Sample and Data Collection

To estimate the difference between those with solar and those without, I oversampled solar users compared to the population in the county. While data available from the county suggests 994 households with solar in 2009 (knoema, 2009), evidence from company sales suggests far more installations as of 2019. One company indicated over 1400 active installations in the county (and the company started after 2010). Nevertheless, it is difficult to estimate the total number of households with solar in Trans-Nzoia County.

Three companies provided data is in response to a questionnaire indicating which sub-counties and wards in Trans-Nzoia have solar to help ensure that the areas sampled had a sufficient number of households with solar. Trans-Nzoia County has five sub-counties: Kwanza, Endebess, Saboti, Kiminini, and Cherangany. All three companies that provided location data had sales in Kiminini, two of the three also had sales in Cherangany, and two of the three had sales in Kwanza, Endebess, and Saboti. The next level down from sub-county in Kenya is ward. Across sub-counties in Trans-Nzoia, 15 of the total 25 wards were randomly selected and are indicated in Table 7.4. Initially, I planned to randomize at the village-level within each ward based on villages likely to have solar and those less likely to
have solar, but this was too difficult in practice based on logistics with enumerators and to achieve an even distribution by ward within the sample.

Table 7.4: Sub-counties and wards in Trans-Nzoia County, Kenya sampled in this survey, including total N per sub-county and the percent of those households with solar

<table>
<thead>
<tr>
<th>Sub-county</th>
<th>Randomly Selected Ward</th>
<th>N</th>
<th>% with solar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kwanza</td>
<td>Kwanza</td>
<td>58</td>
<td>62%</td>
</tr>
<tr>
<td></td>
<td>Keiyo</td>
<td>55</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>Kapomboi</td>
<td>56</td>
<td>52%</td>
</tr>
<tr>
<td>Endebess</td>
<td>Chepchoina</td>
<td>58</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Matumbei</td>
<td>59</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td>Endebess</td>
<td>58</td>
<td>52%</td>
</tr>
<tr>
<td>Saboti</td>
<td>Machewa</td>
<td>59</td>
<td>61%</td>
</tr>
<tr>
<td></td>
<td>Matisi</td>
<td>61</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>Tuwani</td>
<td>67</td>
<td>52%</td>
</tr>
<tr>
<td>Kiminini</td>
<td>Hospital</td>
<td>60</td>
<td>52%</td>
</tr>
<tr>
<td></td>
<td>Kiminini</td>
<td>57</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>Nabiswa</td>
<td>57</td>
<td>54%</td>
</tr>
<tr>
<td>Cherangany</td>
<td>Motosiet</td>
<td>70</td>
<td>64%</td>
</tr>
<tr>
<td></td>
<td>Sinyerere</td>
<td>58</td>
<td>59%</td>
</tr>
<tr>
<td></td>
<td>Chepsiro/Kiptoror</td>
<td>60</td>
<td>68%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>893</td>
<td>56%</td>
</tr>
</tbody>
</table>

Due to the saliency of solar users to this study’s purpose, I oversampled those with solar in their household. As solar use in the home may be associated with respondent perceptions of solar quality and protections this oversampling represents a form of nonprobability sampling, but allows for relevant comparisons (Henry, 2009). Based on the assumptions in Gelman and Hill (2007), I targeted a sample of solar households of 330-390 of a total sample of 835-840. The sample collected resulted in a total sample of N = 893, with 504 with solar and 389 without solar. While the proportion of those with solar was greater than calculated at the outset of data collection, enumerators in Chepsiro/Kiptoror and Motosiet reported that it was difficult to find households without some form of solar (ranging from small solar lanterns to larger solar home systems). Solar users in this sample range from those that use only a pico-lantern that provides a single point of light to home systems that provide much larger system capacity, indicated in Table 7.5.

At the household level, randomization for respondent selection in each village relied on
Table 7.5: Distribution of solar use in sample: Solar type and stacking of multiple solar products

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>% of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>has solar</td>
<td>504</td>
<td>56.44%</td>
</tr>
<tr>
<td>has pico-lantern</td>
<td>143</td>
<td>16.01%</td>
</tr>
<tr>
<td>has multifunction lantern</td>
<td>256</td>
<td>28.67%</td>
</tr>
<tr>
<td>has solar home system</td>
<td>181</td>
<td>20.27%</td>
</tr>
<tr>
<td>has 2 solar products</td>
<td>59</td>
<td>6.61%</td>
</tr>
<tr>
<td>has 3 solar products</td>
<td>17</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

the enumerators following specific guidance on how to randomize at the household-level. Enumerators were instructed to follow the Afrobarometer Survey practice for randomization in their data collection. Daily checks were conducted using geolocation data to check for the general location of where enumerators were operating each day. The Afrobarometer guidance is as follows:

- Start your walk pattern from a starting point that has been randomly chosen. Team members must walk in opposite directions to each other (this was not as big of an issue in this sample as most enumerators were collecting data a distance away from others).

- Use a 5/10 interval pattern to select a household. That is, walking in your designated direction away from the start point, select the 5th household for the first interview, counting houses on both sides of the street. After the first survey interview, continue on in the same direction, this time selecting the 10th household, again counting houses on both the right and the left sides of the street.

Fifteen enumerators assisted in data collection, each enumerator collecting data in one ward of Trans-Nzoia County. Due to the distance between different areas in the county it was not often feasible to have more than one enumerator per ward, thus there is overlap in the variables indicating ward and enumerator. Collecting survey data from a single ward minimized transportation costs across different areas of the county.\(^6\)

7.3.2 Key Variables and Descriptive Statistics

The range of intermediaries active in different models of solar services are reflected in the responses in Figures 5-4 and 5-5. Also evident in those figures is the unevenness of reliance

\(^6\) I reject the null hypothesis \((\alpha = 0.05)\) that there is no association between ward and enumerator, finding strong support for an association between the two \((\chi^2(196, N = 893) = 1.1e + 04 = p = 0.000))\. The only enumerators who collected data in multiple wards were those who completed responses for four enumerators who had to depart early. A small number of responses were recollected to ensure all responses in the ward were of high quality (that the enumerator spent sufficient time going through the questions, collected the data in the correct location, did not have a large number of errors in responses, especially write in numbers). Daily check-ins with enumerators allowed for some errors to be caught immediately and procedures to improve throughout the process.
on intermediaries, for example, 59% of respondents reply they would go to solar agents (what I call “networking solar agents” in the typology from Chapter 5 or “solar agents” more generally) for help. For building awareness, people report learning from a wider range of individuals about off-grid solar. The numbers in either intermediary category – awareness or help – required recoding as some intermediary categories had very few responses per category.

To emphasize an ongoing relationship with frontline solar intermediaries, not just initial awareness, the key independent variable of interest is who people would go to for help first if they have a problem with solar.7 As those they would go to for help more likely approximate the bidirectional link of an intermediary compared to the person who only introduced them to solar. The responses to this question are in the first graph in Figure 5-5. There is some overlap in intermediaries acting to build awareness and provide after-sales services. Table 7.6 illustrates how the figures from Chapter 5 (5-4 and 5-5) were combined into more balanced categories for this analysis. For intermediaries acting to build awareness about solar (the leftmost column in Table 7.6 and Figure 5-4) local leaders, elders, teachers and other community members were all combined into community influencer, group leaders and other group members were combined to indicate group influence generally, and friends or family members are in other social ties. For frontline intermediaries acting to provide help with solar (proxy for ongoing engagement with an frontline intermediary), (top row in Table 7.6 and Figure 5-5), community influencers were too few to have their own category so local leaders, teachers, groups and NGO staff are all included in other, while family, friends, or neighbors are included in other social ties. Based on this data, the importance of solar agents and local electricians for ongoing help parallels the trends in Table 7.3.

### Table 7.6: Two-way table of responses indicating intermediaries for awareness and help

<table>
<thead>
<tr>
<th>awareness</th>
<th>entrepreneur</th>
<th>electrician</th>
<th>solar agent</th>
<th>other social ties</th>
<th>other</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>community influencer</td>
<td>7</td>
<td>29</td>
<td>39</td>
<td>10</td>
<td>9</td>
<td>94</td>
</tr>
<tr>
<td>entrepreneur</td>
<td>21</td>
<td>36</td>
<td>80</td>
<td>24</td>
<td>6</td>
<td>167</td>
</tr>
<tr>
<td>group</td>
<td>3</td>
<td>14</td>
<td>34</td>
<td>11</td>
<td>13</td>
<td>75</td>
</tr>
<tr>
<td>solar agent</td>
<td>4</td>
<td>18</td>
<td>204</td>
<td>19</td>
<td>7</td>
<td>252</td>
</tr>
<tr>
<td>other social ties</td>
<td>15</td>
<td>83</td>
<td>166</td>
<td>32</td>
<td>9</td>
<td>305</td>
</tr>
<tr>
<td>total</td>
<td>50</td>
<td>180</td>
<td>523</td>
<td>96</td>
<td>44</td>
<td>893</td>
</tr>
</tbody>
</table>

**An Emphasis on Solar Agents**

In this chapter, and in prior discussions, the importance of solar agents is evident: they are the most common frontline solar intermediary. In Table 7.6, respondents shifted from a wider range of intermediaries at the awareness stage to an emphasis on solar agents for help with a solar problem: 252 respondents reported hearing about solar from agents, while

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7 This parallels the DV question in the previous chapter, but does not focus on trust as that chapter did.
523 reported they would go to them for help if they had a problem. Other differences include very few reporting going to community influencers or groups for help. Notably, respondents indicate they would go to local electricians, or *mafundi*, for help, a category not present in awareness-building. The frontline intermediaries people go to for help comprise the key independent variable of interest in this chapter. While these do not mirror exactly the typologies developed in Chapter 5, the patterns in Table 7.6 illustrates some of the transitions in intermediaries across stages of solar services, supporting the emphasis on community influencers in awareness and sales but limited engagement in after-sales. Of the intermediary typologies, agents and entrepreneurs are able to provide more ongoing engagement with solar users (see Figure 5-10).

**Dimensions of Knowledge**

Most surveys measure perceptions or beliefs rather than knowledge, for example trust in an intermediary or solar provider cannot be right or wrong. Understanding how frontline solar intermediaries may act as *knowledge brokers* requires assessing if there is variation in how intermediaries influence consumer knowledge about solar. While this survey data will not capture *how* intermediaries make information salient and usable or if solar users then use this knowledge to hold providers or oversight agencies accountable, it can provide a first indication of where consumers seek knowledge about solar to support more lasting services.

To assess consumer knowledge of off-grid solar use and protections, I asked nine questions in the form of multiple choice, select all that apply, or write in. Each question was then recoded to indicate if the respondent answered the question correctly or not. The questions included to form this count of solar knowledge include:

1. How long does a solar warranty last? (Answer: 12-24 months)
2. What happens if you use a warranty within the warranty period? (Answer: repair or replacement)
3. What does a warranty cover? (Answer: manufacturing defects or early component failure)
4. If you believe a warranty should be honored and it is not, what do you do? (Answer: file a complaint)
5. What does runtime mean for a solar product? (Answer: how many hours can use solar given different use options)
6. Do solar products generate AC or DC electricity? (Answer: DC)
7. Is pay-as-you-go more, the same, or less expensive than buying all at once? (Answer: more expensive)
8. What happens if someone stops paying for their solar (if it is financed)? (Answer: repossess system or lock system)
9. Do you know the name of the agency responsible for ensuring consumers are not cheated by companies making untrue claims? (Answer: Yes - Kenya Bureau of Standards or Competition Authority of Kenya)

The questions selected represent key dimensions of consumer knowledge for PAYGo solar,
including key quality and protections (warranty information), use (runtime, DC), payment terms, and the agency responsible for ensuring protections. These questions reflect the blurring of the sector – financial services with solar – and trends that emphasize the importance of quality and broader consumer protections. As described in Chapters 2 and 3, frontline solar intermediaries play an important role in the transparency and communication of consumer protections from companies to consumers. Capturing respondents’ knowledge about these key aspects of solar services suggests if consumers are learning about off-grid solar protections from frontline solar intermediaries, and if yes, which type is most influential.

Each of the questions included in this count is designed to capture key knowledge intermediaries should convey to solar users. Solar company training aims to ensure that agents can communicate key aspects of solar system performance – from lighting to battery management (see training discussion in 5.4.1). The questions presented here as dimensions of consumer knowledge reflect the different goals in Table 7.1:

- comprehension measures: warranty duration, terms, use and electricity type indicating (Q1, Q2, Q3, Q5, Q6);
- salience measures: actions or impacts (Q4, Q7, Q8);
- resources: responsibility for protections (Q9).

All of the knowledge variables in Table 7.7 are binary indicators and the knowledge count variable (knowledge_count) is a sum of all the knowledge variables (Q1 - Q9) for each individual. Over 90% of respondents knew the purpose of a warranty and what happens if you stop paying for a financed solar product. Additionally, over 80% know that buying solar using pay-as-you-go is more expensive than buying it all at once (proxy for knows there is interest on financed products). The two measures respondents knew the least were the type of electricity from solar (32%) and the name of the agency ensuring consumer protections (21%).

