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MOVING FORWARD?

Building foundational capabilities in Kenyan and Tanzanian off-grid solar PV firms

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Abstract

In this chapter, we ask how firms in the off-grid solar photovoltaics (PV) sectors in Kenya and Tanzania have accumulated their innovation capabilities. This enables us to provide a novel categorisation of solar PV companies in the two countries according to their levels of innovativeness. Further, and with reference to latecomer theory, we develop an argument on the importance of nurturing a 'pre-latecomer phase' in which foundational capabilities are built that could support sustainable industrialisation. In the off-grid PV sector in Kenya and Tanzania, this has taken about 30 years, consisting of various types of cumulative learning processes. With this foundation in place, in the 2010s, a number of start-up firms began to innovate in the countries' off-grid PV sectors to the extent that some of them are now world-leading. While most highly innovative companies are of foreign origin, this creates opportunities for local firms to strengthen their learning and potentially enter an 'early latecomer' phase where they could build increasingly complex capabilities, including for manufacturing. We end the chapter by discussing the policy issues and uncertainties relevant to nurturing these more complex capabilities.

Introduction

Sustainable industrialisation is based on a progressive increase of environmentally friendly and enduring industrial activities firmly rooted in the local economy (see Hanlin et al., in this volume). And, as argued in this book, building renewable electrification capabilities can support sustainable industrialisation. In this chapter, we analyse how innovation capabilities have been accumulated in the off-grid solar photovoltaics (PV) sectors in Kenya and Tanzania. Most of

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the solar firms' activities are in servicing off-grid electrification demand, and their innovativeness is primarily in new business models facilitated by technologies designed and manufactured outside Africa (Rolffs et al., 2015; Byrne et al., 2018). However, there are signs of some features of original equipment manufacturing (OEM) present in Kenya, suggesting we may be close to seeing so-called latecomer firms emerge there (Hobday, 1995, 2001). If so, and something similar occurs in Tanzania, the experience of how innovation capabilities have been accumulated in off-grid solar PV may form a 'pre-latecomer' story that offers insights on how to foster industrialisation in countries with currently limited industrial bases. As such, our analysis helps us identify a range of issues policy makers must address if they wish to promote sustainable industrialisation in the poorer countries of the Global South.

The latecomer literature assumes the presence of local manufacturing, especially the literature drawing on Hobday's (1995) analysis of electronics firms in East Asia and his characterisation of capability-accumulation through the OEM-ODM-OBM[1] sequence. Analysis in this literature focuses on how such firms use international technology transfer mechanisms – e.g., licensing, joint ventures, and others – to establish an international market presence and gradually upgrade their capabilities until they can manufacture their own internationally competitive products. In countries with few manufacturing firms who can attract investments for local OEM activities, as is the case in much of Africa, latecomer theory is of limited direct value. For countries in this situation, we need analyses that can illuminate how to foster what we are calling a pre-latecomer phase.

Entrepreneurial firms are witnessing increasing turnover and sales in the off-grid PV sector (Lighting Global, 2020). Global investment for off-grid electricity access start-ups intensified in the 2010s – growing from USD 20 million (2013) to nearly USD 400 million (2018) – especially targeting solar home systems, and more recently mini-grids (REN21, 2020, p. 156). We guide our analysis by asking 'how have solar PV firms in Kenya and Tanzania accumulated their innovation capabilities?' From this basis, we argue that we can see significant effort over about 30 years in both countries to build foundational capabilities relevant to the evolution of their off-grid solar PV markets. This period of foundational capability-formation is what we call the pre-latecomer phase, and the presence of entrepreneurial firms could signal an early latecomer phase. The growth in entrepreneurial firms who are developing variously innovative business models and technologies is exemplified by the use of mobile finance – an important component of pay-as-you-go (PAYG) business models (Rolffs et al., 2015) – and part of the rise of start-up culture. Our analysis helps us reflect on the policy implications for countries looking to develop new sectors to promote sustainable industrialisation.

After briefly reviewing the literatures on entrepreneurship and latecomer theory, we explain our analytical framework, which focusfes on firms' innovation capabilities, and describe our methodology. We then provide a historical overview of initial efforts to promote the adoption of off-grid solar PV in Kenya and

Tanzania. In our analysis, we elaborate on the processes of learning revealed by the activities of off-grid solar PV firms, after which we reflect on the economic value of such endeavours. We then discuss the relevance of these Kenyan and Tanzanian developments, their position with reference to a potential latecomer phase, and the policy issues and related uncertainties they raise. Summarising remarks conclude our chapter.

Analytical framework and methodology

To explain our analytical framework, we first describe the features of entrepreneurial firms, who we position as key actors in the pursuit of sustainable industrialisation, and reflect briefly on what latecomer theory says about how developing-country firms can build their capabilities. We then present our framework, which characterises firms in terms of levels of innovation capabilities, and we finish the section with a description of our methodology.

Entrepreneurial firms

Entrepreneurs stem from specific contexts and so hold diverse profiles (Audretsch, 2012). An entrepreneurial firm searches for new business opportunities (Schumpeter, 1934) while a start-up, more specifically, is an entrepreneurial firm who uses innovation to thrive and grow (Ries, 2011). Social entrepreneurs also use this logic (Miller, 2009) to generate ideas for products or services (Picken, 2017). Firms benefit from experience (Shane, 2000), as opportunities may arise from technological and value shifts (Kim and Mauborgne, 1997; Rohrbeck, 2010). Enabling conditions and a supportive environment can help them (Grilli et al., 2018) as they are easily affected by discontinuities and changes in the policy environment (Georgallis and Durand, 2017). A challenge for entrepreneurship-oriented policies in African countries (Poole, 2018) is that capability gaps in these contexts may affect entrepreneurs more than their international peers (Gabriel et al., 2016).

