Productive Use of Energy – PRODUSE

# Firm Performance and Electricity Usage in Small Manufacturing and Service Firms in Ghana


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On behalf of BMZ Federal Ministry for Economic Cooperation and Development

ESMAP Energy Sector Management Assistance Program

THE AFRICA ELECTRIFICATION INITIATIVE

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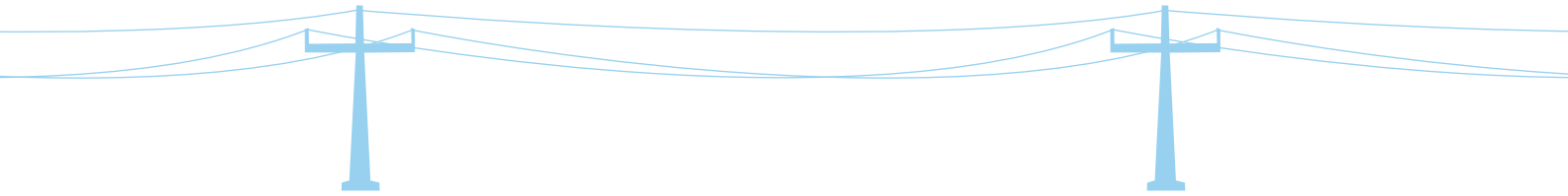

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Productive Use of Energy – PRODUSE

# Firm Performance and Electricity Usage in Small Manufacturing and Service Firms in Ghana

*By Jörg Peters, Maximiliane Sievert and Colin Vance*[40]

## Abstract

In recent years, interest in electrification has risen substantially among governments in developing countries and donor organisations. Productive uses of electricity are particularly seen as a promising way to contribute to economic development. This paper examines the impact of electricity usage on the performance of micro-enterprises in the Brong Ahafo Region in Ghana. Using cross-sectional firm-level data from the service and manufacturing sector, we investigate the impact of being connected to the electricity grid on firm profits. No significant difference can be observed with the result being robust across different methods like Ordinary Least Squares and an instrumented variables approach.

## 1. Introduction

Although the overall business climate in Ghana has improved in recent years, also due to the pro-market policies of the government, micro and small enterprises in informal firm clusters in the town centres face periodic attempts of communal governments to be relocated to areas outside of the towns. In these zones, electricity and other services are frequently not available. Overall, about half the population has access to grid electricity (UNDP/WHO 2009). Weak supply growth combined with low rainfalls resulting in a shortage of water for hydropower production had been answered with nationwide load-shedding in 2006 and 2007.

The *Energising Development* or *Industrial Zone Development* component of the *Programme for Sustainable Economic Development,* implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Directorate-General for International Cooperation of the Dutch Ministry of Foreign Affairs (DGIS), has been assisting selected districts in Ghana to establish or upgrade industrial zones for MSEs since 2007. The project provides these zones with materials for grid extension and technical assistance to the enterprises and the district government. In some cases, the project has also supplied roads, water supply and sanitary facilities. The companies located in the industrial clusters receive Business Development Services (BDS) including financial training to develop a business plan and apply for loans at micro-finance institutions. The underlying premise of the project is that a service package comprising improved electricity supply, systematically provided BDS, access to micro-finance and operating in a designated clustered area together with other enterprises improves business performance more effectively than providing these services individually.

Against this background, this chapter examines the impacts of grid electricity use on the performance of enterprises employing less than 20 employees in small towns in Ghana's Brong Ahafo Region. Using cross-sectional firm-level data on 236 businesses from the service and manufacturing sector that was collected in this region in 2007, we describe energy usage patterns in the firms and investigate the impact of electricity use on firm performance with firm profits as the major indicator. The identification strategy relies on a comparison of firms that are connected to the electricity grid to those that are not. In order to address potential underlying selection processes we employ – in addition to descriptive statistics – Ordinary Least Squares (OLS) regression to gauge the correlations while controlling for other variables. To correct for endogeneity in the relationship between profits and electricity usage, a Two Stage Least Squares (2SLS) approach is subsequently applied.

The remainder of this chapter is organised as follows: *Section 2* presents the methodology for data collection and analysis. *Section 3* describes the economic conditions in the surveyed regions. *Section 4* examines impacts on the intermediate level, this is energy usage and factor inputs. Following the presentation of descriptive statistics, *Section 5* examines the impacts by the application of regression techniques. *Section 6* contains concluding remarks.

40) We are grateful for valuable comments and suggestions by Samuel Adoboe, Benjamin Attigah, Mirka Bodenbender, Anna Brüderle, Marco Hüls, Raya Kühne, Lucius Mayer-Tasch, Sven Neelsen and Kilian Reiche.