To measure the effect of intermediary type on the count of knowledge questions, I used a Poisson model as the outcome is a discrete count from 0 - 9 rather than a continuous variable able to take on any value within the range. The variation in the count variable is also in Table 7.7, with a mean value of 5.7 (and a median value of 6). The basic Poisson form is,

\[ y_i = \text{Poisson}(\theta_i) \]  

and \( \theta_i \) is defined as,

\[ \theta_i = \exp(X_i \beta) \]  

and I fit this model on a logarithmic scale where \( X \beta \) is the linear predictor for individual, \( i \), assuming \( \theta_i \geq 0 \) (Gelman and Hill, 2007, 111).

While a variable on knowledge about how long a battery lasts was collected, it had a negative correlation with four other knowledge indicators and so I was uncertain how accurately it was capturing the same kind of knowledge.
In Appendix A.0.9, I provide nine logistic regression models regressing intermediary type and control variables on each individual knowledge variable. The Poisson model measures the effect on the count of questions correct, whereas the logistic regression models illustrate the effect of intermediaries and other demographics on a single binary measure of solar knowledge rather than a count (the overall explanatory power is higher for these individual models than for the count model). In addition to the main focus of this chapter on knowledge brokerage for off-grid solar, I also examine how individuals perceive the intermediaries they go to for help.

**Intermediary Characteristics**

Following the survey question about who respondents would go to for help if they had a problem with solar, I asked a set of questions about these individuals they would go to for help, ranging from experience to their connections to the provider. Unlike other analyses in this chapter, intermediary type is the dependent variable (see Table 7.6) and the following characteristics are the independent variables to test what influences who respondents reported going to for help. These questions parallel the attributes in Chapter 6 and measure individual-level perceptions of intermediaries for after-sales services. I provide these variables in Table 7.8 and all variables are either binary or ordinal. In addition to these six variables, I also asked each respondent if the sector of the intermediary mattered to them – allowing them to indicate, not important, company, government, or NGO. The response breakdown is as follows: not important (49.38%), company (39.75%), government (7.73%), and NGO (3.14%). The use of these variables to understand why people go to agents for help provides a comparison to the previous chapter (Chapter 6), but uses an alternative survey instrument design. The questions identifying intermediary characteristics include:

- Please rate how much you think this person knows about how to install or fix solar? (know nothing to very knowledgeable; unsure = 0)
- If you are unsure how to operate your solar, is this person able to help you operate your solar product? (yes/no)
- If you are unsure about the terms of your solar warranty, is this person able to clarify that for you? (yes/no)
- If you are unsure about what is included in the user manual that comes with your solar product, what will this person do? (nothing, refer to someone else, discuss manual contents)
- Imagine your solar battery stops working, what will this person do? (nothing, try to fix battery, connect to company to provide new battery)
- If you have an issue with your solar product, you expect this person to communicate your problem to the manufacturer (yes/no)
- Does it matter to you if the person who assists you with solar is affiliated with the government, an NGO, or a company? (no, government, NGO, company)

Given the unbalanced nature of the responses indicating intermediary, with over 58% indicating they would go to an agent for help with solar, this model tests the effect of those
characteristic variables on a binary version of intermediary type: agent or other.\textsuperscript{9} Using a binary outcome variable, I use a logistic regression since the outcome variables are only able to take on 1 (if reported going to an agent for help) and 0 (if reported any other intermediary type). This follows the form for a binary logistic regression:

\[
P_r(y_i = 1) = \logit^{-1}(X_i\beta)
\] (7.3)

**Additional Control Variables**

While intermediary type in after-sales activities is the key independent variable of interest, I include additional independent variables that control for experience with solar, household appliances, economic variables, electricity connection, participation in groups, and respondent demographics. I include a larger table of the polychoric correlations and summary statistics in Appendix A.0.8. Here, I include only those that contributed to a more parsimonious model in Table 7.9 and Table 7.10.\textsuperscript{10}

### 7.4 Findings

The effect of intermediaries on consumer knowledge about solar reinforces the importance of the solar agent model in off-grid solar. In Table 7.8, the shift from other intermediaries to solar agents for ongoing help with solar suggests that the models promoted by companies like SunnyMoney that shift from community influencers to agents for after-sales needs, parallel broader trends in the sector. Further, the layering of agent networks with local scouts and introductions to *chamas* may encourage awareness-building from a wider variety of intermediaries than those people rely on for ongoing help. Underpinning the importance of agents is their greater, positive effect on consumer knowledge of solar than other intermediary types. Other local resources should not be overlooked for off-grid solar services: electricians too are associated with an increase in knowledge.

#### 7.4.1 Building Consumer Knowledge

The results for the effect of intermediary on consumer knowledge about solar are in Table 7.11. Solar agents and electricians consistently have positive, significant effects on knowledge across all models. Model 1 regresses knowledge count only on the intermediary indicator and subsequent models add relevant controls, ward (Model 2), appliance use (Model 3), and finally demographics including socio-political indicators of *chama* and community meeting participation (Model 4). As previously mentioned, while I collected a much larger number of control variables the majority of the demographic and socio-economic variables did not

\textsuperscript{9}It may be useful to test this as a multinomial logistic regression using agent, electrician, and other as it may provide a better comparison on intermediary characteristics.

\textsuperscript{10}Tabulating across when respondents purchased solar and if they are grid connected illustrates that 68% of respondents that do not have solar are connected to KPLC, but access to electricity did not provide to have a significant effect on knowledge count.
improve model fit. In the final model, Model 4, seeking help from agents and electricians both result in positive increases in knowledge compared to the reference category of entrepreneur. Additionally, those with higher education levels (above high school), who are not farmers or business owners, and who are in a chama and attend community meetings are all associated with higher knowledge at statistically significant levels.

For the key variable of interest, intermediary type there is a significant and positive effect for both electrician ($\beta = 0.0804$) and solar agent ($\beta = 0.109$). As described in Chapter 5 local electricians do not always have links back to the provider and therefore function less as a frontline intermediary in off-grid solar compared to other local actors. Nevertheless, these results suggest that electricians remain important resources for solar. Poisson coefficients can be interpreted as multiplicative effects (after exponentiated), so the difference in relying on an electrician for help is ($e^{(0.0804)} = 1.08$) an 8% increase in the expected knowledge count compared to entrepreneurs, holding all other variables constant.\footnote{Factor change in expected count = 100($e^{(0.0804)} - 1$) = 8%} For those who go to off-grid solar agents for help, the most common frontline solar intermediary, there is an 11% increase in the expected count ($e^{(0.109)} = 1.115$), compared to entrepreneurs and holding all other variables constant.\footnote{Guidance on interpretation from Gelman and Hill (2007, 111) and Long (1997, 228)}

In addition to intermediary type, increases in expected knowledge count are also associated with access to a TV or radio, higher education, and social connections (participation in lending group/chama). Having a radio or a TV in the house are similar in effect to relying on an electrician, 7% and 8% respectively holding all other variables constant (radio: $e^{(0.0684)} = 1.07$; TV: $e^{(0.0797)} = 1.08$). While education levels including and above completing high school (or secondary school) are positive and significant, having a university degree or higher has the strongest effect with an expected increase in knowledge count by 23% ($e^{(0.208)} = 1.23$), holding all other variables constant. For more social or collective activities, participating in a lending group increases the expected knowledge count by 3% ($e^{(0.0303)} = 1.03$) and for every additional community meeting attended there is a 0.16% ($e^{(0.00162)} = 1.0016$) increase in expected knowledge count, holding all other variables constant. While the effect size of agent is positive for expected knowledge count and supports the importance of agents as knowledge brokers, overall this model has a very low McFadden’s pseudo $R^2$ which suggests limited explanatory power of these independent variables. Adding additional socio-economic variables had little impact on increasing the model fit.\footnote{McFadden’s $R^2$ is not equivalent to an $R^2$ in ordinary least squares regression so should therefore be interpreted with caution, other pseudo $R^2$ measures find a better model fit: Cragg & Uhler = 0.128, but all should be used with caution.}

In addition to testing the effect of intermediaries on knowledge about off-grid solar, one of the challenges posed in the beginning of this chapter is if this knowledge, and the intermediaries that facilitate said knowledge, translates to action. Action, while difficult to measure, it approximated by the indicators in Table 7.3. The categories of responses in Table 7.3 were provided to respondents as a “select all that apply” option, and thus, like knowledge, can be categorized as a count of problem-solving actions (0-4). The count breakdown is as follows:

11 Factor change in expected count = 100($e^{(0.0804)} - 1$) = 8%
12 Guidance on interpretation from Gelman and Hill (2007, 111) and Long (1997, 228)
13 McFadden’s $R^2$ is not equivalent to an $R^2$ in ordinary least squares regression so should therefore be interpreted with caution, other pseudo $R^2$ measures find a better model fit: Cragg & Uhler = 0.128, but all should be used with caution.
Table 7.12 shows the results of regressing problem-solving count on whether the intermediary relied on for help is an agent. Unlike the previous model, the model in Table 7.12 is restricted to only those in the sample who actually experienced a problem with their solar system, and is therefore a much smaller sample of N = 202. Also given this sample size there were not enough responses to use all intermediary types, thus this just test agent vs. other.

While an increase in problem-solving count does not inherently indicate more or less responsive service – it could indicate that consumers know that there are multiple resources for help and they take advantage of that, or it could indicate that early attempts for help were unsuccessful. The results in Table 7.12 suggest that for those who actually get their problem resolved (prob_fixed = yes) there is a 33% increase ($e^{(0.290)} = 1.33$) in the expected count of problem-solving attempts. This suggests that minimally an increased count in this model has a positive relationship with actually resolving issues. The key independent variable of interest, if they go to a solar agent for help, is significant ($\alpha = 0.10$) and going to an agent is associated with a 23% increase ($e^{(0.207)} = 1.23$) in the expected count. Again, this is not inherently good or bad, it could indicate that agents are effective at referring to the shops if additional help is needed to effectively problem-solve, or it could indicate, as in Chapter 1 that they cannot help and the solar user must resort to another resource for help. The indicator of knowledge count (the DV in the previous model) is not significant, but like the previous model higher levels of education are the most influential variables on problem-solving count. For problem-solving, being more politically active (attending community meetings or contacting the government to raise an issue) are both positive and significant, although small in magnitude (for every additional community meeting attended there is a 1.1% ($e^{(0.01108)} = 1.011$) expected increase in problem-solving count).

### 7.4.2 Why Solar Agents?

While the previous chapter examined the attributes of intermediaries generally, this data allows for further exploration of the agent model. Clearly, solar agents play an influential role in not only sales, but building consumer knowledge. In turn, why do consumers rely on solar agents? Using the same intermediary indicator for who people go to for help as in Table 7.6 but coded to indicate agent and all other intermediary types (agent = 1, other = 0; agent = 527, other = 370), I use a logistic regression to regress agent on a series of variables likely influential on why people rely on different intermediaries. Results are in Table 7.13, with Model 1 including only the variables associated with intermediaries, Model 2 including ward, Model 3 including the respondent’s experience with solar, and Model 4, the final model, including respondent occupation (McFadden’s $R^2 = 0.43$).

The results in Model 4 suggest that a solar agent’s position in-between the consumer and
company matters to consumers. The most influential factor on relying on an agent for help is the expectation that they will communicate with the manufacturer if the end-user has a problem with their solar system. The probability of going to an agent for help with solar if they are also expected to communicate with the manufacturer given any problems is 12.5% compared to other intermediaries, holding all other variables constant \((\beta = 2.26).\) Additionally, affiliation with a company increases the probability of going to an agent for help by 5%, compared to others and holding all other variables constant \((\beta = 1.45).\) Prior experience with an agent – if solar was purchased from an agent – also increases the probability of going to an agent for help by 6%, holding all other variables constant \((\beta = 1.50).\) From this model it is uncertain if prior experience indicates convenience, familiarity, trust, responsive service – or some combination. There is some evidence that people prefer intermediaries with knowledge about how to install or fix solar, although this is less influential than other dimensions included in the model, the probability of going to an agent is 3% greater than others, for those who think they are very knowledgeable about installing or fixing solar, holding all other variables constant. These results follow trends related to information and decision-making more broadly in the solar sector, as indicated in Figure 3-3 company is the most commonly relied upon indicator for making decisions about solar.