Firms in Tanzania suffer from a low technological base and weak opportunity-recognition (Goedhuys, 2007), while some small and medium-sized enterprises in Kenya are in the early stages of internationalisation (Osano, 2019). Thus, entrepreneurial off-grid solar PV firms in Kenya and Tanzania face a range of challenges when seeking to benefit from the opportunities presented to them by, for example, the rising investments earlier noted. Amongst these challenges are enhancing the firms' innovation capabilities. If cultivated successfully, these capabilities will benefit an individual firm and can also benefit the wider national economy, if many local firms similarly develop their innovation capabilities. We next briefly discuss evidence and analyses in the latecomer literature that describes how firms can become internationally competitive.

Latecomer theory

Latecomer theory is interested in how developing-country firms aim to compete in international markets. In this vein, much academic theorising has been done on how to build innovation capabilities, and mostly on the basis of Asian and Latin American experiences (e.g., see Hobday, 1995; Bell, 1997, 2009; Bell and Figueiredo, 2012).

Hobday (1995) describes the experience of electronics firms in East Asia and how they succeeded in developing their capabilities. Initially, in East Asia's pre-latecomer phase, foreign firms possessed a technological advantage, and few local firms performed any manufacturing activity. The foreign firms began to act as examples for them after the local firms had acquired necessary basic-level capabilities. Some local firms were able to start performing assembly services for the foreign ones and thereby capture more of the value-added for themselves. Others went further, learning basic manufacturing skills, supported by national efforts and strategies (Hobday et al., 2004).

Acquiring such capabilities was achieved through different kinds of relationships with foreign firms: e.g., subcontracting, joint ventures, and licensing. Under subcontracting relationships, leading companies in East Asia trained local managers, engineers, and technicians to build important knowledge and skills for the future. For instance, in South Korea, firms benefited from visits by foreign engineers and visits by Koreans to overseas factories. Joint ventures, in turn, are strategic partnerships where the partners have a relatively equal footing. In licensing, a local firm pays for the right to manufacture, and the foreign firm transfers the required technology to that local firm. Licensing can be deep or shallow (Lall, 1992) but may require more complex capabilities than a joint venture. Other examples of these kinds of learning and technology transfer relationships can be seen across Asia: e.g., in India and China (Lema and Lema, 2013), in China (Watson et al., 2015), and in Thailand (Reinauer, 2019), amongst others.

The latecomer approach has not, to the best of our knowledge, been applied in the Kenyan and Tanzanian contexts, where there is relatively little manufacturing, and perhaps not in the African context more generally. To overcome the challenge of engaging in latecomer analysis, we begin by considering how firms in these environments can acquire foundational capabilities. As elaborated later, there have been considerable efforts in Kenya and Tanzania to build such capabilities in the off-grid solar PV sector. According to latecomer theory, this could represent a pre-latecomer phase. Once foundational capabilities are built, a specific question concerns how local firms can further raise their competitiveness and build more complex capabilities. Although the OEM-ODM-OBM learning sequence characterises the accumulation of production capabilities (Bell, 2009), the latecomer analysis also implies that firms in general benefit from becoming more innovative. In fact, given the aim of sustainable industrialisation, entirely novel configurations and constellations of environmentally friendly innovations are expected from a wide range of firms (Bell, 2012, p. 25).

With this in mind, we now consider what the literature states on different levels of innovation capabilities and how they are built, as the basis of our analytical framework.

Innovation capabilities of firms

Capabilities can be those that a firm already has or competences it needs to cultivate and/or acquire from other actors. Knowledge, as a firm's most significant capability, is embedded in human resources, procedures, and routines, making knowledge contextual, firm-specific, and tacit (von Hippel, 1994). To create novel ideas, firms rely on technological capabilities that enable them to master a specific technology, but they also need non-technological capabilities such as those in management, design, or foresight. And a feature of a globalised economy is that innovation is also global (Liu, 2017), implying that a firm's innovation capabilities are also affected by related dependencies such as the position of the firm in global networks.

Bell and Figueiredo (2012) reviewed 25 years of research on learning and innovation capability-building in firms in developing economies, providing an illustrative framework of capability levels through which firms might move over time. As can be seen in Table 9.1, Bell and Figueiredo identify four distinct levels of innovation capabilities: 'basic', 'intermediate', 'advanced', and 'world leading'. In their assessment, 'basic' innovative activity includes capabilities to make minor product, process, or organisational adaptations, often in informal conditions. Moving down the table, we see characterisations of innovative activity that refer to increasingly complex and formal innovation capabilities. These chime with the Oslo Manual (2018) definitions of change: 'intermediate' innovative activity (Bell and Figueiredo) is similar to activity that is 'new to the firm' (Oslo Manual); 'advanced' is similar to 'new to the economy/market'; and 'world leading' is similar to 'new to the world'. We make use of these heuristic categorisations but, considering that the framework is based primarily on research in Asia and Latin America, the illustrative elements of the capability levels may not be entirely applicable for our study context. For this reason, we adapt the characterisations given in the centre column into more general statements, given in the right-hand column.

Looking at the Bell and Figueiredo characterisations, they each describe the kinds of knowledge, skills, and actor-networks associated with the different levels of innovation capabilities. We use these categories across each of the levels and provide descriptions that indicate the differences we might expect to see in each category and level. For example, a firm who possesses world leading innovation capabilities may have highly specialised, formal, and frontier knowledge; and skills to create such knowledge imaginatively and with originality. Leading firms tend to act in substantial, professional, internationally recognised, and collaborative networks. It is these four sets of general descriptors we use as our analytical framework to categorise off-grid solar PV entrepreneurial start-ups in Kenya and