## 2. Empirical Strategy and Data

### 2.1. Sampling and Survey Design

The data used for this chapter was collected as part of the joint GIZ-ESMAP study *Productive use of Energy (PRODUSE) – Measuring Impacts of Electrification on Small and Micro Businesses in Sub-Saharan Africa* in September 2007 under the supervision of the *Institute of Statistical Social and Economic Research* (ISSER) of the University of Ghana (see Steel 2008). In total, 236 interviews were conducted in four district capitals; Techiman (65,000 inhabitants), Berekum (58,000 inhabitants), Goaso (15,000 inhabitants) and Nkoranza (25,000 inhabitants) in the Brong Ahafo Region in Mid-Western Ghana. Three of the four sampled towns are target districts of the GIZ intervention. The interviewed companies belong to the service and manufacturing sectors. See *Table 34* for the distribution across different sub-sectors.

Table 34: Subcategories in the Service and Manufacturing Sector

| **Service** | |
|---|---|
| Hairdressing, barber | 28 % |
| Communication service | 21 % |
| Electrical services | 19 % |
| Mechanic, engine repairs | 17 % |
| Restaurant | 14 % |
| **Manufacturing** | |
| Dressmaking, tailoring | 61 % |
| Blacksmith, locksmith, metalworker, welding | 21 % |
| Carpentry worksho-process | 18 % |

In order to improve representativeness with regards to location, companies were stratified into two groups – those that work in an industrial zone and those that work in either the town centre, a market area, or dispersed zones. Industrial zones are defined as areas where light industrial companies prevail. No distinction is made between officially declared industrial zones outside the town centres and informal zones. The informal zones are former residential areas where clusters of firms grew without regulation and very few residential houses remain. The official zones are areas, which are explicitly declared for light industrial uses and only host workshops like carpenters, car repair shops, agro processing entities and some food shops. The few firms that employ more than 20 workers were excluded from the survey, since they are not deemed to be comparable with the small and micro firms.

Two qualification criteria for a firm to be included in the survey were applied. First, firms have to be in a permanent structure or a kiosk. Second, the production site is located outside the home. Home businesses are thereby excluded.

The sample size per town was roughly proportional to the size of the different towns and the respective number of companies. Information about the total population of companies and its distribution was provided by an enumeration survey (Steel 2008). The interviewed firms were selected using simple random sampling. Furthermore, qualitative key interviews were conducted with district assemblies, the energy utility company Northern Electricity Department (NED), a subsidiary of Volta River Authority (VRA), BDS providers and financial institutions but also with key informants among the enterprises.

As in most enterprise surveys – in particular in Africa – many answers are missing in the data because respondents refused or did not know the answer. In line with the argumentation in King et al. (2001) and using their multiple imputation procedure, we imputed missing values.

## 2.2. Potential Impacts and Outcome Indicators

Electricity usage facilitates mechanisation and automation and thereby increases outputs quantitatively or qualitatively. The usage of electrical lighting is cheaper than traditional lighting sources and delivers a much better lighting quality. That, in turn, might contribute to extended working hours, more customers or higher quality products (see *Chapter 3*, methodology). All these effects lead directly or indirectly to higher productivity in the sense that less input is needed to produce the same output. This increased productivity might either lead to higher profits for the firm owner or higher incomes for workers. While we present descriptive statistics on all of these variables, the econometric analysis focuses on the firm's monthly profit as the final outcome variable.

Enterprise surveys in Africa face measurement difficulties in most cases. This is mostly due to a lack of written records, recall problems and the unwillingness of respondents to reveal certain information. To address this, the survey raised information on practically all aspects of firm activity on a detailed level. Particularly sensitive variables were elicited in different ways. With regards to profits, for example, owners were asked directly to categorise their income of the last month into one of five income brackets. Alternatively, the questionnaire offers the possibility to calculate owner incomes by subtracting all running expenses from monthly sales. While De Mel, McKenzie and C. Woodruff (2009) argue in favour of directly elicited profits, Daniels and Mead (1998) as well as many survey experts state that information on income should be calculated by gathering detailed data on its components. Our data supports the latter view: most respondents chose the lowest income bracket, although their sales and cost figures suggest profits that are clearly positive and much higher than they indicate. While it cannot be ultimately answered which response indicates the true profit, the tendency to understate answers to direct profit questions advocates in favour of calculated profits.

## 2.3. Identification Strategy

The study intended to follow the overall PRODUSE methodology as described in *Chapter 2* of this publication. This methodology proposes to survey the target region of an electrification project before the intervention and, in addition, a further region with access to electricity. In the case study from Ghana, however, it was not possible to identify a comparable region as a control group. The reason is that unlike the set-up described in the Methodology Chapter, the GIZ project in Ghana targets peri-urban regions that are basically already provided with electricity. Since the electrification process in Ghana is relatively advanced, it was not possible, however, to find non-electrified regions comparable in terms of size, distance to business centres and economic base. As a consequence, all firms in the sample have, essentially, access to the grid and the effects of electrification can only be examined by comparing firms that are connected to the electricity grid to those which are not.