7.5 Discussion: Knowledge-building in Off-Grid Solar

For the effective use of solar systems, after-sales services, and consume safeguards, individuals must know what options exist, what to do in different situations, and why taking action matters. While this process of acting building knowledge and acting on said knowledge is not unique to off-grid solar, examining consumer knowledge for solar given the growth of PAYGo solar is applicable to mobile money, electricity access (even from the centralized grid), and issues related to repairs and waste management. Few academic or gray literature studies examine consumer knowledge about solar, but what has been studied, illustrates the importance of how and what people are told about solar at point-of-sale. Prior research from the Consultative Group to Assist the Poor (CGAP) highlights that:

- solar users may misunderstand the terms and conditions (such as payments or remote lockouts/deactivation) due to rushed sales or inaccurate explanations of contract terms that may be viewed as unfavorable (Zollmann et al., 2017);
- despite the perceived benefits of pay-as-you-go financing, transparency about what happens after missed payments may reduce interest in PAYGo solar (Waldron and Swinderen, 2018);
- solar operators in East Africa are entering into mobile money markets in regions with high late-payment and default rates (Izaguirre et al., 2018).

In Kenya, accurately providing information to end-users can help differentiate between companies operating in a competitive market and ensure a more reliable or loyal consumer base.

\[ Pr(y = 1) = \frac{1}{1 + e^{-(\beta_0 + \sum \beta_k x_k)}} \]
I highlighted in the beginning of this chapter that solar users in Kenya are aware of warranties for issues like battery maintenance, but few actually use them to replace failed solar products (Kenya Climate Innovation Center, 2017). The responses about warranties in this chapter support strong awareness about warranties in rural Kenya and when faced with a solar problem Table 7.3 illustrates that people rely on a range of resources, from agents to call centers, or some choose to take no action. Stojanovski et al. (2017, 43) posits that “a lack of culture of customer engagement and feedback” inhibits responsive and ongoing services for solar. Here, the scholarship on when information leads to action (Lieberman et al., 2014) or the “action cycle” between users and service providers (Kosack and Fung, 2014) is particularly salient for quality assurance and emerging consumer protections. For off-grid solar in Kenya, awareness about warranties and service terms appears to be relatively strong. While this chapter did not directly study every stage, from providing initial information to behavior change, the influential role of frontline solar intermediaries and other local actors indicates possible steps towards enhancing accountability for solar services.

The data I used in this chapter to form the knowledge variable – or knowledge count – provides an initial baseline of consumer knowledge about solar in Kenya. While simplified into binary indicators, responses parallel the emphasis in the sector on pay-as-you-go financing and labeling requirements from programs like Lighting Global. The mean values in Table 7.7 indicate high levels of knowledge associated with a warranty’s purpose (repair or replacement) and that a system will be locked or repossessed if they stop paying. Broadly, indicators of service terms (warranty, payments) are better known than more technical information (use indicators (runtime) or that solar generates DC electricity) or information on responsible government agencies. The knowledge about payment terms and warranties suggests that these topics more central to the off-grid solar business model are more effectively conveyed to end-users, compared to dimensions that support understanding how off-grid solar differs from the grid or who has authority to hold solar providers accountable. While my results suggest that intermediary models – namely, solar agents – do matter for consumer knowledge, they also suggest that other efforts to build knowledge more generally also have an effect on expected solar knowledge; the most influential variable on expected knowledge count was higher education. Addressing issues of consumer knowledge about solar may not be only an issue of promoting effective service models using salient intermediaries, but broader efforts to promote higher education are also critical.

7.5.1 Agents as Knowledge Brokers

In the “coding” stage of knowledge brokerage – where brokers act to develop comprehension, salience, and knowledge of resources or actions (see Figure 7-1) – solar agents are associated with a higher expected knowledge count. Relying on an agent for help with solar is associated

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15In Appendix A.0.9, results suggest that solar agents have a positive, significant effect on knowing warranty purpose, filing a complaint, and runtime, while a negative, significant effect on warranty terms. This supports that agents may be providing information that is most favorable to making a sale (as suggested by Zollmann et al. (2017), knowing that a warranty may offer a return or replacement may enhance sales while explaining that it only covers defects or early component failures may deter customers.
with an 11% increase in expected knowledge count. Relying on an agent is also associated with a 23% increase in expected problem-solving count; this measure of problem-solving count attempts to capture the later stages of the information to action process in Figure 7-1. While higher education in general, is associated with a larger increase in expected knowledge count and problem-solving, relying on an agent is the most influential variable that can be changed or improved in the short-term by solar providers. While relying on agents may, at times, be risky given mixed incentives from providers and the range of actual experiences people have with agents, they may be a better ongoing resource than other frontline solar intermediaries. Undoubtedly, solar agents are a complex part of off-grid solar distribution and service models.

The layering of agents as frontline solar intermediaries with other social groups and networks – indicated by the term networking solar agents in Chapter 5 – also has the potential to enhance consumer knowledge. Participation in a *chama* is also associated with an increase in expected knowledge count, thus while this layering (as described in Chapter 5) may create more distance between end-users and the company, the social or peer learning that may occur in these groups can contribute to greater knowledge.

A “good” solar agent not only makes sales, but also tells the truth – they are thorough and transparent about pricing and the advantages of solar (interview 190619, interview 191015). While training sessions – that balance the cost of training and high agent turnover – seem to be effective in ensuring that agents can describe basic service terms to customers, current training curricula may be limited in their ability to train agents to convey more complex, in-depth, or new information: the information that may contribute to the later stages of changing behavior. Efforts like BBOXX’s “BBOXX Academy” indicate that some companies are providing continuous training of agents and professional development opportunities that may enhance an agent’s reputation to encourage the kind of honesty and transparency necessary for reliable agent-to-customer education.

The effect of agents on consumer knowledge is only one component of a knowledge broker for off-grid solar. The other key element is associated with their in-between position, as a type of intermediary they link consumers to service providers. This communication link matters to those who rely on agents, the probability of relying on an agent is greater if the consumer believes that agent can communicate with the manufacturer if there is a problem (see Table 7.13). Solar agents provide an active link between providers and end-users that bridges a gap in access. The example in Chapter 5 of Sharon, the agent in Kakamega, supports this link in multiple ways: she actively took a customer to the company store for assistance, she shared that she would provide ongoing help to her customers, and she emphasized that while agents build customer sales networks, they also network with one another for help or assistance with products from other companies. The importance of having this brokering or bargaining link to the service provider is also supported in the results from the conjoint experiment in Chapter 6. Consumers rely on agents, in part, because they offer a continued connection to solar providers whose company offices may be located far away, too far to travel for assistance.  

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16This ongoing link, in the strongest form of transparency suggested by Kosack and Fung (2014) would
Impact of Solar Agents and Knowledge-building

The findings from this chapter suggest relationships between frontline solar intermediaries and consumer knowledge and problem-solving actions. In Table 7.12 which suggests that those who go to agents for help are expected to take more actions when faced with a problem, the count of knowledge variable is not significant – but most importantly, it is not entirely clear if problems actually get solved. Figures 7-2 and 7-3 suggest some patterns for future exploration, they use the knowledge count variable and whether someone reported that their problem was fixed. While the sample size is relatively small for those who experienced problems with their solar system (N = 202), examining knowledge by problems being fixed and by after-sales intermediary suggest that knowledge may influence whether or not issues with solar are fixed, but the difference may be small, more data is needed to test this relationship. With the majority of respondents answering between five and six questions about solar correctly, most of those who were able to fix their problem with solar answered seven (see peak for “fixed” in Figure 7-2).

As described earlier, across this sample respondents relied on solar agents more than any other type of intermediary and this is also apparent in Figure 7-3, with higher counts across all categories in Figure 7-3 than other intermediaries. For solar agents, there are clear peaks in density for those who were able to fix their problem with higher knowledge, but other intermediaries follow a less extreme version of this trend as well, including electricians and entrepreneurs (to some extent other social ties). Those who rely on broader social ties, such as family and friends, exhibit the expected patterns for knowledge and fixing solar: those able to answer less questions also had trouble fixing their problem, while those with more knowledge reported fixing their problem with solar. While the sample sizes are quite small in these categories – suggesting just descriptive patterns – many with comparable levels of knowledge had different outcomes for solar repairs. While frontline solar intermediaries, especially solar agents, do have an effect on consumer knowledge, intermediaries with these links back to providers are a key pathway to making solar services more responsive to after-sales issues.

7.5.2 Other Local Resources

The role of *mafundi* or local electricians has permeated this discussion of the varied experiences consumers have with off-grid solar. The story described in Chapter 1 suggests that people default to electricians: if agents or other frontline solar intermediaries fail to serve the customer, they turn to electricians. In this earlier story, the local electrician failed to solve the problem.17 In Chapter 5, I suggest that they fail to link back to the provider because as independent, local operators their ties to solar providers are much weaker or nonexistent. Results in this chapter support this, in Table 7.13 local electricians are in the “other” group, also allow for provider responsiveness to how consumers use knowledge provided by agents, in this research I was unable to find support for or data on how (or if) companies collect and make changes based on agent experiences.

17 Cross and Murray (2018) also illustrate that electricians cannot always fix broken solar products.
Figure 7-2: Plot of respondent knowledge by if their solar problem was fixed or not (N = 202) (or if they had no problem with their solar, or have no solar, total N = 893)

expected to have less ongoing communication with manufacturers. In Figure 7-3, those that rely on electricians for help exhibit patterns similar to those relying on agents, but with less extreme peaks; still those able to fix their solar problem tend to have more knowledge (with a peak of seven correct answers, similar to solar agents).

The previous analysis in Chapter 6 found stronger trust in intermediaries with government affiliations and NGO affiliated training – the reliance on independent electricians in this chapter further supports the need for services external to PAYGo solar companies. While the agent model and company provided training are having a positive effect on knowledge, local electricians provide additional opportunities to enhance consumer knowledge about off-grid solar. While currently, mafundi operate somewhat independently from companies, agencies, or NGOs, these results suggest that future training and education programs may benefit from including electricians in after-sales services.\textsuperscript{18}

\textsuperscript{18}If such opportunities were created local electricians may begin to function more like intermediaries with links to EPRA or other organizations that provide training or licensing programs. Additional models where local electricians work with companies to provide “certified repair” may leverage the strengths of different actors operating in off-grid solar. This is not currently supported by the dominant approach from companies to have proprietary, in-house agent and repair networks.
Figure 7-3: Plot of respondent knowledge by who they would go to for help (intermediary at after-sales stage) and if their solar problem was fixed or not (N = 202) (or if they had no problem with their solar, or have no solar, total N = 893)
Table 7.7: Polychoric correlations and summary statistics for binary knowledge variables included in the dependent variable and knowledge count variable; summary statistics for dependent count variable in last row (knowledge_count is a sum of the other binary variables in this table)

<table>
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<th>(2)</th>
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<th>(6)</th>
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- Row (knowledge_count) is a sum of the other binary variables in this table.
Table 7.8: Summary statistics for variables describing why respondents rely on different intermediaries

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<th>min</th>
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Table 7.9: Polychoric correlations and summary statistics for knowledge count models

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Table 7.10: Nominal (unordered categorical) control variables for education and occupation

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</table>

**DV: Knowledge count**

**Control Variables**
- Has radio: 0.0761, * (2.27)
- Has TV: 0.107, *** (6.04)

**Respondent Education**
- Reference: informal
  - Some primary: 0.0209, (0.41)
  - Primary completed: 0.0427, (0.87)
  - Intermediate or some secondary: 0.0703, (1.48)
  - Secondary or hs completed: 0.126, ** (2.68)
  - Post secondary non university: 0.132, ** (2.79)
  - University completed or higher: 0.208, *** (4.01)

**Respondent Occupation**
- Farmer: -0.0418, + (1.95)
- Owns business: -0.133, * (2.19)

**Ward**

<table>
<thead>
<tr>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.033</td>
<td>0.028</td>
<td>0.024</td>
<td>0.028</td>
</tr>
<tr>
<td>0.893</td>
<td>0.893</td>
<td>0.893</td>
<td>0.893</td>
</tr>
</tbody>
</table>

**Pseudo \( R^2 \)**
- Model 1: 0.006
- Model 2: 0.024
- Model 3: 0.028
- Model 4: 0.033

* t-statistics in parentheses, robust standard errors
* \( p < 0.1 \)
* * \( p < 0.05 \)
* ** \( p < 0.01 \)
* *** \( p < 0.001 \)
Table 7.12: Poisson Model: Problem-solving Actions