TABLE 9.1 Levels of innovative activity

Level of innovative activity (novelty)	Illustrative capability elements *(Human capital, knowledge bases, etc.)*	*General descriptors*
Basic ***(Limited innovation)***	Groups of engineers and qualified technicians working informally on experiments and incipient or informal R&D activities. Dedicated groups of engineers and qualified technicians and well-trained operators working on the implementation of minor adaptations in products, production processes, and organisational and/or automated systems.	**Knowledge** Disciplinary, 'applied', informal **Skills** Ability to apply and incrementally adapt existing knowledge **Actor-networks** Small, narrow, professional, and operational, single-unit intra-firm
Intermediate ***(New to the firm)***	Increased number of specialised engineers and technicians allocated in different and dedicated organisational units involved in product development, product re-design, process engineering, and automation systems. These professionals work on activities such as duplicative and/or creative imitation to advanced modifications to products, large-scale production systems, software. Firms tend to give preference for professionals with good technical skills and some cognitive skills (problem solving and framing) for creative imitation.	**Knowledge** Specialised, 'applied' **Skills** Ability to duplicate, creatively imitate, or substantially modify existing knowledge and problem-solve **Actor-networks** Narrow, professional, single- or few-unit intra-firm
Advanced ***(New to the economy/ market)***	Various types of design and development engineers, researchers and other specialised professionals in different functional areas within and outside the firm. Among these are those with additional skills for new knowledge-sharing and external knowledge screening/searching and leveraging, knowledge-bridging people, 'multilingual managers', technological gatekeepers. These professionals implement applied research, design, and development of complex products/services and production systems that are *close to the international innovation frontier.*	**Knowledge** Specialised, near-frontier, formal **Skills** Ability to screen, share and apply new knowledge (absorptive capability), bridge knowledges, choose technologies **Actor-networks** Broad, professional, multi-unit intra-firm, inter-firm collaborative

(*Continued*)

TABLE 9.1 (*Continued*)

Level of innovative activity (novelty)	Illustrative capability elements *(Human capital, knowledge bases, etc.)*	*General descriptors*
World-leading ***(New to the world)***	A substantial body of internationally recognised R&D personnel with a number of teams of highly specialised engineers and related professionals working on cutting-edge research. Some teams may be engaged in precompetitive forefront research. Large incidence of people with sophisticated cognitive skills for generating imaginative and original innovations. These are distributed across different organisational units in the firm and also work on a collaborative basis with professionals from other organisations.	**Knowledge** Highly specialised, frontier, formal **Skills** Ability to create and apply frontier knowledge imaginatively and with originality **Actor-networks** Substantial, professional, internationally recognised, multi-unit intra-firm, inter-firm collaborative

Source: authors, adapted from Bell and Figueiredo (2012) and Oslo Manual (2018).

Tanzania. However, the 'levels' should be understood as indicative steps along a continuum rather than rigidly distinct categories.

Methodology

The materials on the historical evolution of the off-grid PV sector were gathered over the period 2007 to 2014, with fieldwork in two visits (see Byrne, 2011; Ockwell and Byrne, 2017): in both Kenya and Tanzania between 2007 and 2008; and in Kenya during 2013. In addition to desk-based work, the material included over 100 hours of interviews and information gathered in two stakeholder workshops. The analysis of firms' innovation capabilities draws on the observation of the Kenyan and Tanzanian off-grid solar PV sectors from 2013 onwards, a database of off-grid solar PV firms, field work in three visits between 2015 and 2019, three stakeholder workshops, and selected interviews. In line with the aim of understanding how innovation capabilities affect firms (Oslo Manual, 2018, p. 103–126), we analysed firms' revealed capabilities: i.e., what entrepreneurs and firms actually do.

The firms were identified from interviews, electronic platforms such as the Crunchbase and Owler for venture capital, the Energy and Environment Partnership project site, and industry reports. Selected case studies were built from the interviews and secondary data. The 2019 update provided a sample of off-grid solar PV firms, with 63 active (and three non-active) firms in Kenya, and 52 active

(and six non-active) in Tanzania, yielding 94 active firms altogether after duplicates of those present in both markets were removed. The sample reveals that the sector is relatively young: with the exception of retail firms, 78% of the firms in the Kenya sample and 75% of those in Tanzania were established in 2007 or later.

In Kenya, 39% of the firms operate in solar lanterns and/or solar home systems (SHSs), sometimes having started in the lanterns market segment; 20% are in consultancy or engineering, procurement, and construction (EPC); and 8% are in the mini-grid sector. Firms in Tanzania are typically in lanterns and/or SHSs (32%), consultancy/EPC (31%), retail (15%), or mini-grids (13%). Some firms apply solar for productive uses (in agriculture, refrigeration, water pumping) or for other activities. In the database, 36% of the firms in Kenya and 29% of those in Tanzania are of local origin.[2] Local firms generally operate in one country, whereas foreign firms typically have a presence in numerous markets. The sample includes manufacturing and non-manufacturing firms, and many firms interact with one another.

Descriptions were written to elaborate the firms' skills (business model, characteristics, innovation, value proposition), knowledge (age, evolution, ownership, team, technology), and actor-networks (background, finance, geography, partnerships). Using this detail, we organised the firms according to the descriptors introduced in Table 9.1, enabling us to develop characterisations of their capabilities and how they have acquired them. These findings are summarised in Table 9.2. We then were able to reflect on the economic significance of their innovation activities by reviewing industry reports from 2015 to 2019. And, building on this, we could extend our discussion to sketch some of the features of what may be a pre-latecomer phase in off-grid solar PV in Kenya and Tanzania, and to identify a range of policy issues that may need addressing if the sector is to be further developed.

Accumulation of foundational capabilities

To understand the historical evolution of the off-grid solar PV sector in Kenya and Tanzania, we briefly explain how foundational capabilities in the sector were built. More detailed descriptions can be found in Byrne (2011) and Ockwell and Byrne (2017).