Methodologically, this is problematic since the usage of electricity and our outcome variable, profit, affect each other simultaneously. In other words, an electricity connection might positively affect the firm's profits, while at the same time better-performing firms are certainly more inclined to get connected. Additionally, unobserved factors such as the motivation level of the owner may influence the decision to connect and, at the same time, motivation may also affect profits. This leads to endogeneity of the treatment variable and a selection bias in ordinary univariate or multivariate analyses. In *Section 5* we take these endogeneity considerations into account and investigate the impacts of being connected to the grid by simple difference in means, namely OLS and a 2SLS approach. For the latter method, in the first stage, the potentially endogenous variable – in our case the connection dummy – is regressed on all control variables and, additionally, identifying variables, also called Instrumental Variables (IV). The basic idea behind this approach is to let the IV capture the effect of that part of the variation in the endogenous explanatory variable that is correlated with the IV. Such IV have to fulfil two conditions: (1) the instruments have to be correlated with the endogenous explanatory variable and (2) the instruments have to be uncorrelated with the dependent variable, except for the correlation via the endogenous variable. Results from the first stage regression are then used to generate predicted values of the endogenous variable. In the second stage, the outcome variable, profits, is regressed on all control variables, with the predictions from the first stage used as instruments replacing the endogenous variable. Two binary variables in our data qualify for this: whether the firm is located in an industrial zone and whether the firm is located in a so-called dispersed area (see *Section 5*).

# 3. Economic Conditions in Surveyed Area

Notwithstanding the predominantly agrarian economy, real GDP growth in Ghana amounted to 6.3 % in 2007.[41] Roughly 56 % of the labour force in 2008 was employed in the agricultural sector, followed by 29 % in services and 15 % in industry (CIA 2008, EIU 2008). The business-friendly policies of the current administration contributed to Ghana's ranking as a 'top ten reformer' by the World Bank, reaching position 87 out of 178 countries in an evaluation of the ease of doing business (World Bank 2007). Still, the policy focus has predominantly been on the formal sector and policy interventions targeting informal businesses have aimed mainly to formalise them. Sometimes local governments can be said to even have a hostile policy towards SMEs, when their interventions focus on trying to keep informal businesses out of town centres (Steel 2008).

The Brong Ahafo Region, where both the GIZ project's and the survey's target districts are located, is situated in Mid-Western Ghana. It is a transition zone between Ghana's poorer Northern regions and its more densely populated and wealthier central and coastal zones. In the agricultural sector, the cultivation of commercial crops like maize, yams, cassava, plantain or cocoa is the most important source of income. The non-farming sector is dominated by commerce activities. All of the surveyed towns have markets at least once a week, where traders from all over the region arrive. Techiman has one of the biggest agricultural markets in West Africa. Furthermore, agro-processing activities such as palm oil production or grain milling, woodwork – mainly producing furniture – tailoring and car-related services are core economic activities.

### 3.1. Access to Infrastructure

Ghana has one of the highest electrification rates in Sub-Saharan Africa, which was 54 % at the time of this study (UNDP/WHO 2009). The generation capacity in 2008 totalled 1,730 MW and was mainly provided by the hydro power plant of Akosombo at Lake Volta but increasingly also by thermal plants. The Ghanaian grid is part of the West-African Power Pool and has interconnections with Benin, Côte d'Ivoire and Togo. In 2007, electricity demand in Ghana could not be met by the production capacities, both because demand had been growing and because supply had decreased due to low water levels in Lake Volta. Historically, Ghana almost solely relied on hydro power and was an important electricity exporter to neighbouring countries. Today, by contrast, Ghana is still exporting but to fuel its thermal plants Ghana relies heavily on crude oil and gas imports.

To face these problems, a load shedding policy was developed leading to frequent but announced blackouts at the time of the survey. In addition, grid connected firms often face unforeseen blackouts and voltage fluctuations. Firms that use grid-electricity reported an average of 2.8 times per week of unannounced blackouts lasting approximately 4.4 hours on average.

The grid was extended to the surveyed towns between the end of the 1980s and the beginning of the 1990s. At the time of surveying, the percentage of connected households in the surveyed towns was above 70 %. In some areas, virtually all households are connected. Connection costs differ substantially depending on the distance to the distribution lines and, hence, how much material, i.e. poles and cables, are required. The average initial connection costs paid by surveyed firms are 106 GH¢.[42]

The main roads leading to and passing through the surveyed towns are tarred. Only feeder roads are in a more problematic state. In the industrial zones surveyed, most roads were not tarred, making it difficult to reach some of the businesses in the rainy season. The towns lie at the main roads connecting Northern Ghana and neighbouring countries to the coastal regions. This leads to a high number of potential customers passing through the towns and large weekly markets. In all towns, postal services, internet connections and fax or fixed telephone lines are available. The main communication medium is the mobile phone, used by 70 % of all businesses in the survey.

41) The description of the economic conditions refers to the situation when the data were collected by the end of 2007. Later developments, especially in the electricity sector, have not been taken into account.