<table>
<thead>
<tr>
<th>Key IV: go to agent for help (intermediary type)</th>
<th>(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>0.207$^+$ (1.88)</td>
</tr>
<tr>
<td>Problem with solar fixed</td>
<td>0.290$^*$ (2.23)</td>
</tr>
<tr>
<td>knowledge_count</td>
<td>0.0195 (0.53)</td>
</tr>
<tr>
<td>Married</td>
<td>-0.309$^*$ (-2.35)</td>
</tr>
<tr>
<td>Male</td>
<td>-0.179$^+$ (-1.72)</td>
</tr>
<tr>
<td>Respondent Education</td>
<td></td>
</tr>
<tr>
<td>Reference: informal</td>
<td></td>
</tr>
<tr>
<td>some primary</td>
<td>0.446 (1.37)</td>
</tr>
<tr>
<td>primary completed</td>
<td>0.480 (1.46)</td>
</tr>
<tr>
<td>intermediate or some secondary</td>
<td>0.319 (0.94)</td>
</tr>
<tr>
<td>secondary or hs completed</td>
<td>0.311 (0.93)</td>
</tr>
<tr>
<td>post secondary non university</td>
<td>0.682$^*$ (2.11)</td>
</tr>
<tr>
<td>university completed or higher</td>
<td>0.514$^+$ (1.65)</td>
</tr>
<tr>
<td># attended community meeting</td>
<td>0.0111$^+$ (1.66)</td>
</tr>
<tr>
<td># times contacted gov</td>
<td>0.00660$^+$ (1.83)</td>
</tr>
<tr>
<td>Ethnic group</td>
<td></td>
</tr>
<tr>
<td>Reference: other</td>
<td></td>
</tr>
<tr>
<td>kalenjin</td>
<td>0.177 (0.62)</td>
</tr>
<tr>
<td>kikuyu</td>
<td>0.395 (1.46)</td>
</tr>
<tr>
<td>kisi</td>
<td>0.579$^+$ (1.89)</td>
</tr>
<tr>
<td>khu</td>
<td>0.451$^+$ (1.79)</td>
</tr>
<tr>
<td>luo</td>
<td>0.878$^*$ (2.41)</td>
</tr>
<tr>
<td>Ward</td>
<td>✓</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.161$^{**}$ (-2.71)</td>
</tr>
</tbody>
</table>

Observations: 202
Pseudo $R^2$: 0.091

$t$ statistics in parentheses, robust standard errors

$^+ p < 0.10, ^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$
Table 7.13: Logistic Regression on Agent as Intermediary

<table>
<thead>
<tr>
<th>Model</th>
<th>DV: Go to Agent for Help (intermediary type)</th>
<th>Control Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DV</td>
<td>Respondent Occupation</td>
</tr>
<tr>
<td></td>
<td>DV</td>
<td>Farmer</td>
</tr>
</tbody>
</table>

### Model 1

**DV:** go to agent for help (intermediary type)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Help with operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarify warranty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expect person to communicate with manufacturer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Model 2

<table>
<thead>
<tr>
<th>Purchased solar from agent</th>
<th>Reference: Do nothing</th>
<th>Reference: Try to fix battery</th>
</tr>
</thead>
</table>

### Model 3

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>Reference: Not Important</th>
<th>Reference: Government</th>
</tr>
</thead>
</table>

### Model 4

<table>
<thead>
<tr>
<th>When purchased solar</th>
<th>Reference: Never</th>
<th>Reference: Within past 2 years</th>
<th>Reference: More than 2 years ago</th>
</tr>
</thead>
</table>

**Control Variables:**

- Respondent Occupation
  - Farmer
  - Owns business
- Ward

- **Constant**
  - Farmer
  - Owns business

- **Observations:** 893

- **Pseudo R²:** 0.367, 0.417, 0.424, 0.431

- **t statistics in parentheses, robust standard errors**

- **p < 0.001**, **p < 0.01**, **p < 0.05**
Chapter 8

Conclusion: How Frontline Solar Intermediaries Enhance the Durability of Off-Grid Solar Services

The image of off-grid solar as a single lantern, sometimes distributed by NGOs or government agencies at no or reduced cost to provide basic lighting, may still ring true in some cases, but is by and large no longer the dominant model in Kenya. Growth in the Kenyan solar market is now associated with up-selling existing customers to larger solar systems with more appliances, selling these larger systems to new customers, or cross-selling customers to new services (Global Off-Grid Lighting Association, 2019b). Continued growth of off-grid solar and ongoing relationships between customers and solar providers depends on frontline solar intermediaries. Kenya’s 2018 National Electrification Strategy provides electricity to citizens in more remote areas with off-grid solar; therefore, this research did not compare off-grid solar (solar lanterns and home systems) to grid electricity, but rather recognized that off-grid solar is minimally a medium-term solution for many in Kenya. Even for households with a connection to the grid, off-grid solar may continue to be relied upon as a backup source, given outages or poor-quality electricity, for many years to come. Given this reality, my focus on frontline solar intermediaries addresses how this growing sector is building local connections and using these connections for more than just sales – also for consumer education to support more informed decisions about solar quality and service.

Through my research on frontline solar intermediaries in Kenya, I uncovered four important factors that are key to considering how off-grid solar can build the trust that underpins the repeated after-sales interactions and consumer safeguards required for durable or lasting PAYGo solar services responsive to on-the-ground customer experiences and needs.

First, I proposed a model of frontline solar intermediaries that includes a bidirectional information flow and repeated interactions; such repeated engagements have the potential to strengthen the end-user experience and offer providers insight into what is occurring on-the-ground (see Figures 2-4 and 5-1). Initially when I set out to study frontline solar intermediaries, I expected to find that providers use the lessons learned from intermediaries to improve service, but that was not the case on-the-ground. Rather I found that the expe-
periences of frontline solar intermediaries remain a relatively untapped resource for providers: few are making the effort to actively learn from intermediary experiences. In fact, issues with solar agent turnover and difficulty managing solar agent networks suggest that companies are investing less in training sessions and efforts to build strong connections with intermediaries, rather companies are trying to circumvent this on-the-ground relationship and centralize feedback via customer call centers.

As I proposed in Chapter 5, local shop managers and field officers (or called by other companies group coordinators), can mediate the disconnect between what frontline solar intermediaries know and experience in their regular interactions with solar users, and how solar providers use or even collect these experiences. My typology in this chapter emphasized four primary frontline solar intermediaries who are connected to solar providers, but not to employees, a dimension common to these primary four but that differentiates them from the shop managers and field officers. Both managers and officers have substantial influence on off-grid solar services in a given shop or region, as they are employees of a provider with management authority and influence over training.¹

As I described in Chapter 5, managers and officers often hold training sessions, meetings, and check-ins with their on-the-ground teams. In some cases, such as One Acre Fund, the field officers, rather than group leaders, are responsible for information about warranties and service terms (see Figure 5-9). The importance of these two additional intermediary types – officers and managers – was unexpected based on my initial typology of frontline solar intermediaries, but the field officers and shop managers may have the most influence on after-sales services (see Figure 5-10) and offer stronger links back to the providers to enhance the bidirectional information flow initially proposed in my frontline intermediary model.

The efforts that do exist to incorporate intermediary experiences into operations, as suggested by the “action cycle” of transparency (see Chapter 7), are often led by managers or officers.² Frequent, weekly or biweekly meetings between agents and shop managers or group leaders and field officers, suggest that those in these managerial roles actually have substantial discretion in how they engage the networks of other frontline solar intermediaries that, in turn, engage directly with customers. Meetings between, for example, agents and the shop manager, help build interpersonal connections and a resource network for solar agents, such that agents can ask each other questions and verify information to provide more reliable, accurate service to customers. While solar headquarters may not take advantage of this wealth of frontline experience, those who are learning from the wide network of frontline solar intermediaries are these shop managers and field officers. As employees of companies

¹The shop managers are common to the larger solar companies operating in Kenya such as M-Kopa, BBOXX, Sun King, and Mobisol, as well as smaller operations like Solar Panda. The field officer model is most commonly associated with the group-based approaches of large NGOs like One Acre Fund or smaller lean start-ups like Bidhna Sasa or Zawadisha.

²As one shop manager described: “I hold meetings every Monday, for all the agents. For every shop, we do it on Mondays. During meetings you are able to train them everyday, and then after three months, we have a regional meeting where all sales agents are mentored and get the new information. [Agents can attend] if you qualify, that is if you sold 10 units. If you don’t, you won’t be able to attend the regional one, but the weekly one we do for everyone” (interview 190719).
or NGOs, shop managers and field officers provide critical links to what is happening on the ground.\footnote{While actively incorporating frontline intermediary feedback is a missed opportunity for companies, the focus on sales rather than mutual learning is not all that surprising given the status quo from other distribution and agent models. The model perhaps most similar to solar agents – mobile money agents – also fails to use the vast network of on-the-ground Safaricom M-Pesa agents for customer feedback or to better understand their customer base (see Chapter 5 and Wellen and van Dijk (2018)).}

Companies in off-grid solar rely primarily on frontline solar intermediaries (of all types) for sales, but appear to underestimate the value of these actors in ongoing learning about the consumer experience. Solar-users do use the customer call centers for assistance with problems, but they rely on solar agents just as much. Data in Chapter 7 shows that if people face a problem with their solar, they tend to go to agents, call the company, or simply do nothing in equal measure. A strong, positive customer-company relationship is key to what companies see as the next round of growth in the sector, associated with appliances or additional services. From the perspective of the companies, it is easier to shift continued engagement to options with easier oversight, such as a call center, but in practice, this shift overlooks the interpersonal, local connections that underpin trust in intermediaries and, in-turn, providers.\footnote{I provide a theoretical framework for building and transferring trust in Chapter 6, Figure 6-1.}

Solar company efforts to identify and recruit solar agents mirror results from Chapter 6 that find trust in frontline intermediaries in off-grid solar is strongly associated with embeddedness – people trust those they know. The feasibility of shifting away from an embedded connection may be more difficult than just providing a customer care number or even a number for a shop manager. While companies recognize the instrumental role of local intermediaries to build trust (Moore, 2015), trust that comes with local embeddedness may not be immediately transferable from a local intermediary to other company resources.

Second, I found that solar agents matter more for ongoing solar services than previously emphasized by academic scholarship or by industry reports. Solar agents – what I unpacked in Chapter 5 as a “networking solar agent” due to their drive to extend their sales reach to new social networks – are truly relied upon by rural communities for both awareness and ongoing help with solar, but especially for help (see Figures 5-4 and 5-5 or Table 7.8); who people rely on for help with solar is not evenly distributed across intermediary types, far more people rely on agents. A recent industry report cited solar agents as “the single biggest factor in consumer protection” (Global Off-Grid Lighting Association, 2019a, 11), as agents often mediate what information is shared with customers and how accurate and transparent that information is about solar services. Information shared at point of sale details terms and conditions for off-grid solar services, including repayment information, warranties, and after-sales assistance. Consumer knowledge and use of these warranties and after-sales services are key to impactful consumer safeguard policies and programs. With the blurring of solar and financial services, described in Chapter 3, solar agents must be equipped to handle both solar sales and accurate explanations of and information on financing, which not only requires more training from providers, but engages solar agents in consumer protections for both solar and financial services.
Often reports – and even my framing in Chapter 1 – focus more on the gaps or unmet service expectations associated with solar agents; but as I showed with my analysis of consumer knowledge in Chapter 7, solar agents have a positive association with consumer knowledge. While the on-the-ground, more qualitative accounts of solar experiences do often emphasize the failure to return or repair solar products – this clearly suggests a breakdown in solar after-sales services – I showed that actually agents are engaging in consumer education. This somewhat surprising finding that solar agents are associated with an increase in consumer knowledge suggests that solar agents are having a positive impact despite these on-the-ground issues with reliability and transparency. Solar agents have the potential to further enhance emerging efforts to support quality assurance and consumer protection in the off-grid solar sector. As this sector continues to evolve, the training sessions provided to solar agents may be more easily modified to incorporate new areas of consumer education, compared to longer-term higher education initiatives that I find in Chapter 7 also influence consumer knowledge, but take much longer to prototype, test, and implement.\footnote{In the case of overall solar knowledge (count of correct answers) owning solar was not statistically significant and did not improve model fit. This is not necessarily direct experience with a solar agent that is part of the solution, but knowing that they can be a resource for help. Based on Table 7.11 it would appear that people may be exposed to the agents or at least the concept of agents by participating in community activities or achieving higher education. The closest study to a more systematic look at how agents have positive and negative impacts may be in the recent report released by 60 Decibels, which describes the importance of off-grid solar, but also the gaps in after-sales services (Harrison et al., 2020).}

Third, the wide variety of frontline solar intermediary behavior suggests that the incentives used by solar providers are not achieving the behavioral outcomes to consistently support broader goals of transparency and customer education. For example, solar agents “are the lifeblood” of solar distribution models, yet solar providers continue to struggle with how to recruit, train, and retain agents (Chang, 2017). As I described in Chapter 5, solar agents are commission-based and, while they undoubtedly value their commissions, their loyalty to service providers may be tenuous. If they can work the system to gain more benefits – sell an appliance secondhand, encourage a customer to buy solar on incomplete information – there is little to stop them.

Scholarship on how intermediaries link citizens to key resources often focuses on the intermediary-citizen relationship, rather than the intermediary-provider relationship. Off-grid solar providers follow this trend as well, solar providers seem to devote less attention to how they can build a stronger relationship with on-the-ground actors to help remedy the reality of inconsistent intermediary behavior. The vignette of Sharon, the agent working in Kakamega, in Chapter 5, suggested that some agents put in the effort to be responsive to their customers because they are looking at this customer relationship as a long-term investment.