Although solar PV equipment first arrived in East Africa around the late 1970s, it was not until the mid-1980s that the SHS concept emerged (Ockwell and Byrne, 2017). A market for SHSs developed almost immediately in Kenya, but it took practically another two decades before it started growing in Tanzania. Over three decades, many interventions – usually donor-funded – helped build a range of foundational capabilities in the off-grid PV sector in both countries (Byrne, 2011). These interventions addressed issues such as a lack of awareness, finance, maintenance, and service delivery (Ahlborg and Hammar, 2014; Hansen et al., 2015) and intensified after several development actors became interested from the late 1990s. Over time, their interventions consisted of various capacity-building and learning experiments with the technology and

TABLE 9.2 Levels of innovation capabilities in Kenya and Tanzania's off-grid PV sector based on categorisation in Table 9.1

Level of innovative activity	*Illustrative capability elements*	*Examples of knowledge, skills, actor-networks*	*Examples of firms*
Firms with limited innovation capabilities (*Limited innovation*)	• Limited abilities to invest in or implement innovation activities • Adapt to new requirements, make few changes in the business model • Attract little to no foreign investment	• Focus in the business and management of the supply chain • Weak or no linkages to global innovation networks, possible linkages to product networks (e.g., foreign exporters, retailers) and technical experts • Tanzanian solar retailer mainly focuses on sales (Zara Solar)	Multiple firms (distribution, retail, supply, installations)
Experimentation, build-up, and international partnerships (*New to the firm*)	• Attempt innovation and perform search activities, but accumulation and scaling up may take time • Many local actors, start-ups, or SMEs, some nurtured in local incubators • Emerging access to global innovation networks, some may attract seed financing for pilots and demonstrations	• A pioneer who has evolved with the sector, moving from lanterns to solar home systems and into mini-grids (Ensol) • Tanzanian founder started as a teenager by selling Chinese-imported mobile phones, studied in China, took a loan to import solar products into Tanzania (Helvetic Solar) • Early pioneers in Kenya who developed their skills through international partnerships (SolarWorks, SunTransfer) • Social enterprise established hubs, conducted surveys, and trained employees to expand work with rural farmers on clean energy solutions with a grant from an international donor (Boma Safi)	Baraka Solar, Boma Safi, Ensol, Helvetic Solar, Juabar, Sikubora, SolAfrique, SolarWorks, SunTransfer

(*Continued*)

TABLE 9.2 (*Continued*)

Level of innovative activity	*Illustrative capability elements*	*Examples of knowledge, skills, actor-networks*	*Examples of firms*
Advanced capabilities and technological sophistication *(New to the economy/ market)*	• Drive sector evolution with incremental innovation and technological sophistication • Imitated and adopted the pay-as-you-go model, may operate in several markets • May train local entrepreneurs and create employment to build skills • Attract substantial investment for demonstrations and scaling up	• Solar-powered roof tiles designed in Kenya, hosted in local accelerators and incubators (Strauss Energy) • Partnerships and financing from donors and development banks (JUMEME) • Founders followed an initial idea, left their expert positions, performed years of search activities, moved to Tanzania (Devergy) • Construction of mini-grids in Kenya, Tanzania, and Zambia (PowerGen)	Angaza, Devergy, JUMEME, Powergen, Powerhive East Africa, Steama.co, Strauss Energy
Leading frontier capabilities *(New to the world)*	• Find key solutions for fundamental barriers with complex problem-solving activities despite uncertainty • Push the innovation frontier, set benchmarks • Begin to attract large-scale venture capital and private investment in millions, over multiple funding rounds	• Extensive piloting of solutions, a partnership with Safaricom, Kenya's telecommunications giant (M-KOPA Solar) • Machine-learning algorithm adjusts solar power output according to average system usage, weather patterns, and battery power (Azuri) • Grow to attract investment worth millions of USD from impact funds, private equity funds, and banks (BBOXX, ZOLA) • Establishing a partnership with e-waste and battery recyclers for recycling off-grid solar components (Mobisol)	Azuri, d.light, BBOXX, M-KOPA Solar, Mobisol, ZOLA Electric

Source: authors

microfinance, all of which also expanded and strengthened the off-grid solar PV actor-networks. Publications of reports, market information, and market surveys in part contributed to advocacy for favourable energy policy, which included the removal of tax on PV equipment, the introduction of PV standards and regulations, and more. These activities also built up necessary capabilities. Lessons learned were publicly shared and awareness of SHSs grew amongst many Kenyans and Tanzanians.

Market activity was nevertheless limited for a long time. For example, in Kenya in 1997, the International Finance Corporation (IFC) tried unsuccessfully to implement a USD 5 million market transformation initiative (IFC, 2007). But the markets were immature and local technicians, although trained, lacked funding, so few local businesses emerged. Results were more successful ten years later when the IFC began implementing the Lighting Africa project that promoted solar PV lanterns (Lighting Africa, 2008). In addition to capacity-building, Lighting Africa conducted consumer education campaigns to drive demand in Kenya, and supported the private sector seeking to enter the market. In Tanzania, intensified capacity-building activities resulted in the eventual growth of the PV market within just a few years from almost nothing to a value of USD 2 million or more in 2008. These successes can be partially attributed to the many donor-funded activities that aimed to build knowledge, skills, and actor-networks in the sector.

In 2011 in Naivasha, Kenya, a joint venture between a Dutch investor and a Kenyan holding company began operating a module assembly plant[3] (Ockwell and Byrne, 2017). Growth of the solar lantern market has spurred further growth of the SHS markets, and the private sector has begun to provide pico-scale solar systems on a commercial basis in Kenya and Tanzania (Nygaard et al., 2016; Davies, 2018). The use of mobile money, emerging technologies, and the PAYG model have become benchmarks in the nascent industry (Rolffs et al., 2015). Under the social entrepreneurship ethos, new activities continue to emerge according to Odarno et al. (2017), Tanzania leads in East Africa for mini-grid development, and applying solar PV for productive uses is a novel frontier. Owing to these diverse activities, a range of products from lighting to appliances has emerged in multiple categories (Lighting Global and GOGLA, 2018).

Overall, this pre-latecomer phase saw the building of foundational capabilities, the growth of several market segments, and the introduction of a range of new technologies. It is into this context that many new firms, as entrepreneurial start-ups, have entered.