42) At the time of the survey, the exchange rate was 1 Ghanaian New Cedi (GH¢) = 1.06 US $.

### 3.2. The Surveyed Firms: Access to Markets, Finance and Business Development Services

On average, the surveyed firms have 3.3 employees in addition to the firm owner. While the largest firm has 19 employees, 82 % of the interviewed firms have less than 5 employees, 94 % have less than 10. Virtually all have been created in the last 5 years. Around 22 % of firm owners are women (also in the manufacturing sector). In terms of educational background, most firm owners have a secondary school degree (53 %), around 26 % have primary school or no education and only few have technical school education.

Integration with external markets is very limited in the survey region – both for electricity using and non-using firms. As depicted in *Table 35* hardly any manufacturing firm sells to exporters or retailers. As a further indicator for market access, firm owners were asked whether they know where their products are consumed in the end. The vast majority declares that their goods are consumed in the region and only very few believe that the final destination of their products is in other regions.

Table 35: Integration with External Markets (only manufacturing firms)

| Majority of goods is ... | Connected | Non-Connected |
|---|---|---|
| ... sold from the enterprise | 97 % | 100 % |
| ... consumed in the same town | 91 % | 85 % |
| ... consumed outside the town, in district | 3 % | 8 % |
| ... consumed outside district, in Ghana | 5 % | 8 % |
| ... consumed outside Ghana, in Africa | 2 % | 0 % |
| ... sold to private individuals | 95 % | 90 % |
| ... sold to manufacturers | 2 % | 0 % |
| ... sold to traders and retailers | 2 % | 8 % |
| ... sold to exporters | 2 % | 0 % |
| ... sold to pub | 0 % | 2.5 % |

Finance is frequently cited as a major constraint to the growth of micro-enterprises. In rural Ghana, a wide variety of micro-finance institutions is present. Commercial banks work in all four surveyed towns. Nevertheless, the most important sources to cover both start-up and running costs are personal savings, earnings from the business and support from family and friends, according to the survey. Loans played a minor role in financing the business.

*Table 36* depicts the general access and usage of credits. The vast majority of firms has a bank account and declares to have appropriate collaterals that would qualify them to obtain credits. There is no stark difference between the two sectors and connected and non-connected firms in this respect. Between 30 % and 50 % of firms has ever applied for a loan. Here, the connected firms, in particular the manufacturers seem to be more active. Most of the firms that have applied also have received a loan. The average amount of the credit was around 770 GH¢ for connected firms in both sectors. While connected service firms received credits of an average amount of roughly 1,000 GH¢, connected manufacturing firms on average took credits of 2,000 GH¢.[43] The creditors are mainly micro-finance institutions and commercial banks. Only five percent of the firms took a credit from moneylenders or traditional itinerant savings collectors. Altogether, credit usage is high compared to rural areas, but still moderate in absolute numbers.

43) The high figure for manufacturing firms is dominated by one outlying firm that declares to have received a credit of 40,000 GH¢. While this response might be plausible taking into account other characteristics of this firm, it is worth noting that omitting that observation reduced the average credit to around 520 GH¢.

Table 36: Access to Finance

| | | Share of firms that ... | | | | |
|---|---|---|---|---|---|---|
| | | have a bank account | declare to have collaterals | have ever applied for a loan | have ever received a loan | Amount of credit if received one (in GH¢) |
| Manufacturing | Connected | 88 % | 73 % | 52 % | 37 % | 2,040 |
| | Non-connected | 80 % | 69 % | 33 % | 28 % | 770 |
| Service | Connected | 84 % | 70 % | 38 % | 34 % | 997 |
| | Non-connected | 79 % | 64 % | 31 % | 24 % | 773 |

To improve understanding of the high share of firms that have never applied for a credit we look at responses to a subjective multiple-choice question in the questionnaire asking respondents to name reasons for having not applied for a credit. As *Table 37* shows, there seems to be no clearly dominating factor. The highest ranked answer was that procedural requirements are too difficult. Yet, also this reason was given by less than one third of the firms. It is interesting to note that few firms complain about high interest rates. This is particularly astonishing as the average interest rate in received credits is around 154 %, which is, however, dominated by three outliers that declare having paid an interest rate of around 1,000 %. But even omitting these three outliers yields an average interest rate of more than 100 %. Even taking into account the relatively high inflation rate in Ghana,[44] this is an extraordinarily high interest rate. For comparison, Morduch (1999) reports nominal interest rates from micro-finance programmes in Asia of between 20 % and 55 %.

A couple of firms also state that collateral demands are too high. Effectively, however, in the majority of assigned credits no collateral at all was required (which partly explains the high interest rates). While such subjective statements have to be interpreted carefully in general, these two reasons for not applying for a credit might indicate a lack of knowledge about micro-credit processes among the entrepreneurs.