A challenge common to the four primary intermediary models I introduced in Chapter 5 is that they have an uncertain duration; some models are designed to be short, but few or none provide intermediaries with a pathway to view solar as a career. Sharon’s emphasis on her aspirations for the future – and responsive service now to achieve those aspirations – could be better incorporated into intermediary incentives. For those agents that do take the
step to go through training and licensing programs run by the government (see Section 3.3.3), not all get jobs as technicians. In fact, how solar companies incorporate certifications and training sessions into their reward mechanisms for frontline solar intermediaries is unclear. In discussions with off-grid solar providers, only one mentioned identifying technicians based on their prior education: solar technicians are hired from local vocational schools. Even in this company’s model the vocational school is used as a recruitment avenue, rather than integrated into the company’s training and capacity-building efforts.

In Chapter 5, I classify the loyalty of solar agents primarily based on financial and reputational incentives, but I did not include how loyalty to the company and responsiveness to end-users may be encouraged by programs or opportunities than enhance an intermediary’s skills to support their aspirational goals. Rather than just try to transfer a connection from frontline intermediaries to call centers, solar companies should consider opportunities beyond the current incentives to enhance intermediary behavior through professional development of frontline solar intermediaries.

Fourth, many solar companies are trying to build everything themselves, which may overlook some of the trusted relationships and existing local capacity. Solar providers see their proprietary training curricula and distribution networks as a competitive advantage (see Section 5.4.1), but my analysis in Chapter 6 found that sector affiliation can influence trust in frontline solar intermediaries in surprising ways that require more cross-sector collaboration. My results showed increased trust for intermediaries with government affiliations and with bargaining connections to service providers to facilitate access to resources and information about solar (see Table 6.7). My analysis in Chapter 7 supported this connection to the solar provider, indicating that company affiliation influences whether people rely on solar agents for help with solar (see Table 7.13). My results suggest a starting point for rethinking frontline solar intermediary models to emphasize cross-sector partnerships to enhance trust

---

6One solar company described that, “for the technician...we normally work with a couple of polytechnic, vocational institutes, and pick out students from there because we normally require someone who at least has a certificate...[and] we normally require people who also know that area...[Then it is the] same thing in terms of training, we have specific trainers, it’s a bit more sophisticated because it’s more technical...they do one week of in-class training, which includes the theoretical part and the practical part, but then they also do another week where they join an existing technician [to] shadow him to do installation or repossession, just to see how this happens....they need to educate the customer on how to use the product...in terms of usage, how they can use the system, how long will they be able to light if they are using all the products and all that” (interview 190619). This quotation illustrates that for those off-grid solar companies that have technicians in addition to solar agents – an organizational structure not used by all companies – these technicians engage with vocational schools prior to joining the company, but have not utilized this opportunity to incentivize behavior while working with a company.

7Other examples, such as the abhas model developed by Tata Power DDL in New Delhi, India offer these frontline intermediaries opportunities to improve their literacy with women-to-women instructional courses. The abhas work with the utility in New Delhi’s informal settlements to curb electricity theft and encourage energy conservation within their communities. As mentioned as an example of intermediaries working in electricity more broadly in Chapter 4, this model developed by Tata Power DDL is being piloted elsewhere in the world, including Kenya.

8The conjoint experiment aims to measure trust in an intermediary, whereas the other survey is measuring if someone reported they would rely on an agent for help.
in intermediaries beyond current status-quo models.

In some cases, strong cross-sector distribution partnerships do exist, like that of Sun King and One Acre Fund, which leverages One Acre Fund’s longtime network of group leaders and field officers; but it seems as though people associate solar more with the distributor than the manufacturer.\(^9\) Opportunities to improve these cross-sector partnerships may leverage existing NGO networks or capacity to build local relationships in more rural parts of Kenya given longer histories working in these areas.\(^10\) Partnerships between companies, funders, and large NGOs are recognized as key opportunities by the leadership sitting in headquarters, but the impact of such partnerships on the individual, on-the-ground experience with solar is less clear. As mentioned in Chapter 6, different sectors may have comparative strengths or advantages, such as NGO provided training sessions, that may further enhance intermediary models in rural Kenya.

It was also surprising that both surveys in this research suggested that NGOs have little influence on trust in an intermediary or on seeking help from a solar agent. While this research cannot answer why this is the case, the shift from NGOs acting in a direct provider role to a support role for the private sector, as described in the end of Chapter 6, supports the notion of hybridity between NGOs and the private sector (MacLean and Brass, 2015). Perhaps this blurring is also rendering the influence and actions of different sectors less visible to off-grid solar end-users. Nevertheless, differences in trust in government affiliated intermediaries and the capacity of NGOs to act in more remote areas suggests opportunities for cross-sector partnerships to enhance frontline solar intermediary models.

Perceptions of joint or cross-sector responsibilities and capabilities for consumer protections in Kenya is evident on-the-ground. In Chapter 3, I showed that respondents in Trans-Nzoia County view both companies and the government responsible for quality. While they view ensuring quality more the job of the government (followed by the private sector), the capacity to actually provide high quality products is shared between the government and companies. The private sector has already illustrated a capacity to organize at the international-level with Lighting Global and within Kenya by coordinating with the Kenya Renewable Energy Association and the Kenya Bureau of Standards. The next challenge is to build these partnerships to not only to enhance consumer education about quality assurance and consumer protections, but to encourage action based on these available safeguards. Designing incentives or programs to promote cross-sector collaboration to encourage the use

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\(^9\)Focus group participants often referred to their Sun King lantern as a One Acre Fund lantern, this suggests the strongest connection to the distributor rather than the manufacturer. In a U.S. context, this may be akin to calling an iPhone from Verizon Wireless, a “Verizon phone” (the distributor) rather than an Apple iPhone (the manufacturer).

\(^10\)One NGO representative described that, “For example, you are going to Western Kenya, we’ve had several activities in Kisumu, and this could be, for example, even with our water and sanitation program. So we have networks, so we get in and build on those networks....We use our – I would say – organizational networks, so in for example in Western Kenya, there are a number of organizations working there, for example GIZ the EnDev program is there, SNV is there, and other organizations, so we use those networks just to reach out and get the message out there. And then once we get the message out there, people, the women [entrepreneurs] will apply, when they apply we take them through a screening process, so that we see those ones that have capacity, those whom we can take on board” (interview 190610)."
of safeguards, such as warranties, is a needed next step in building stronger frontline solar intermediary models.

My four research findings (bidirectional information flow, solar agents as a key resource, professional development incentives, and cross-sector partnerships) suggest ways of improving off-grid solar distribution models to encourage intermediary behavior that may more effectively support responsive service with usable consumer safeguards. As electrification efforts continue in Kenya, these four factors have implications for both off-grid solar programs and broader efforts to influence consumer protections in the energy sector. The first area where my findings can inform ongoing off-grid solar programs is the recent Kenya Off-Grid Solar Access Project (KOSAP), which promotes the use of off-grid solar in the most remote areas of Kenya, discussed in Chapter 2.

The start of KOSAP indicates a change in government engagement in off-grid solar, and based on my findings this engagement from the government has the potential to enhance trust and link off-grid solar to existing local resources. However, publicly available KOSAP materials lack discussions of training or certification requirements. As of now, KOSAP materials do not indicate how training sessions will be conducted or how county-level capacity building will occur. Currently, given the limited knowledge about solar in local government agencies, efforts like the capacity-building in KOSAP may require participation by the private sector to sufficiently ramp-up enough local capacity to sustain new programs to support off-grid solar; such cross-sector partnerships may strengthen this sector. But not all of these local activities for solar need to be built from the ground-up, by examining existing local capacity and identifying the relative strengths of these existing resources, cross-sector partnerships can incorporate the solar expertise from companies with existing county government resources and NGO networks. For example, while companies have invested resources in building independent training programs, new partnerships to support KOSAP could integrate training programs with county vocational schools. For example, while companies have invested resources in building independent training programs, new partnerships to support KOSAP could integrate training programs with county vocational schools. Not only do many vocational schools already exist, but they engage local students with existing social embeddedness that may help build the trusted networks solar companies rely on for sales and ongoing service. Partnerships to provide training sessions or certifications with local vocational schools or other existing county-level institutions may build needed incentives that go beyond the existing financial and reputational dimensions to personal and professional growth that can encourage intermediaries to act, reliably and transparently, with solar users resources.

Without more attention on how solar providers use intermediaries to engage with consumers, decision-makers may not have a full picture of what is happening in practice. With reports of positive experiences with off-grid solar – many in my sample from Trans-Nzoia reported that solar often meets their needs (Figure 3-1) – the more complex, longer-term issues are coming to the fore, such as regulation and after-sales services. In Chapter 3, I describe that at point-of-sale or for ongoing questions, the frontline solar intermediary has substantial discretion in what to tell the customer. This action of informing solar users about existing safeguards is the basis for consumer protection policies and programs. The responsibility for the most basic form of participation – informing citizens – relies on multiple responsible parties, including local intermediaries (Muzzini, 2005). This action to adequately inform
“citizens of their rights, responsibilities, and options can be the most important first step toward legitimate citizen participation” (Arnstein, 1969, 219). As I described earlier, frontline intermediaries in solar rarely share on-the-ground consumer experiences with solar providers inhibiting opportunities for end-users to provide feedback, engage in negotiation, or offer input in program and policy design. Recent efforts suggest that, nationally, Kenyans are taking stronger stands on energy issues. While off-grid solar is not central to these current efforts, the recent inclusion of off-grid solar in the Kenya National Electrification Strategy and in KOSAP requires more accountability for off-grid solar quality assurance and consumer protections.

Beyond off-grid solar, my findings are a resource for addressing broader issues of consumer protections and participation in energy decision-making. My focus on intermediaries highlights the interpersonal dimensions, incentives, and knowledge-building associated with intermediaries that can be applied to other cases of consumer protection in the electricity sector. Two recent events stand out as examples of increased participation in energy decision-making in Kenya: #SwitchOffKPLC and deCOALonize. The first, #SwitchOffKPLC, briefly mentioned in Chapter 3, responded to inflated electricity bills resulting in required payments of two to three times the usual amounts. While the conflict with Kenya Power (KPLC) was settled out of court in 2018 – angering many – this illustrates a concerted effort and social activism to ensure consumer protections. The second, deCOALonize, is a coalition formed in 2016 to stop the development of a coal power plant in Lamu County. In June 2019, the license for the plant was revoked based on an Environmental and Social Impact procedure, bolstered by substantial activism from the deCOALonize coalition. These two examples illustrate an appetite to participate in energy decision-making and to support more robust consumer protections.

While efforts are growing in Kenya to participate in energy decision-making, consumer or citizen participation in off-grid solar still remains relatively low, but this too may change. Recently the Energy and Petroleum Regulatory Authority (EPRA) released an evaluation report on their solar photovoltaic regulations, which suggests that, while limited, regulatory agencies in Kenya are starting to provide publicly available evaluations that can provide a basis for action and accountability in the off-grid solar sector (see Sustainable Energy Initiative Ltd. (2019)). Findings in this report suggest weak or no action in key areas of participatory governance, including: limited consumer education and awareness, lack of consumer-facing verification options, and insufficient processes and procedures to receive and respond to complaints. As mentioned before, agents are the lynchpin to a robust consumer protection regime for off-grid solar. Frontline solar intermediaries are relied on to provide the basic education and information about what safeguards exist for solar users, and they have the (untapped) potential to actively improve solar services and safeguards by communicating critical information back to providers.

The principles underlying more democratic energy decision-making rely not only on principles of accountability and participation, but also on equity and justice. For off-grid solar, justice must look beyond adoption, access, and distribution of technologies to the distribution

---

of risk and harm and to consider existing local capacity and resources, after-sales services, and the environmental impact of poorly disposed of systems and components (Cross and Murray, 2018, 101-2). Issues of equity and justice in off-grid solar in Kenya remain on the sidelines. However, KOSAP does have provisions for providing after-sales services to solar home system customers within the program, a first step towards more robust services.

The balance between stories of responsive, customer-first intermediaries and those who take advantage of the system by misleading customers or not sharing all the information can sometimes feel like it leans too far to the latter. Actions across levels, from international to local, suggest that people are starting to demand more from the government and service providers regarding standards of service and climate or environmental goals. As described in the introduction, often when a solar product breaks consumers do not know what to do or who to take it to for repair; just as many people in my sample reported doing nothing when their solar broke as reported returning a broken solar product to their local agent. As off-grid solar providers continue to offer PAYGo systems with more functionality, but at a higher cost, people may start feeling the financial impact of poor service (like with #SwitchOffKPLC). Additionally, actions taken by the government, such as EPRA’s recent evaluation of their solar photovoltaic regulations or the implementation of KOSAP, suggest more attention from agencies within Kenya to “steer” the private sector and support efforts to provide consumer education. The range of efforts striving to improve off-grid solar products and services in Kenya only reinforces the importance of providing frontline solar intermediaries with adequate incentives to educate consumers in their in-person interactions and to convey these on-the-ground experiences back to decision-makers to enhance off-grid solar as a service for lasting electricity access.