Innovation capabilities of off-grid solar PV firms

Our analysis of the innovation capability levels of firms in off-grid solar PV in Kenya and Tanzania begins with those who have limited innovation capabilities. Firms at the second level seem to accumulate capabilities through experimentation and through learning from international partnerships. Advanced firms,

placed at the third level, can use emerging technologies. At the highest level are leading firms who, with sophisticated capabilities, perform highly complex problem solving. See Table 9.2 for a summary of our analysis.

Firms with limited innovation capabilities

Firms at this first level offer products and services such as retail, wholesale, distribution, dealership, and installations, and they constitute the majority of firms in the sector. Any firm must learn about the technology, whether a small or medium-sized shop or retail firm selling products and equipment for cash (KCIC, 2017). One example is Zara Solar, an early pioneer, launched in Tanzania in 2005. Initial learning efforts won it the Ashden Award in 2007. Operating a small core staff, it employed a network of freelance technicians who were first trained through a United Nations Development Programme (UNDP) project. The firm continues to perform installations and sales in Mwanza and Dar es Salaam.

The firms in this category use technical, management, and marketing capabilities, but the limited nature of their capabilities means few of them attract investment or can connect with frontier knowledge. Operating in a nascent sector is in itself a kind of innovative behaviour but, without an ability to innovate further, they will likely remain at this level. Nevertheless, even firms who do not perform more innovative activities provide an essential function in the sector through the economic activity they generate. For example, after an increasing diversity of off-grid solar products and services came onto the market, between 2014 and 2016 alone, around five million devices were sold in Kenya and Tanzania (Lighting Global and GOGLA, 2018). Many of these devices would have been sold through firms with limited innovation capabilities.

Experimentation, build-up, and international partnerships

Firms placed at the second level are those who aim to adapt their business models, suggesting they are more entrepreneurial and that they possess more innovative capabilities than those at the first level. For example, Sollatek Electronics, a wholesale and distribution firm established in 1985, has experimented with crowdfunding. In Tanzania, Ensol was one of the early PV companies, established in 2001, and has since been involved with solar lanterns, SHSs, and mini-grids. The Tanzanian founder of Helvetic Solar, founded in 2007, started his first business as a teenager in Arusha selling Chinese-imported mobile phones. Having studied in China before a return to Tanzania, he got a loan to import solar products. After initial success, the firm established a philanthropic foundation who partnered with international agencies. International exposure seems to have benefited the capability-acquisition of firms in Kenya such as SunTransfer, a distributor of solar products, and SolarWorks, a project company, both established in 2009.

An especially interesting case is Chloride Exide, a customary battery manufacturer and retailer in Kenya. According to the website of the owning company,

ABM Group, the manufacturer began operations in 1963 to produce batteries for the Chloride Group, its UK-based founder, and for others.[4] It has innovated in several ways since beginning operations, including introducing a modified car battery for use in SHSs, achieved through a donor-funded project in the late 1990s. Now, it produces a variety of own-brand batteries, has manufacturing facilities in Tanzania and Uganda, and claims to be the largest battery and renewable energy distributor in the East Africa region. It invested in the Naivasha solar PV module assembly plant (mentioned earlier) when it was being set up in 2011. Majority-owned in Kenya by Solinc, the plant does not fabricate solar cells but has made incremental process innovations to double its initial production capacity of solar modules (Ockwell and Byrne, 2017). In 2018, Chloride Exide partnered with the industry leader M-KOPA Solar.

Certain start-ups belong at this level. A Kenyan entrepreneur learned about 'green' entrepreneurial models at Strathmore Business School when carbon finance was introduced to Kenya in the late-2000s. After initial search activities, the entrepreneur founded a solar micro-grid firm, serving clients through a power purchase agreement.[5] In Tanzania, a Stanford-educated director and a small local team worked in a start-up called Juabar. In its franchise model, the firm has a network of solar kiosks in off-grid areas, which are leased to local entrepreneurs who then sell electricity for phone charging. In Boma Safi's model, founded by a Kenyan, rural women sell products through an order and delivery system, enabled by energy and distribution hubs and village credit organisations. Firms placed at this level may attract seed funding for pilot and demonstration efforts but are distinguished from more advanced firms by their smaller size, slower growth trajectory, and less complex and technology-intensive activities.

Advanced capabilities and technological sophistication

In the early 2010s, the industry pioneers introduced the PAYG model, and many foreign early-stage firms with advanced innovation capabilities entered the market in their tail. The typical founder of an advanced firm has a degree from a world-leading university combined with past consultancy, finance, and IT experience. These companies' advanced marketing capabilities help in brand differentiation for customer-acquisition, market-expansion, and scalability. A noticeable feature is their ability to integrate emerging technologies, which makes them attractive for financing. Some test new products with dedicated R&D facilities outside of the countries.

In this sense, mini-grid companies who incorporate the PAYG model and latest technologies can be placed at this level. Devergy, a mini-grid operator in Tanzania, piloted its model also in Ghana. JUMEME builds solar-hybrid micro-grids in Lake Victoria. PowerGen, established in 2011, has constructed mini-grids in Kenya, Tanzania, and Zambia. Funding from CrossBoundary Energy Access, a mini-grid project finance facility, contracted the firm to build 60 mini-grids in Tanzania. Power Corner Tanzania and Rafiki Power have raised the

interest of large energy corporations. And, given the undeveloped nature of the productive-uses market segment, firms aiming to use PV for agriculture, refrigeration, and water pumping can also be placed in this category.

Almost no firms of local origin operate at this advanced level. An exception is Strauss Energy in Kenya, who have piloted solar PV roof tile manufacturing and experimented with compressed-air energy storage. The experienced founder learned about solar energy already in 2002 during an MSc-level project (Ciambotti et al., 2019), designing a PV roof tile from low-cost materials. Strauss Energy has benefited from the accelerator and incubation programmes at Kenya Climate Innovation Center (KCIC) in Strathmore University. Although the solar tiles are now produced and assembled by Shenzen Solar in China, Strauss Energy's technological capabilities are 'new to the market'.