Table 37: Subjective Reasons For Not Applying For Credits

| | | Procedure of demand too difficult | Interest too high | The amount of credit is too small | Reimbursement might be difficult | Collateral requirements are too high | No need for loan |
|---|---|---|---|---|---|---|---|
| Manufacturing | Connected | 20 % | 13 % | 13 % | 23 % | 13 % | 13 % |
| | Non-connected | 31 % | 23 % | 8 % | 4 % | 8 % | 8 % |
| Service | Connected | 27 % | 13 % | 0 % | 10 % | 13 % | 21 % |

Multiple Answers possible

In the surveyed region, different BDS programmes are offered by the public sector and donors. As a consequence, around one third of the firms has received technical or business training. Only one firm claims to have participated in an IT training.

44) The inflation rate (consumer prices) was persistently above 10 % between 2000 and 2007 with peaks of up to 33 % in 2002 (see *www.data.worldbank.org*).

Table 38: BDS Usage

| | | Ever Used BDS |
|---|---|---|
| Manufacturing | Connected | 35 % |
| | Non-connected | 38 % |
| Service | Connected | 27 % |
| | Non-connect | 27 % |

While more than 70 % of those firms that have benefited from a BDS programme declare that their participation had a positive impact on their business, according to key informants the quality of the programmes was generally rather poor. In the last years before the survey, non-commercial BDS providers granted allowances for the participation in workshops. Not surprisingly, most firms that participated in BDS activities were led by financial incentives rather than interest in the training. The entry of private BDS providers was inhibited by this public or donor subsidisation and few are available.

# 4. Intermediate Impacts of Electricity Usage

## 4.1. Energy Sources

The four surveyed towns have been connected to the national electricity grid since the beginning of the 1990s. 62 % of the surveyed firms are connected to the electricity grid – equally distributed across the service and manufacturing sector. As shown in *Table 39*, connection rates are most elevated among blacksmiths, dressmakers, barbers and electricians.

Table 39: Connection Rates in Selected Business Types

| Business Type | Total Number | Grid Connected | Connection Rate |
|---|---|---|---|
| Manufacturing sector | 105 | 65 | 62 % |
| Dressmaker | 34 | 25 | 74 % |
| Blacksmith | 34 | 23 | 68 % |
| Carpenter | 12 | 5 | 42 % |
| Food processing | 8 | 2 | 25 % |
| Service sector | 131 | 82 | 63 % |
| Barber shop | 31 | 26 | 84 % |
| Electrician | 15 | 13 | 87 % |
| Repair Shop | 63 | 19 | 30 % |

Virtually all non-connected firms deliberately decided not to use electricity. Only few businesses in the sample are located beyond the outreach of the grid and have no possibility to get connected. Around 22 % of non-connected firms, however, have already requested a connection but have not been served yet (see *Table 40*).

Table 40: Reason for Not Connecting to the Grid (multiple answers possible)

| | Percentage |
|---|---|
| 'Electricity is not needed for the enterprise's operation'. | 27 |
| 'The enterprise cannot afford the connection fee'. | 24 |
| 'The enterprise cannot afford the payments for consumption'. | 23 |
| 'Grid is available and a connection has been requested but has not yet been established'. | 22 |
| 'Public street lighting is sufficient'. | 5 |
| 'There is no grid available'. | 3 |
| 'Cables are always stolen whenever enterprise is connected'. | 1 |
| 'Electricity supply through grid is too unreliable'. | <1 |

The most prominent reasons are that firms do not need electricity for their business or that they cannot afford it. In spite of the announced and unannounced outages described in *Section 2*, unreliability does not seem to be an important reason for not connecting. It is therefore consistent that only 13 % of the connected firms use backup facilities, mostly generators.

Among the electricity using firms, 30 % are connected informally by extensions from neighbouring houses or businesses. In some cases, businesses also use the connection of other businesses on demand only and pay for it directly.

Apart from grid electricity, firms do not use non-human energy sources much. Charcoal is the most common source and used by only 17 %, principally by dressmakers for ironing and blacksmiths for forging. Dressmakers continue to use charcoal irons even if electricity is available. Alternative electricity sources, mostly generators and car batteries, are used by 13 %. Dry cell batteries or kerosene are used by less than 10 %.

### 4.2. Lighting

As in most electrified regions in Africa, lighting is the most widely used energy service. The frequently cited advantages of electric lighting as compared to traditional lighting devices are higher quality, more convenience and lower costs per unit of light output (e.g. Nieuwenhout 1998). This is widely expected to translate into higher accuracy of work and longer operating hours.

In total, 61 % of the surveyed firms use some sort of lighting, most of which are connected to the grid (see *Table 41*). The most common electric lighting devices are fluorescent lamps followed by energy saving lamps (compact fluorescent lamps). One reason for the extensive use of energy savers is a governmental energy saving initiative that distributed six million energy savers for free. Only few firms use traditional lighting sources like candles or wick lamps. Businesses with a grid connection use candles twice as much as firms without a connection. These firms rely on lighting and use candles as a backup in case of blackouts after nightfall. It is also striking that non-connected firms hardly use any artificial lighting. This might on the one hand suggest that electricity facilitates lighting usage. On the other hand, it is also likely that firms that require lighting are more inclined to get a connection.