Beyond Kenya, intermediaries can help build trust and consumer education critical to the social and interpersonal connections that underpin accountability in off-grid solar services. Trust and consumer education, while not as commonly studied for electricity and infrastructure systems, play an important role in the transition to new technologies. Transitions to more renewable and resilient energy systems may require more end-user interactions and a rethinking of electricity infrastructure to uphold measures of reliable, quality service with more distributed solutions. Trust is rarely the primary topic in scholarship on energy, but the role of trusted intermediaries in energy processes may help scholars and practitioners understand how to encourage consumers to participate in determining the priorities for resource planning and responses to key issues such as climate change.

Trust in intermediaries opens the discussion about infrastructure systems, and the related organizations and individuals that construct, finance, and manage those systems, to the interpersonal relationships that influence implementation. Understanding what erodes trust – from unplanned electricity outages to negative health and environmental impacts – and

---

12 As a component of more democratic energy processes, justice “calls attention to the distribution of risks and benefits in relation to energy decisions, who is participating in decision-making, whether there are equitable relationship and the role of structural inequalities” (Feldpausch-Parker et al., 2019).

13 Table 7.3

14 See Bakke (2016) for an overview of the socio-technical development of U.S. electricity infrastructure and the increasing role of resilience in reimagining electricity infrastructure.
then how to rebuild trust in the organizations that provide key services is relevant across contexts.\textsuperscript{15}

While trust helps identify what matters to people and what influences behaviors, decisions, and willingness to participate, a focus on consumer education provides a baseline about the thresholds for service and what others previously determined as reasonable measures of cost, reliability, and broader measures of quality. This knowledge in turn helps people evaluate if these existing thresholds are satisfactory. Consumer education such as this provides a foundation for holding providers and policymakers accountable to policy goals: people have to know what to expect in order to judge performance. In a conversation in Kitale, Kenya someone responded to my comment about the prevalence of counterfeit solar products available in the local market, with, “well, this is Kenya” and laughed, as if to ask me: what do you expect? Frontline solar intermediaries play a role – along with others – to establish baseline expectations for the critical services that underpin daily life (electricity, water, gas, air quality, health, etc.). Intermediaries engage people – at different scales of policy and decision-making – in discussions of what standards of services we expect, what kinds of behaviors from utilities or other service providers (such as off-grid solar companies, micro-grid operators, energy service companies) are reasonable, and what measures of service quality are most important.

Using intermediaries as a lens for energy services identifies the interpersonal connections that can facilitate engagement in decisions about distributed generation, start conversations about the quality of off-grid solar services, and implement existing policies and programs. Similar to the opportunity to engage existing local capacity and resources, such as cross-sector partnerships and local vocational schools, studying frontline solar intermediaries requires that scholars, solar providers, and policymakers take stock of existing capacity, social capital, and expertise to implement safeguards and build the foundational knowledge that can inform participation in decisions about distributed solar technologies and services.

\textsuperscript{15}Recent examples, such as the PG&E outages in California, the #SwitchOffKPLC movement or continued unreliable electricity access in rural areas in many countries, illustrate this broad relevance. Poppo et al. (2016) differentiate between calculative trust (rewards and penalties) and relational trust (based on past behavior and identity) in supplier performance. Differentiating between different kinds of trust in key services is an important dimension for further exploration, as not all efforts may build trust in the same manner.
Appendix A

A.0.1 Detailed Diagrams: Solar Sister and One Acre Fund

Figure A-1: Outline of the Key Actors in Solar Sister Distribution Model

<table>
<thead>
<tr>
<th>Roles in Distribution Model</th>
<th>Responsibilities</th>
<th>Employment Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Sister Management</td>
<td>Identify and coordinate with manufacturers (Solar Sister is purely distribution with no in-house manufacturing), train and recruit BDAs</td>
<td>~5 HQ staff per country, 15-20 remote staff (below) per country (ToroWorks, 2017)</td>
</tr>
<tr>
<td>Business Development Associate (BDA)/Regional Manager</td>
<td>Train and recruit SSEs (1-25/BDA), hold monthly meetings with SSEs (training/distribution), manage logistics and sales transactions</td>
<td>Direct, locally-hired field staff (work in designated region); Report to country manager; Part-salaried, part incentive tied to number of active-this-month entrepreneurs (ToroWorks, 2017)</td>
</tr>
<tr>
<td>Solar Sister Entrepreneurs (SSE)</td>
<td>Sell/distribute clean energy (lighting and cooking) products to last-mile communities</td>
<td>Self-employed (CRW and Solar Sister, 2016); Commission-based (10% of each sale, Asker et al., 2015)</td>
</tr>
</tbody>
</table>

NGOs, SACCOS, informal groups

Social Enterprise → BDA → SSE

“trust networks”
Figure A-2: Outline of the Key Actors in One Acre Fund Distribution Model

One Acre Fund: Group Liability

<table>
<thead>
<tr>
<th>Roles in Distribution Model</th>
<th>Responsibilities</th>
<th>Employment Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Office (Kalamago)</td>
<td>Coordinate across regions and countries, trial methods to improve outreach, products, and efficiency; coordinate with suppliers internationally</td>
<td>Employee</td>
</tr>
<tr>
<td>Field Officer</td>
<td>Attending regular group meetings (for all groups in the FO’s area), distribute products, collect payments, provide trainings for group leader and group</td>
<td>Employee; Some group leaders will be identified as candidates for field officers; and move from volunteer to full-employment</td>
</tr>
<tr>
<td>Group Leader</td>
<td>Coordinating group meetings, distributing products and ensuring group works collaboratively on farms</td>
<td>Volunteer (may receive small incentives, e.g. t-shirts, calendar, etc.)</td>
</tr>
</tbody>
</table>
A.0.2 SunnyMoney Distribution Model

**Figure A-3:** Description of SunnyMoney Distribution Model with Schools and Agents. The SunnyMoney website describes the School Campaigns as “the catalyst” for the market with agents and shops to “develop market further by selling and distributing the full range of affordable solar lights and products” (SunnyMoney, 2020)
### A.0.3 Field Visits 2018-2019 (Not Including Survey Collection)

**Table A.1:** Data Collection - Field Visits Used to Inform Research Design and Provider Qualitative Data on Consumer Use of Solar, Challenges, and Opportunities within the Sector

<table>
<thead>
<tr>
<th>Location</th>
<th>Activity</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kisumu, KE</td>
<td>Field visit</td>
<td>M-Kopa field visit with Deputy Regional Manager and agents, visit 2-3 M-Kopa customers</td>
</tr>
<tr>
<td>Vihiga, KE</td>
<td>Field visit</td>
<td>Field visit Bidhaa Sasa field visit with group manager and office manager, visited 5 group leaders for Bidhaa Sasa</td>
</tr>
<tr>
<td>Kisumu, KE</td>
<td>Field visit</td>
<td>Marketplace and shops</td>
</tr>
<tr>
<td>Voi, KE</td>
<td>Field visit</td>
<td>Zawadisha group visit, interviews</td>
</tr>
<tr>
<td>Arusha, TZ</td>
<td>Field visit</td>
<td>Four days of field visits with Zola</td>
</tr>
<tr>
<td>Kitale, KE</td>
<td>Field visit</td>
<td>Household visits in tandem with focus groups in Kiminini, visit to OAF group leader</td>
</tr>
<tr>
<td>Sibanga, KE</td>
<td>Field visit</td>
<td>Weekly large market and small shops in town center</td>
</tr>
<tr>
<td>Eldoret, KE</td>
<td>Field visit</td>
<td>Visit to local shops and discussions with shop staff</td>
</tr>
<tr>
<td>Kakamega, KE</td>
<td>Field visit</td>
<td>Shadow agent, meet with other agents, visit market and customers</td>
</tr>
</tbody>
</table>
## A.0.4 Interviews Conducted

### Table A.2: Interviews: Date, Type of Organization, and Position

<table>
<thead>
<tr>
<th>Date</th>
<th>Organization</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-7-19</td>
<td>Solar Company</td>
<td>CFO</td>
</tr>
<tr>
<td>6-19-19</td>
<td>Solar Company</td>
<td>Head of Operations</td>
</tr>
<tr>
<td>7-25-19</td>
<td>Solar Company</td>
<td>Special Projects Coordinator</td>
</tr>
<tr>
<td>6-28-19</td>
<td>Solar Company</td>
<td>Chief Operations Officer</td>
</tr>
<tr>
<td>8-12-19</td>
<td>Solar Company</td>
<td>Co-Founder/Director</td>
</tr>
<tr>
<td>7-10-19</td>
<td>Solar Company</td>
<td>Shop Manager</td>
</tr>
<tr>
<td>7-12-19</td>
<td>Solar Company</td>
<td>Shop Owner</td>
</tr>
<tr>
<td>7-19-19</td>
<td>Solar Company</td>
<td>Agent</td>
</tr>
<tr>
<td>7-19-19</td>
<td>Solar Company</td>
<td>Agent</td>
</tr>
<tr>
<td>7-21-19</td>
<td>Solar Company</td>
<td>Shop Manager</td>
</tr>
<tr>
<td>7-14-19</td>
<td>Solar Company</td>
<td>Electrician</td>
</tr>
<tr>
<td>6-5-19</td>
<td>Research</td>
<td>Independent</td>
</tr>
<tr>
<td>9-2-19</td>
<td>Research</td>
<td>Director</td>
</tr>
<tr>
<td>3-28-19</td>
<td>NGO</td>
<td>Data Analyst</td>
</tr>
<tr>
<td>6-10-19</td>
<td>NGO</td>
<td>Technical and Consulting Unit</td>
</tr>
<tr>
<td>8-13-19</td>
<td>NGO</td>
<td>Technical and Consulting Unit</td>
</tr>
<tr>
<td>7-26-19</td>
<td>NGO</td>
<td>Senior Policy Officer</td>
</tr>
<tr>
<td>8-8-19</td>
<td>NGO</td>
<td>Corporate Operations</td>
</tr>
<tr>
<td>8-6-19</td>
<td>NGO</td>
<td>Founder</td>
</tr>
<tr>
<td>4-4-18</td>
<td>NGO</td>
<td>Director of Development</td>
</tr>
<tr>
<td>6-18-19</td>
<td>Industry Group</td>
<td>Staff</td>
</tr>
<tr>
<td>8-9-19</td>
<td>Industry Group</td>
<td>Staff</td>
</tr>
<tr>
<td>8-6-19</td>
<td>Government, REA/REREC</td>
<td>Chief Manager, Renewable Energy</td>
</tr>
<tr>
<td>8-13-19</td>
<td>Government, REA/REREC</td>
<td>Staff</td>
</tr>
<tr>
<td>8-5-19</td>
<td>Government, KEBS</td>
<td>Electrotechnical Department</td>
</tr>
<tr>
<td>7-9-19</td>
<td>Government, Trans-Nzoia County</td>
<td>Member of County Assembly</td>
</tr>
<tr>
<td>8-6-19</td>
<td>Government, EPRA</td>
<td>Renewable Energy Engineer</td>
</tr>
</tbody>
</table>
# A.0.5 Focus Groups Conducted

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Group Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-10-19</td>
<td>Trans-Nzoia, Makutano</td>
<td>Single Mother's Group</td>
<td>8</td>
</tr>
<tr>
<td>7-11-19</td>
<td>Trans-Nzoia, Kiminini/Big Tree</td>
<td>Village Group</td>
<td>11</td>
</tr>
<tr>
<td>7-11-19</td>
<td>Trans-Nzoia, Kiminini</td>
<td>Boda Boda Group</td>
<td>11-6</td>
</tr>
<tr>
<td>7-11-19</td>
<td>Trans-Nzoia, Kiminini</td>
<td>Dairy Farmers Group</td>
<td>14</td>
</tr>
<tr>
<td>7-13-19</td>
<td>Trans-Nzoia, Kwanza</td>
<td>Community Based Organization</td>
<td>80+</td>
</tr>
<tr>
<td>7-15-19</td>
<td>Uasin-Gishu, Moi’s Bridge</td>
<td>Mix/Informal</td>
<td>12</td>
</tr>
<tr>
<td>7-19-19</td>
<td>Kakamega, Kakamega</td>
<td>Market vendors</td>
<td>5</td>
</tr>
<tr>
<td>7-20-19</td>
<td>Kakamega, Matete</td>
<td>Mix/Informal</td>
<td>15-18</td>
</tr>
<tr>
<td>7-20-19</td>
<td>Kakamega, Tande</td>
<td>Boda Boda Group</td>
<td>12</td>
</tr>
<tr>
<td>7-20-19</td>
<td>Kakamega, Butali</td>
<td>Boda Boda Group</td>
<td>10</td>
</tr>
<tr>
<td>7-21-19</td>
<td>Kakamega, Kakamega</td>
<td>Youth group</td>
<td>10-12</td>
</tr>
</tbody>
</table>
A.0.6 Conjoint Survey Instrument and Implementation

Survey Instrument (in Kiswahili)

This section provides information on the survey instrument used for data collation in Machakos, Kenya. Responses were collected using the Qualtrics offline App using the conjoint tool developed by Meyer and Rosenzweig (2016). Figure A-4 is an example screenshot of what the tablet looked like to respondents, while the majority of the survey was in Kiswahili, some key words were also provided in English. The order of the attributes (leftmost column) was randomized by respondent, but consistent across the five choice sets each respondent answered. For each profile (A and B), the levels of each attribute were randomized.