Leading frontier capabilities

Firms at the 'highest' level are able to conduct complex problem-solving efforts. M-KOPA Solar – the PAYG pioneer – was established around 2010. The firm's founders joined forces with a microfinance expert and learned about mobile money when it was in its infancy, innovated with potential customers, and enrolled in technology competitions. Before commercial sales, the firm attracted international finance and established a partnership with Safaricom, Kenya's leading mobile network operator. M-KOPA Solar designed a user-friendly 'plug-and-play' solar kit that included a two-year warranty and a durable battery. The data chip in the kit was connected to a technology platform that handled customer payments, inventory, accounting, and customer relations.

Achievement of industry milestones may place a firm in this category. D.light and Greenlight Planet were early pioneers in solar lanterns, and the UK-based Azuri Technologies entered the PAYG space directly in 2012. Azuri's system includes a machine-learning algorithm, which adjusts house lighting according to usage, weather patterns, and battery power. The firm trains local employees in finance and marketing but has a product design factory in the UK. Its research teams study potential customers and pilot different products locally. It partners with an airtime distribution network and an experienced local agent network that has distributed jewellery beads.

Mobisol, a German firm who had social impact investors and international development agencies as initial owners and lenders, established an academy in Tanzania that trains local entrepreneurs, contractors, and staff. It also established partnerships for battery recycling and electronic waste. ZOLA Electric, established in 2011 and originating from San Francisco in the United States, has a proprietary software platform that provides a personalised service for customers and real-time data to track product sales, service and installation teams. It claims it learned from the electric vehicle and large-scale solar industries, and its investors include Tesla, GE, EDF, and Helios.

Discussion: innovation capabilities in the pre-latecomer phase

Having differentiated the innovation capabilities of the off-grid solar PV firms by their knowledge, skills, and actor-networks, we can see that interactive learning is an important activity for any firm and that firms serve complementary market roles. The local Kenyan firms are within the first two 'levels' of capabilities, except for Strauss Energy. In Tanzania, most firms operate at the basic (or the intermediate) level, and no Tanzanian firm possesses advanced or world-leading capabilities. PV module assembly and battery manufacturing, both in Kenya, are the only production capabilities.

In Kenya, those firms who are more involved in innovative activities have learned through joint ventures and partnerships with foreign firms. Indeed, any local innovative firm seems to have international linkages. Still, in the sampled firms, 64% in Kenya and 71% in Tanzania had a non-local CEO and/or founder, often from the United States or UK, but also of German, Dutch, French, or Italian origin, including expatriates who have long lived in these countries. This suggests that the advanced and world-leading capabilities largely stem from outside of Kenya and Tanzania. Advanced and leading firms are also employers who can contribute to local capabilities in support, sales, services, and management.

Once a firm succeeds in establishing a customer base, a revenue model and can repeatedly solve challenges, they are able to attract (sometimes substantial) funding or finance. The current industry leaders evolved in the 2010s by first attracting seed capital from development partners, then social impact funds and, eventually, venture capital. According to Wood Mackenzie (2019), M-KOPA Solar went through six finance rounds and had raised USD 190 million by 2018. Globally, only four firms attracted two thirds of all the financing that went into building the off-grid PV sector: ZOLA Electric (USD 261m), D.Light (USD 188.5m), Lumos (USD 108m), and Greenlight Planet (USD 82m) (Lighting Global and GOGLA, 2018).

The value of the off-grid solar lighting products sold in Kenya and in Tanzania suggests that PAYG firms are attractive businesses. Altogether, almost six million products were sold in Kenya and 1.5 million units in Tanzania in the late-2010s. The lines rising in 2017 show that the value of a PAYG unit sold is considerably more than that of traditional PV products, shown by the lower lines (Figure 9.1). Industry figures for late 2018 estimated the value of cash sales in Kenya at USD 13 million but the value of PAYG services amounted to USD 59 million. The difference is starker in Tanzania, where the value of cash sales was USD 1.5 million and PAYG sales were USD 21.7 million. In East Africa, the value of cash products was USD 25 million compared to USD 110 million for PAYG units. Globally, PAYG firms accounted for 24% of the sales volume but 62% of the revenue (GOGLA, 2019).

Cash sales may generate much less revenue than the more lucrative PAYG business models, but they continue to play an important role in at least three ways. First, the number of PV units sold for cash remains greater than under PAYG terms. Therefore, many small firms – who may be widely distributed across both

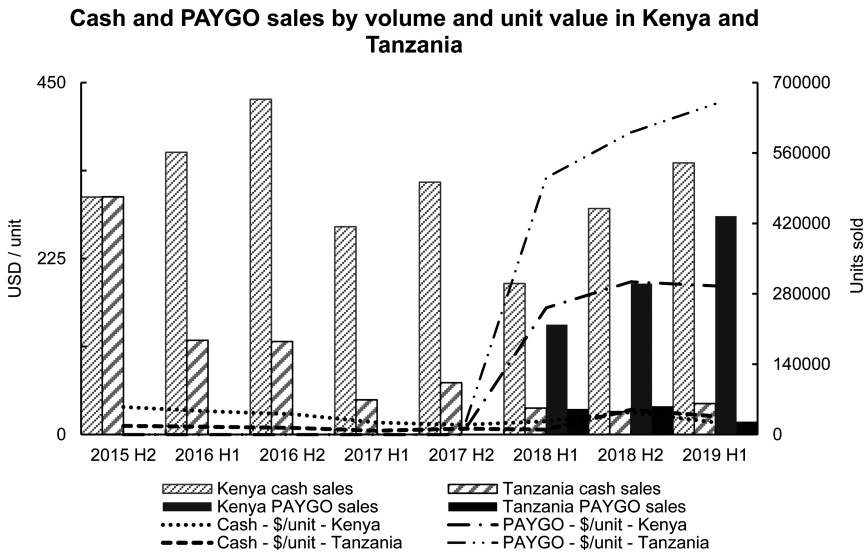

FIGURE 9.1 Off-grid solar lighting products sold in cash and PAYG in Kenya and Tanzania by volume and unit value. *Source: GOGLA bi-annual market reports (2015–2019).*