Table 41: Lighting

| | Lighting Usage in % | | | Hours Used Per Day* | |
|---|---|---|---|---|---|
| | All firms | Connected | Non-Connected | Connected | Non-Connected |
| Total | 61 % | 91 % | 12 % | 22.27 | 3.64 |
| Grid-based electric lighting | 59 % | 90 % | 8 % | | |
| Fluorescent lamp | 30 % | 48 % | - | 8.90 | - |
| Energy Saving bulb | 27 % | 38 % | - | 7.46 | - |
| Incandescent bulb | 27 % | 43 % | - | 8.78 | - |
| Rechargeable light | 8 % | 8 % | 8 % | 2.89 | 1.57 |
| Candle | 8 % | 11 % | 3 % | 1.93 | 0.56 |
| Wick lamp | 3 % | 3 % | 2 % | 1.70 | 3.25 |
| Solar lamp | 1 % | 1 % | 0 % | 3.25 | 0.00 |
| Hurricane lantern | 3 % | 3 % | 2 % | 5.14 | 8.00 |
| None | 39 % | 9 % | 88 % | N/A | N/A |

* Averages of electricity using firms

Cost reduction potentials become evident if common electrical lighting devices (energy saving bulb) are compared to the most common traditional ones (wick lamp, candle). If we take the average lighting hours used in the sample and local prices for the respective energy sources and operational cost, which are depicted in *Table 42*, the result shows a great disparity. The effective costs per months of candles and wick lamps are five and ten times higher, respectively, than those for energy savers – although the electric light bulbs are used for many more hours. The costs per operation hour are 20 and 32 times higher. These factors increase to 1,280 for candles and 640 for wick lamps when compared to energy savers.

Table 42: Cost Reduction Through Electric Lighting

| Cost | Candle | Wick Lamp | Energy Saving Bulb |
|---|---|---|---|
| (A) Unit cost lamp (in GH¢) | 0.14 | 5.6 | 7.5 |
| (B) Lamp life (in hours) | 2 | 5,500.0 | 9,000.0 |
| Unit cost per hour | 0.07 | 0.001 | 8.33 *10-4 |
| (C) Operating hours per month | 49.02 | 55.21 | 189.63 |
| Monthly hard ware cost per lamp (in GH¢) = C / B * A | 3.25 | 0.06 | 0.16 |
| Monthly maintenance cost per lamp1 (in GH¢) | 0 | 0.62 | 0 |
| Monthly electricity cost per lamp (in GH¢¢) = Lamp power (watt) * Average electricity cost (in GH¢/kWh) * C / 1,000 | 0 | 0 | 0.48 =18 W *0.14 GH¢ / KWh *189.63h / 1000 |
| Monthly fuel cost per lamp ( in GH¢) | 0 | 5.49 | 0 |
| Total cost per month (in GH¢) | 3.43 | 6.17 | 0.64 |
| Total cost per operation hour (in GH¢) | 0.069 | 0.11 | 0.0034 |
| Lumen hours consumed a month | 686.28 | 2,484.45 | 161,185.5 |
| Cost per 10,000 lumen hours (in GH¢) | 49.98 | 24.8 | 0.039 |

1) Costs for replacing wick

### 4.3. Energy Expenditures

Total average monthly spending on energy varies considerably between connected and non-connected firms. While connected firms spend on average 29.47 GH¢ a month, the energy bill only amounts to 5.55 GH¢ among the non-connected. Even if spending on electricity for grid-connected firms is subtracted, energy costs are still twice as high for connected than for non-connected firms.

*Table 43* lists, first, the expenditures per energy source of those firms that use it and, second, the time that is required on average to obtain the respective energy source, which is frequently cited as a considerable non-monetary burden of traditional energy sources. In most cases it is not considerable: to obtain candles or charcoal, the most commonly used traditional sources, firms spend only between 20 and 57 minutes per month, with grid-connected firms exhibiting the higher figures.

Table 43: Monetary Expenditures and Time Spent to Obtain Respective Energy Source

| Energy Source | GH¢ per Month | | Minutes per Month | |
|---|---|---|---|---|
| | Connected | Non-Connected | Connected | Non-Connected |
| Candles | 7.0 | 2.6 | 40.2 | 21.5 |
| Charcoal | 42.1 | 14.7 | 56.8 | 43.2 |
| Petrol | 31.9 | 33.7 | 84.1 | 106.7 |
| Car battery | 7.7 | 4.9 | 80.1 | 91.5 |
| Diesel | 83.2 | 45.8 | 113.8 | 179.3 |
| Kerosene | 16.4 | 2.1 | 32.3 | 19.0 |
| Dry cell batteries | 1.6 | 2.7 | 16.0 | 20.5 |
| Electricity from the grid | 22.0 | | 40.4 | |

*Averages of electricity using firms

More striking are the timely efforts for petrol and diesel: those firms that use them require between 84 and 179 minutes getting them. It has to be noted, however, that only few firms use diesel and petrol (mostly for generators), so that the sample size to calculate the time burden is very small. It might come as a surprise that firms also need more than 40 minutes per month to 'obtain' electricity. The reason for this is that firms have to show up at the operator's agency in order to pay their electricity bill.