![Figure A-4: Image of Instrument in the Qualtrics Off-line App](image)

The instrument was tested for two days in Kikuyu, Kenya within a nearby distance to Nairobi in order to make subsequent changes and align with the data collection schedule. Based on the field-testing changes were made to the instrument to clarify the directions (an example was added) and to simplify some of the levels of attributes.

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1 The code provided by Meyer and Rosenzweig (2016) was modified to allow for two conjoint experiments to be present in one survey, this allowed for data collection for this dissertation research and for another paper on perceptions of quality in off-grid solar upgrade decisions. The order in which respondents saw each conjoint experiment was randomized automatically in the Qualtrics Offline App.
Kiswahili to English Translation of Instrument

While Figure A-4 provides an example of what respondents actually saw on the tablet using the Qualtrics offline app, this table provides the Kiswahili and English for the introduction to the survey, attributes and all levels, and the conclusion. This section does not include the first section of the instrument which was a human subjects research consent protocol, screening questions, and questions about solar use. This survey was done in conjunction with another conjoint survey experiment about upgrading solar home systems (not a part of this dissertation) and the order of the two experiments was randomized.

1. Introduction about intermediaries We are interested in understanding why you trust one person more than another to provide you with solar services. When thinking about these choices please think about the person you first heard about solar from or anyone you have gone to if you have problems with your solar system. Please reflect on why you trust that person to help you with solar. This can include when you purchase solar and also as you continue to use the solar system in your household. For example, you might go to this person if you have any problems with your solar, need maintenance or repairs, or want to change anything about your solar system.

   Tunapendelea kuelewa mbona unaamini mtu mmoja kuliko mwingine kukupa huduma za solar. Unapofikiria kuhusu hizi chaguo, tafadhali fikiria kuhusu mtu wa kwanza uliye pata habari kuhusu solar kwa mtu yeye yote uliye enda kwa shida ya solar yako. Tafadhali tafakari mbona unamuamini mtu huyo kukusaidia na solar. Hii inaweza husisisha wakati unapofanya solar na pia unaendelea kutumia solar nyumbani kwako. Kwa mfano, unaweza kuenda kwa mtu huyo ikiwa una matatizo yoyote na solar yako au ungetaka kubadilisha kitu chochote kuhusu solar yako.

2. Introduction to attributes We will first discuss these options with you, for this set there are four things that differentiate this person who you would talk to about how to get solar services.

Kwanza tutajadili chaguo hizi pamoja na wewe, kwa seti hii kuna vitu vinne vinavyotofautisha mtu kutoka kwa shirika ambalo ungezungumza naye kuhusu solar jinsi ya kupata huduma za solar.

- Sector: is this person affiliated with the government, an NGO, or a company.
  
  Sekta: Ni mtu ambaye ana uhusiano na serikali, shirika lisilo la kiserikali, au sekta ya kampuni.

- Your relationship with this person: is this person from your community - meaning you already know them and have a relationship to them - or not.
  
  Uhusiano wako na mtu huyu: Mtu huyu anatoka kwenywe kijiji hiki - Kumaanisha tayari unawajua na una uhusiano nao - au la.

- Who does this person have a personal relationships or connections with? These relationships may help share information with about solar.
  
  Mtu huyu ana uhusiano wa kibinafsì na nani? Uhusiano hwe unaweza saidia kusambaza habari kuhusu solar.
• Activities/expertise: What is this person able to provide you? For example, do they provide you with information about solar, for example, or pricing or system capacity. Can they offer you financing for solar so that you do not have to pay for the system all at once, or do they offer training on how to use your solar system and battery effectively (so you always have light) and know what appliances work on the solar system and what do not.


3. Do you have any questions? Una maswali yoyote?

4. Which of the two would you trust more to help you get solar services?
   Ni ipi kati ya hizi mbili ungeweza kuamini zaidi kukusaidia kupata huduma za solar?

5. (Here enumerators were reminded to emphasize that this question is about trust, nor just which profile they prefer.)

6. Respondent selected from randomly generated profiles, attributes and levels with English and Kiswahili in Table A.4. As illustrated in Figure A-4 the attributes were provided in both Kiswahili and English, while levels were only provided in Kiswahili.

7. Following the completion of both conjoint experiments and the rankings, each respondent was asked for demographic, economic, and electricity questions. The order or the demographic questions in the survey sequence was not randomized, they were always at the end.
<table>
<thead>
<tr>
<th>Attributes</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Your relationship with this person</strong></td>
<td>outsider not from community</td>
</tr>
<tr>
<td></td>
<td>family from community</td>
</tr>
<tr>
<td></td>
<td>elder from community</td>
</tr>
<tr>
<td><strong>Uhusiano wako na mtu huyu</strong></td>
<td>mtu kutoka</td>
</tr>
<tr>
<td></td>
<td>familia</td>
</tr>
<tr>
<td></td>
<td>mzee kutoka</td>
</tr>
<tr>
<td></td>
<td>nje ya jamii yako</td>
</tr>
<tr>
<td></td>
<td>kutoka kwa jamii yako</td>
</tr>
<tr>
<td></td>
<td>jamii yako</td>
</tr>
<tr>
<td><strong>Personal connections</strong></td>
<td>connection to politicians from your area</td>
</tr>
<tr>
<td></td>
<td>connection to local service provider</td>
</tr>
<tr>
<td></td>
<td>connection to local NGO</td>
</tr>
<tr>
<td><strong>Uhusiano wa kibinafsi</strong></td>
<td>uhusiano na wanasiasa</td>
</tr>
<tr>
<td></td>
<td>uhusiano na anayetoa</td>
</tr>
<tr>
<td></td>
<td>uhusiano na shirika lisilo</td>
</tr>
<tr>
<td></td>
<td>uhusiano na anayetoa la kiserikali au NGO</td>
</tr>
<tr>
<td></td>
<td>uhusiano na anayetoa la kiserikali au NGO</td>
</tr>
<tr>
<td><strong>Activities - expertise</strong></td>
<td>provide information</td>
</tr>
<tr>
<td></td>
<td>provide training</td>
</tr>
<tr>
<td></td>
<td>provide financing</td>
</tr>
</tbody>
</table>

| **Shughuli - ustadi**                          | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |
|                                                | mtu anayeweza                               |

| **Sector affiliation**                         | private                                     |
|                                                | government                                  |
|                                                | non-profit or NGO                           |
| **Sekta**                                      | kampuni ya kibinafsi                        |
|                                                | (private)                                   |
|                                                | serikali                                    |
|                                                | shirika lisilo                              |
|                                                | (private)                                   |
|                                                | la kiserikali au NGO                        |

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A.0.7 Diagnostics for Conjoint Survey Data

These considerations each offer a possible diagnostic to test the validity of a conjoint experiment. (Hainmueller et al., 2014) suggest the following definitions of each of these issues and tests for validity:

1. Carryover effects: information in a prior choice set or task should not influence what respondents choose in later tasks; diagnostics: run sub-sample regressions or interact attributes to task indicator

2. Profile order effects: the order in which profiles are presented should be similar whether in profile A or profile B; diagnostics: interact attributes with profile indicator

3. Randomization: randomization should result in well balanced groups; diagnostics: compare responses across groups; regress respondent characteristics on attribute indicators

4. Attribute order effects: the position of an attribute in the profile should not influence choice; diagnostic: row position dummies

5. Atypical profiles: realism of the profiles, while this should be addressed in design as well, it is possible to generation unlikely profiles.

For this research, atypical profiles were not described as an issue in either testing or data collection – a frontline solar intermediary could plausibly fall into the different arrangements proposed by the levels. Perhaps the most unlikely situations are combinations of social capital measures that do not align. For example, an outsider with connections to politicians, yet even this is plausible given the examples of layering connections in Chapter 5, indeed an intermediary may have connections visible most to citizens with a local leader rather than a service provider or NGO if they work closely with local influencers.

The primary concerns for this research were carryover effects and profile order effects as each respondent was asked to answer five choice sets. Randomization of attribute order was designed into the instrument: the order of the attributes varied by respondents. Unfortunately, these orders are not currently captured by the Qualtrics offline app, but the randomization was designed to reduce any bias from seeing attributes in any specific order. To reduce confusion, the order of attributes was consistent across a single respondent (see Meyer and Rosenzweig (2016)). To test for profile order effects, I interacted each attribute with the variable indicating alternative (A or B) and found no substantial effects on the model trends. As indicated in Table A.5, Model 3 is the final main effects model presented in Table 6.7, comparing Model 3 and the Profile Order Model, none of the interaction terms are significant and the significance levels, direction, and magnitude of coefficients are relatively consistent across both models. To test for carryover effects, I subset the sample to just the first round of responses. While this sample has a much smaller sample size, the patterns in direction and significance of the model coefficients are again similar to Model 3. Although, given the smaller sample size in the subsample, it is more difficult to detect significance, so
outsider, government, and some of the controls are not significant at the same $\alpha$ level as in Model 3. The comparisons between Model 3, Profile Order, and Carryover do not suggest substantial bias due to the repeated responses.

Table A.5: Diagnostic Tests for Conjoint Experiment, “which of the two would you trust more to help you get solar services?”
Dependent Variable: choice (0 = No/1 = Yes)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Profile Order</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Carryover</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative-Specific Variables</td>
<td></td>
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<td><strong>Embeddedness</strong></td>
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<tr>
<td>Family</td>
<td>-0.0880 (-0.99)</td>
<td>-0.0662 (-0.53)</td>
<td>0.0422 (0.19)</td>
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<tr>
<td>Outsider</td>
<td>-0.578*** (-5.87)</td>
<td>-0.518*** (-4.02)</td>
<td>-0.427* (-1.92)</td>
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<tr>
<td><strong>Bargaining</strong></td>
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<tr>
<td>Politicians</td>
<td>-0.578*** (-6.37)</td>
<td>-0.722*** (-5.59)</td>
<td>-0.902*** (-4.14)</td>
</tr>
<tr>
<td>Service provider</td>
<td>0.236** (2.59)</td>
<td>0.163 (1.32)</td>
<td>0.290 (1.30)</td>
</tr>
<tr>
<td><strong>Affiliation</strong></td>
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<tr>
<td>Reference: Company</td>
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<tr>
<td>Government</td>
<td>0.515*** (5.48)</td>
<td>0.588*** (4.64)</td>
<td>0.439* (1.98)</td>
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<tr>
<td>NGO</td>
<td>0.0149 (0.17)</td>
<td>0.101 (0.78)</td>
<td>0.00228 (0.01)</td>
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<tr>
<td><strong>Expertise</strong></td>
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<tr>
<td>Reference: Financing</td>
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<tr>
<td>Provide information</td>
<td>-0.0861 (-0.89)</td>
<td>-0.105 (-0.79)</td>
<td>0.0953 (0.42)</td>
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<tr>
<td>Provide training</td>
<td>0.0574 (0.58)</td>
<td>-0.0526 (-0.40)</td>
<td>0.166 (0.68)</td>
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<td><strong>Profile Interaction</strong></td>
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<tr>
<td>Reference: A</td>
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<tr>
<td>Family × B</td>
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<td>-0.132 (-0.77)</td>
<td>-0.151 (-0.91)</td>
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<td>Outsider × B</td>
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<td>-0.151 (-0.91)</td>
<td>-0.156 (-0.88)</td>
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<td>Government × B</td>
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<td>NGO × B</td>
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<td>0.279 (1.52)</td>
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<td>Politicians × B</td>
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<td>0.144 (0.85)</td>
<td>0.144 (0.85)</td>
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<td>0.0324 (0.18)</td>
<td>0.0324 (0.18)</td>
<td>0.0324 (0.18)</td>
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<td>Provide information × B</td>
<td>0.225 (1.25)</td>
<td>0.225 (1.25)</td>
<td>0.225 (1.25)</td>
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<td>Provide training × B</td>
<td>0.225 (1.25)</td>
<td>0.225 (1.25)</td>
<td>0.225 (1.25)</td>
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<td><strong>Individual-Specific Variables</strong></td>
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<tr>
<td>First solar</td>
<td>0.347* (2.24)</td>
<td>0.356* (2.28)</td>
<td>0.643* (1.68)</td>
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<td>Household size</td>
<td>0.0394+ (1.88)</td>
<td>0.0392+ (1.86)</td>
<td>0.0708 (1.18)</td>
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<tr>
<td>Has electricity</td>
<td>-0.361* (-2.28)</td>
<td>-0.354* (-2.21)</td>
<td>-0.473 (-1.15)</td>
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<td>Village FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Enumerator FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.455 (-1.08)</td>
<td>-0.494 (-1.01)</td>
<td>-1.845+ (-1.65)</td>
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</table>

Observations: 3730 3730 746

$t$ statistics in parentheses; $^+ p < 0.10, ^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$; clustered standard errors at respondent-level.
A.0.8 Additional Descriptive Statistics on Demographics and Socioeconomic Variables in Trans-Nzoia County Survey

Table A.7 provides the polychoric correlation between variables often considered relevant for electricity access studies and the summary statistics. In addition to the binary, ordinal, and continuous variables in Table A.7, the breakdown in ethnic group in the sample is in Table A.6, recoded to have slightly more balanced groups within the variable.