countries – are benefiting from at least some business activity compared to the more concentrated PAYG segment. And it may also mean that more people are getting electricity access through cash sales than through PAYG. Second, the firms selling PV for cash are owned locally whereas PAYG firms tend to be foreign owned. As such, more of the profits are likely to remain in the local economy compared with those from PAYG businesses. Third, the price per PV unit would appear to be much lower for cash sales than for PAYG terms, although we should note this is a crude comparison based on aggregate sales revenue per units sold and so the observation is open to further analysis. Nevertheless, if this price differential is real, it means those who cannot afford upfront purchase of PV systems pay a higher cost for electricity access, raising social justice concerns. There may also be other useful metrics to develop a fuller picture of the relative importance of cash versus PAYG market segments and their associated advantages and disadvantages, such as the number and quality of jobs created and sustained in each segment. These metrics are important for achieving a more refined understanding of current capabilities in Kenya and Tanzania, and of those that could be enhanced or created.

Policy issues for off-grid solar PV and sustainable industrialisation

Building on the analysis of the capabilities of off-grid solar PV firms operating in Kenya and Tanzania and related economic dynamics, we can reflect on

the policy issues that arise for how to enhance the gains of the countries' pre-latecomer phase with a view to entering a latecomer phase and encouraging sustainable industrialisation. Our discussion begins with the implications of cash versus PAYG market segments. We then consider the policy issues relevant to building innovative capabilities centred around technologies and manufacturing, and argue that other perspectives besides latecomer theory may need to be marshalled if the various complexities involved in capability-building efforts are to be fully understood and addressed.

Cash sales, PAYG, and foundational capabilities

Based on the importance of cash sales, we could argue it is essential to maintain and strengthen this segment, which raises several policy issues. The capabilities of actors in the supply chains need to be built or enhanced to maximise both the quality of PV technologies supplied and the quality of customer services provided (sales, technical support, etc.). And customers themselves need help to build their own capabilities for understanding the technology and service options offered to them, as well as for using PV systems. These issues have been long-standing in Kenya and Tanzania, and various efforts have been made to address them. In Kenya, for example, the IFC market transformation initiative, mentioned in the historical section, funded capacity-building efforts that included training of PV technicians and vendors alongside publication of information manuals tailored to each of these groups and to customers. Kenya also established PV standards – later strengthened to regulations – and has more recently introduced a national-level PV training curriculum and certification of PV market actors (Ockwell and Byrne, 2017). It is unclear how these measures have affected capabilities in Kenya as, to the best of our knowledge, no research has been done on their impacts. Nevertheless, they provide examples of the kinds of action that policy can take to help build or strengthen at least some of the foundational capabilities in off-grid solar PV. Thinking more broadly about supply chains, there may be potential to build innovative capabilities for increasing efficiencies, lowering costs, and improving sustainability throughout supply chain operations. Included in these capabilities are likely to be finance and management competences, among others, that could be transferrable to sectors beyond off-grid PV and so contribute more generally to sustainable industrialisation.

Technological innovation capabilities

Policy interventions and the efforts of a variety of actors aimed at building technologically centred innovative capabilities will tend to be more complex, expensive, time-consuming, and uncertain. Firms and other actors with varying capabilities need to learn to interact with each other in collaborative as well as competitive ways across varied innovation contexts. Building innovative capabilities requires a great deal of formal training throughout education systems as

well as on-the-job training and other lengthy processes of experiential learning. This is all expensive and time-consuming. Such features pose a great deal of uncertainty about how developments will unfold. Indeed, as we write, the world is trying to respond effectively to the coronavirus pandemic, showing us an especially dramatic example of how uncertain the future can be. One of the most immediate effects of the global response to the pandemic has been the drastic reduction in economic activity. According to the Managing Director of the International Monetary Fund,[6] as a result, the world seemed to be facing its worst recession since the Great Depression. No-one can know the longer-term social, political, and economic consequences of such a recession, nor how long any consequences will take to be fully realised. But, taking an optimistic view, we may return to some kind of normality over the next few years, enabling once again the kinds of international efforts required to tackle the challenges of building innovative capabilities.

In thinking about what these efforts would look like, we can turn to what the latecomer and other literatures tell us about past experiences. For Kenya and Tanzania directly, the groundwork to establish the pre-latecomer phase was achieved through a multitude of donor-funded projects intervening on a range of challenges – e.g., technical skills, technological products, consumer finance, market research, standards, policies – and included some attention to local manufacture. According to Ockwell and Byrne (2017), for example, in the late 1990s and early 2000s in Kenya there were donor-funded attempts to develop the local manufacture of battery charge regulators for SHSs. Despite early promise such manufacture would succeed, it failed because of better quality and cheaper products imported from China. We do not have a deep analysis of these local manufacturing efforts, but we could argue they may have failed because they were ad hoc, involved just one firm, and were implemented without any national-level strategic cooperation. If they had taken a more systemic nurturing approach, such as working with policy makers to establish a degree of protectionism while investing in the capability-building of several local firms, they might have been more successful. Kenya does, however, have at least two examples of manufacturing success related to off-grid PV, already noted earlier. One is the Solinc module assembly plant in Naivasha and the other is the battery manufacturer Chloride Exide (whose Kenyan owner part owns Solinc[7]).