The energy usage patterns described in this section show that electricity-using firms decided to connect to the grid because they had required already more energy before. An indication for this is the observation that grid-connected firms also exhibit higher expenditures for traditional energy sources. One might also expect a causal relation in the other direction – thanks to the grid connection energy usage is strongly stimulated. Our data suggests differently. Half of the non-connected firms do not even use non-human energy at all. As a matter of course, the grid connection might still induce the take up of new appliances and thereby increase energy consumption even more. The great share of connected firms that use electricity to run equipment and machinery (84 %) supports this idea.

### 4.4. Capital and Employment

This section examines the relation between usage of grid electricity and capital endowment of firms, measured in terms of resale value of all capital items. As presented in *Table 44*, grid-connected firms employ capital amounting to 3,714 GH¢ against 1,630 GH¢ for the non-connected. In both cases, the value of buildings exceeds that of other capital items many times over. It constitutes 69 % of total capital among non-connected and 63 % among connected firms. Also the difference between connected and non-connected firms is to a large part due to the higher value of buildings among the connected firms. Electric equipment making up 18 % of used capital among connected firms explains the rest of the difference. Firms without grid connection do not use any electric machinery.

Table 44: Resale Value of Capital Endowment (in GH¢)

| | Connected Firms | Non-connected Firms |
|---|---|---|
| TOTAL | 3,713.64 | 1,630.88 |
| **Non-energy** | 2,722.80 | 1,354.7 |
| Buildings | 2,351.49 | 1,121.51 |
| Furniture | 190.66 | 32.91 |
| Vehicles | 12.57 | 10.97 |
| Tools | 173.69 | 181.39 |
| **Non-electric energy** | 323.36 | 275.80 |
| Vehicles | 152.67 | 182.26 |
| Generators | 46.18 | 0 |
| Processing | 2.17 | 27.44 |
| Cooking | 27.57 | 0.69 |
| **Electric energy** | 667.48 | 0.34 |
| Telecommunications | 201.25 | 0 |
| Refrigeration | 26.90 | 0 |
| Processing | 423.80 | 0 |
| Hairdressing | 35.01 | 0 |
| Other | 9.35 | 0.20 |
| Voltage stabiliser | 10.10 | 0.34 |
| Decentralised electricity generation | 51.48 | 0.34 |

As the usage of electricity has a considerable impact on lighting usage of firms, one might expect an effect on the operating hours. After nightfall, electricity provides lighting and therefore businesses potentially can continue their work. In fact, connected firms are working longer (see *Table 45*): grid-connected firms work approximately 11.5 hours per day, while non-connected firms only work 10.65 hours. This reflects the tendency of connected firms to close later, since both groups open roughly at the same time in the morning.

Table 45: Daily Operation Hours

| | Connected | Non-Connected |
|---|---|---|
| Operation hours | 11.47 hrs | 10.65 hrs |
| Time open | 7:12 am | 7:08 am |
| Time close | 6:40 pm | 5:46 pm |

These longer opening hours obviously are also reflected in the labour input. Here, we measure labour input as working hours summed up over all employees. We use operation hours to approximate the labour input of the owner.

Table 46: Labor Input per Week

| | Connected | Non-Connected |
|---|---|---|
| Working hours employees (hours) | 193.5 | 181.3 |
| Working hours owner (hours) | 69.5 | 61.8 |
| Working hours total (hours) | 262.1 | 243.1 |
| Wage employees (GH¢)* | 26.9 | 12.6 |
| * * Monetary pay and compensation in goods for all employees | | |

*Table 46* shows the results of comparing labour input in connected firms to that of non-connected ones. Connected firms register more working hours than non-connected firms, reflecting simply the higher number of hired workers. In particular in light of many apprentices in the work force this result on working hours should not be overstated.

Generally there are no significant differences in the characteristics of the employed workforce apart from one: the percentage of family members employed. As depicted in *Table 47*, the percentage is substantially higher among non-connected firms. On average 32 % of the employees of non-connected firms are family members, whereas among connected firms the share only amounts to 13 %. This difference is also reflected in the compensation of employees. Non-connected firms pay less money than the connected ones do. This is plausible as family members are often paid in-kind.