Table A.6: Nominal (unordered categorical) control variables for ethnic group in Kenya (N = 893), Trans-Nzoia County, Kenya

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<th>variable</th>
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<td>ethnicity</td>
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<td>other</td>
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<td>kalenjin</td>
<td>176</td>
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<tr>
<td>kikuyu</td>
<td>60</td>
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<tr>
<td>kisii</td>
<td>42</td>
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<tr>
<td>luhya</td>
<td>496</td>
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<tr>
<td>luo</td>
<td>45</td>
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### Table A.7: Polychoric correlations and summary statistics for possible control variables for Poisson model

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<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
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<tr>
<td><strong>(2)</strong> has_radio</td>
<td>0.1282</td>
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</tr>
<tr>
<td><strong>(3)</strong> has_tv</td>
<td>0.0424</td>
<td>0.1976</td>
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<td><strong>(4)</strong> monthly_income</td>
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<td><strong>(5)</strong> monthly_expend_kerosene</td>
<td>-0.2446</td>
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<td>-0.2136</td>
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<td><strong>(6)</strong> monthly_expend_food</td>
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<td>0.1126</td>
<td>0.3912</td>
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<td>0.1402</td>
<td>0.1401</td>
<td>0.0482</td>
<td>-0.0039</td>
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<td>0.1537</td>
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<td><strong>(10)</strong> number_school_children</td>
<td>0.1682</td>
<td>-0.0838</td>
<td>-0.0236</td>
<td>0.0838</td>
<td>-0.0067</td>
<td>0.2318</td>
<td>-0.1447</td>
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<td>0.0094</td>
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<td>0.0597</td>
<td>0.0501</td>
<td>0.0132</td>
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<td>0.4551</td>
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<td>0.1498</td>
<td>0.3059</td>
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<td>-0.0995</td>
<td>-0.1598</td>
<td>-0.1914</td>
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<td>-0.3152</td>
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<td>0.1335</td>
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<td>0.0145</td>
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<td>0.0123</td>
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<tr>
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<td>0.0167</td>
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<td>0.0894</td>
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<td>-0.0658</td>
<td>-0.0092</td>
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<td>-0.2107</td>
<td>0.2201</td>
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<td>-0.0266</td>
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<td>-0.0414</td>
<td>0.0046</td>
<td>0.1072</td>
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### Summary Statistics

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</table>
### Table A.8: Logit Models: Binary Knowledge Variables (1-3)

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<th>(1) warranty duration</th>
<th>(2) warranty purpose</th>
<th>(3) warranty terms</th>
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<tr>
<td>electrician</td>
<td>0.307 (0.73)</td>
<td>0.710 (1.10)</td>
<td>-1.036+ (-1.90)</td>
</tr>
<tr>
<td>solar agent</td>
<td>0.614 (1.56)</td>
<td>1.459* (2.39)</td>
<td>-0.923+ (-1.83)</td>
</tr>
<tr>
<td>other social ties</td>
<td>0.358 (0.77)</td>
<td>0.762 (1.20)</td>
<td>-1.138* (-2.06)</td>
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<tr>
<td>other</td>
<td>-0.138 (-0.25)</td>
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<td>-0.640 (-1.07)</td>
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<tr>
<td>Purchased solar</td>
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<td>Reference: never</td>
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<tr>
<td>within past 2 years</td>
<td>-0.00969 (-0.05)</td>
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<td></td>
</tr>
<tr>
<td>more than 2 years ago</td>
<td>0.356+ (1.74)</td>
<td></td>
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</tr>
<tr>
<td>Married</td>
<td>0.482* (2.39)</td>
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</tr>
<tr>
<td>Household size</td>
<td>-0.0933** (-2.71)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent age</td>
<td>0.0132+ (1.73)</td>
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</tr>
<tr>
<td>In chama</td>
<td>0.429* (2.18)</td>
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<td>In informal group</td>
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<td>-1.024** (-2.69)</td>
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<tr>
<td>Has radio in home</td>
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<td>0.733* (1.96)</td>
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</tr>
<tr>
<td>Has TV</td>
<td>0.630* (2.20)</td>
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<tr>
<td>Respondent Education</td>
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<td>Reference: informal</td>
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<td>0.285 (0.61)</td>
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<td>0.510 (1.02)</td>
<td>0.244 (0.53)</td>
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<td>secondary or hs completed</td>
<td>0.742 (1.55)</td>
<td>0.625 (1.39)</td>
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<tr>
<td>post secondary non university</td>
<td>1.452** (2.65)</td>
<td>0.644 (1.37)</td>
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<td>university completed or higher</td>
<td>0 (.)</td>
<td>1.079+ (1.81)</td>
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</tr>
<tr>
<td># times contacted gov</td>
<td>-0.0480* (-2.15)</td>
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<tr>
<td>In church group</td>
<td>-0.797* (-2.04)</td>
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<td></td>
</tr>
<tr>
<td># school-age children</td>
<td></td>
<td>-0.0364 (-0.74)</td>
<td></td>
</tr>
<tr>
<td>Ethnic group</td>
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<tr>
<td>Reference: other</td>
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<tr>
<td>kalenjin</td>
<td>-0.493 (-1.16)</td>
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<td>kikuyu</td>
<td>-0.403 (-0.79)</td>
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<tr>
<td>kisii</td>
<td>-1.040* (-2.04)</td>
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<tr>
<td>luhya</td>
<td>-0.689+ (-1.86)</td>
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<td></td>
</tr>
<tr>
<td>luo</td>
<td>-0.620 (-1.24)</td>
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<tr>
<td>Ward</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Constant</td>
<td>-0.184 (-0.32)</td>
<td>0.488 (0.48)</td>
<td>2.016* (2.54)</td>
</tr>
<tr>
<td>Observations</td>
<td>893</td>
<td>842</td>
<td>893</td>
</tr>
<tr>
<td>Pseudo $R^2$</td>
<td>0.084</td>
<td>0.195</td>
<td>0.223</td>
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$t$ statistics in parentheses, robust standard errors

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Table A.9: Logit Models: Binary Knowledge Variables (4-6)

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<tr>
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<tr>
<td></td>
<td>file complaint</td>
<td>runtime</td>
<td>dc electricity</td>
</tr>
</tbody>
</table>

**Key IV: Intermediary Type**

Reference: entrepreneur

- electrician: 0.470 (1.26) 0.741+ (1.82) 0.280 (0.64)
- solar agent: 0.993** (2.83) 0.670+ (1.76) -0.0791 (-0.20)
- other social ties: -0.0236 (-0.06) 0.681 (1.51) -0.405 (-0.80)
- other: -0.878+ (-1.74) 0.509 (0.98) -1.403* (-2.14)

- Has radio: 0.203 (0.67) 0.253 (0.86)
- Has TV: 0.240 (1.37) 0.427* (2.45)

**Respondent Education**

Reference: informal

- some primary: -0.292 (-0.68) 0.218 (0.34)
- primary completed: -0.214 (-0.51) 0.912 (1.48)
- intermediate or some secondary: -0.461 (-1.06) 0.894 (1.45)
- secondary or hs completed: 0.0723 (0.18) 1.386* (2.34)
- post secondary non university: -0.388 (-0.87) 1.459* (2.35)
- university completed or higher: 0.209 (0.35) 2.009** (2.98)

- Monthly income (KES): 0.0000120+ (1.83)

**Respondent Occupation**

Reference: other

- farmer: -0.200 (-0.96)
- owns business: -0.369 (-1.57)

- In chama: -0.0401 (-0.23)

- # attended community meeting: 0.0152 (0.95)

- Respondent male: 0.227 (1.40) 0.813*** (4.18)

**Purchased solar**

Reference: never

- within past 2 years: 0.106 (0.45)
- more than 2 years ago: 0.531* (2.47)

- Ward: ✓ ✓ ✓

- Constant: -1.260+ (-1.86) -1.818** (-3.10) 0.802 (0.85)

**Observations**

- 893 893 893

**Pseudo $R^2$**

- 0.167 0.237 0.319

*t statistics in parentheses, robust standard errors

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Table A.10: Logit Models: Binary Knowledge Variables (7-9)

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<td>stop paying</td>
<td>paygo cost</td>
<td>agency name</td>
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<td>Key IV: Intermediary Type</td>
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<td></td>
<td></td>
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<tr>
<td>Reference: entrepreneur</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrician</td>
<td>0.319 (0.40)</td>
<td>0.801 (1.60)</td>
<td>0.635 (1.32)</td>
</tr>
<tr>
<td>solar agent</td>
<td>1.236 (1.53)</td>
<td>0.563 (1.32)</td>
<td>0.734 (1.60)</td>
</tr>
<tr>
<td>other social ties</td>
<td>-0.0578 (-0.06)</td>
<td>-0.370 (-0.77)</td>
<td>0.454 (0.82)</td>
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<td>other</td>
<td>-1.292 (-1.33)</td>
<td>-0.605 (-1.10)</td>
<td>0.613 (0.97)</td>
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<tr>
<td>Has TV</td>
<td>0.651+ (1.70)</td>
<td>0.305 (1.34)</td>
<td>0.335 (1.61)</td>
</tr>
<tr>
<td>Respondent male</td>
<td>0.000487 (0.00)</td>
<td></td>
<td>0.547** (2.65)</td>
</tr>
<tr>
<td>Married</td>
<td>0.0627 (0.13)</td>
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<tr>
<td># school-age children</td>
<td>-0.102 (-0.99)</td>
<td>0.153+ (1.93)</td>
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<tr>
<td>Respondent Education</td>
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<tr>
<td>Reference: informal</td>
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<tr>
<td>some primary</td>
<td>-0.360 (-0.41)</td>
<td>0.235 (0.51)</td>
<td>0.731 (1.03)</td>
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<tr>
<td>primary completed</td>
<td>-0.166 (-0.19)</td>
<td>0.159 (0.34)</td>
<td>0.934 (1.37)</td>
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<tr>
<td>intermediate or some secondary</td>
<td>-0.222 (-0.25)</td>
<td>-0.115 (-0.24)</td>
<td>1.084 (1.57)</td>
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<tr>
<td>secondary or hs completed</td>
<td>0.211 (0.26)</td>
<td>0.355 (0.78)</td>
<td>1.901** (2.92)</td>
</tr>
<tr>
<td>post secondary non university</td>
<td>0.0324 (0.03)</td>
<td>0.00986 (0.02)</td>
<td>2.360*** (3.52)</td>
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<td>university completed or higher</td>
<td>0 (.)</td>
<td>0.849 (1.20)</td>
<td>2.727*** (3.81)</td>
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<tr>
<td>In informal group</td>
<td>-1.289** (-2.84)</td>
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<tr>
<td>Has radio</td>
<td>-0.00307 (-0.01)</td>
<td>-0.0965 (-0.26)</td>
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<tr>
<td>Household size</td>
<td>-0.109* (-2.17)</td>
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<tr>
<td># attended community meeting</td>
<td>-0.0127 (-0.92)</td>
<td>0.0140 (0.74)</td>
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<tr>
<td>In chama</td>
<td>0.395+ (1.76)</td>
<td>0.174 (0.80)</td>
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<tr>
<td>Respondent Occupation</td>
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<tr>
<td>Reference: other</td>
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<tr>
<td>farmer</td>
<td>-0.465+ (-1.77)</td>
<td>-0.280 (-1.13)</td>
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<tr>
<td>owns business</td>
<td>-0.448 (-1.58)</td>
<td>-0.213 (-0.76)</td>
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<tr>
<td>Ward</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Constant</td>
<td>3.057+ (1.94)</td>
<td>2.470+ (2.51)</td>
<td>-4.354*** (-4.41)</td>
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<tr>
<td>Observations</td>
<td>684</td>
<td>893</td>
<td>893</td>
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<tr>
<td>Pseudo $R^2$</td>
<td>0.195</td>
<td>0.157</td>
<td>0.215</td>
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</table>

* t statistics in parentheses, robust standard errors
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001
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