We can also learn from the East Asian experience, where local electronics firms upgraded their capabilities through various kinds of relationships with foreign firms. The general policy issue arising from an understanding of this experience is how to translate lessons to contexts such as those in Kenya and Tanzania in the present time. Answering this question will require answering a number of other questions. We would need to know, for example, the extent to which there are similarities and differences between the pre-latecomer phases of the East Asian countries and those of Kenya and Tanzania, and other poor countries in the Global South. The kinds of relationship investments in East Asia that helped nurture innovation capability-building are unlikely to be easily established in

the poorer countries of the Global South, especially those in Africa. Leading PV system technology companies such as those manufacturing PAYG equipment may not see any benefit in moving their manufacturing operations to countries such as Kenya and Tanzania; indeed, they may only see huge risks and a range of disbenefits. Enticing these companies to invest in what may be drawn-out processes of capability-building would likely need complementary and strategic public sector investments. These investments may be beyond the capacity of poorer countries to achieve, suggesting there may have to be a significant role played by donors.

This raises further and perhaps more complex questions probably better answered by drawing upon politically attuned analyses rather than relying solely on the primarily technical streams of innovation studies. For example, under the still dominant neoliberal orthodoxy informing much development cooperation, the preference is to let market forces determine where manufacturing takes place. The problem with this approach is it favours the status quo and may even entrench it. That is, those countries now benefiting from manufacturing comparative advantages are more likely to continue doing so while those countries with no manufacturing comparative advantage are unlikely to ever develop any (e.g., see Reinert, 2007). As Reinert and many others argue, upsetting the status quo will require interventionist public sector action. The challenge for policy makers in the Global South is how to fund innovation capability-building interventions when relying on money from development partners who remain wedded to neoliberal orthodoxy and whose willingness to fund long-term interventions may be weak in the aftermath of the coronavirus pandemic. And a further challenge for Southern policy makers may stem from the potentially disruptive consequences of the so-called fourth industrial revolution, in which the use of robotics for manufacturing is predicted to become pervasive. Despite certain gains, if such predictions prove realistic, the need for human-embodied capabilities will be severely reduced and the types of skill sets will be altered, with drastic consequences for the number and type of jobs available in an economy.

Are we there yet? Building innovation capabilities and sustainable industrialisation

So, we are not there yet. Our analysis paints a mixed picture of the conditions across Kenya and Tanzania – and relevant to other Global South contexts – in relation to the current pre-latecomer phase, and the prospects for fostering latecomer entry that could nurture sustainable industrialisation. The gloomier part of the picture shows a range of complex uncertainties facing Southern policy makers and development partners. But there is also a bright side to the picture from which to draw hopeful inspiration.

The foundational capabilities in off-grid solar PV already present in Kenya and Tanzania can help in accumulating more sophisticated capabilities for mastering the technologies aligned with the aim of sustainable industrialisation. Individual

start-up endeavours may collapse, but human-embodied capabilities remain, can be developed, and can be transferred into new ventures. The experience of off-grid solar PV in Kenya and Tanzania is testament to this view. However, world-leading innovativeness so far primarily results from new business models facilitated by technologies designed and manufactured elsewhere. In line with the thrust of latecomer theory, our chapter calls for much more concerted efforts to build the necessary capabilities for local assembly and manufacturing. Firms, policy makers, development partners, and others will have to strategically build these capabilities over the long-term while navigating a range of uncertainties. If they do not, firms and others involved in the sector will be left to innovate on their own without the necessary capabilities. Under such conditions, they will 'merely keep up rather than catch up' (Hobday, 1995, p. 1186). If relevant actors do succeed in building the necessary capabilities, there are likely to be more opportunities on the part of local firms to assume diverse roles in innovating in the sector, its emerging segments, and realistic hopes of creating sustainable industrialisation development pathways. And lessons from successful demonstration of such pathway creation will be valuable to other sectors and countries in the Global South.

Conclusions

Given the interest in innovation capabilities for renewable electrification that can contribute to sustainable industrialisation, in this chapter we analysed the accumulation of capabilities in the off-grid solar PV sector in Kenya and Tanzania. As an attempt to apply latecomer theory in these contexts when innovating with environmentally friendly technologies, we explained how foundational capabilities in the off-grid solar PV sector have been built. This underscores how important it is to begin by building a sustainable base of capabilities. We disaggregated the innovation capabilities of off-grid solar PV firms active in Kenya and Tanzania and showed the value of these capabilities under a rapidly changing market structure, increasingly dominated by PAYG business models. Some local firms – more so in Kenya than in Tanzania – are manifesting increasingly innovative behaviour, but only simple assembly activities exist in Kenya.

Our analysis generally recommends Kenya and Tanzania to build on the gains of the foundational capability-building period, which we have called a pre-latecomer phase. This means enhancing the ways for local entrepreneurial firms to gain from the innovative developments in the off-grid PV sector. More specifically, these efforts would need to build local production capabilities, enabling firms to move 'up' the value chain. Over time, the achievement of more local assembly and manufacturing would signify entering an early latecomer phase, aligning with the aim of sustainable industrialisation. As a challenge, any capability-building efforts in the sector should be reflected against future uncertainties, such as the potential impacts of the fourth industrial revolution. Finally, experiences in the sector may provide valuable lessons on a range of

issues for policy makers who wish to promote sustainable industrialisation in the Global South.

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Notes

1 OEM is original equipment manufacture; ODM is own-design and manufacture; OBM is own-brand manufacture.
2 On what is a 'local' or 'indigenous' firm, see Jackson et al. (2008).
3 In the mid-2010s, this formerly Dutch-owned joint venture Ubbink East Africa became a Kenyan-owned company called Solinc East Africa.
4 Chloride Exide's history is briefly described on its website at www.chlorideexide.com/about/ (accessed 24 April 2020) and on the ABM Group (Chloride Exide's owner) website at www.abmeastafrica.com/about-us (accessed 24 April 2020).
5 Interview, SME director, 16 May 2016.
6 Kristalina Georgieva's statement of 15 April 2020, 'Exceptional Times, Exceptional Action', Opening Remarks for Spring Meetings Press Conference, available at www.imf.org/en/News/Articles/2020/04/15/pr20162-exceptional-times-exceptional-action-opening-remarks-for-spring-meetings-press-conference (accessed 28 April 2020).
7 See the ABM website describing majority ownership of Solinc at www.abmeastafrica.com/about-us (accessed 24 April 2020).

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