Table 47: Characteristics of Workforce and Compensation

| Labour | Connected | Non-Connected |
|---|---|---|
| **Number of Employees** | 3.24 | 3.72 |
| % Male | 0.66 | 0.61 |
| % Female | 0.34 | 0.39 |
| % Family member | 0.13 | 0.32 |
| **Average weekly working hour** | | |
| per employee | 57.93 | 56.51 |

Total weekly compensation of employees in money and in-kind does not differ significantly between connected firms and non-connected ones as comparison of mean values shows.

## 5. Impact Analysis

In the preceding sections we demonstrated that there are substantial differences in the economic activity and structure of grid connected and non-connected enterprises.

The differences in intermediate outcome variables we observed so far, however, cannot be interpreted causally. The reason is that it can never be ruled out that selection or simultaneity biases distort the comparison. We now turn to the major indicator of this study, firm performance. Taking the difference in mean values of firm profits and revenue as a starting point, we dedicate more efforts to examine the impacts on firm profits: we first employ an OLS regression that controls for observable other influences, followed by a 2SLS that intends to reduce the mentioned biases from unobservable variables and simultaneity.

### 5.1. Sales and Firm Revenue

Several questions were posed to elicit the firm revenue. First, we raised the mean value of sales for three different months: revenues in the month prior to the survey as well as in a good and a bad month. In *Table 48*, the mean revenue-levels as well as values specified for each of the elicited months are displayed.

Table 48: Revenue per Month (in GH¢)

| Revenue per Month (GH¢) | Connected | Non-Connected |
|---|---|---|
| Sales directly elicited (mean) | 775.97 | 375.34 |
| Sales in a bad month | 377.93 | 113.84 |
| Sales in a good month | 839.93 | 594.29 |
| Sales in the last month | 725.33 | 310.43 |

In all cases, the revenue-level of grid- using firms is significantly higher than the one of non-using firms. The directly elicited average sales value amounts to 776 GH¢ for connected firms and 375 GH¢ for non-connected ones. Note that higher output does not necessarily imply higher profits.

If we look at the figures for sales in a good and a bad month, a big difference is visible. It illustrates the fact that seasonality matters in the surveyed region. The month referred to as 'the last month' was October, which is the end of the second rainy season. As purchasing power in the predominantly agricultural economy is higher after harvests, we can expect this value to be rather high.

Putting output in relation to labour input provides insights on labour productivity, which is measured as revenue per total input of working hours. As *Table 49* shows, the labour productivity among grid-connected firms is generally lower if both sectors are examined together. Differentiating between service and manufacturing firms, however, shows that this is mainly due to the loww labour productivity of grid-connected manufacturing firms. In the service sector, connected firms exhibit higher labour productivity.

Table 49: Labour Productivity: Revenue (in GH¢) per Total Input of Working Hours

| Total | | Service | | Manufacturing | |
|---|---|---|---|---|---|
| Connected | Non-Connected | Connected | Non-Connected | Connected | Non-Connected |
| 3.26 | 4.09 | 3.74 | 3.32 | 2.69 | 5.17 |

The reason for this lies in the different sizes of firms and the employment of apprentices. Grid-connected manufacturing firms employ more workers. At the same time, the share of apprentices is much higher in the manufacturing sector and increases with firm size. Apprentices, in turn, work less efficiently than more experienced workers, so that, as a consequence, the smaller non-connected firms have higher labour productivity. In the Brong Ahafo Region, it is very common that especially young men work as apprentices in their families' or friends' enterprise. Hence, the decision to employ these apprentices often is not an economic decision but rather a matter of social commitment. Apprentices have a rather observational role only and barely contribute to the production process. As a consequence, more labour input does not necessarily translate into higher revenue. In fact, we find a significant negative correlation of -0.2 between the number of employees and labour productivity.

Looking at labour productivity for larger manufacturing firms confirms that it is firm size that explains low productivity rather than grid connection status: among firms employing more than five workers grid-connected manufacturers are now more productive than their non-connected counterparts (2.32 vs. 2.01).

### 5.2. Firm Profits: Difference in Means

In this section, we now investigate the effect of being connected to the grid on the firm's profits. The profits were calculated by subtracting all running expenses from monthly sales. A closer look into the data reveals that mean values of profits are dominated by few outliers both at the bottom and the top of the profit distribution: one manufacturing firm reveals a calculated loss, hence a negative profit of more than 5,000 GH¢, while one non-connected manufacturing firm exhibits profits of more than 5,000 GH¢. Also, among connected service firms there are two that turn out to have profits of more than 5,000 GH¢ and 9,000 GH¢, respectively. While we have no reason to doubt the accuracy of these figures it, nevertheless, appears reasonable to delete them from the sample for the subsequent analysis. The methodological reason is that, particularly in small sample sizes like the one underlying this study, it is possible that – by chance – a certain type of firm is oversampled. We suspect the aforementioned outliers to be such non-representative observations. Furthermore, statistical tests for influential observations show that the four mentioned variables are especially influential. *Table 50* now depicts the mean profits in the survey region – excluding those outliers. We see that connected firms exhibit substantially higher profits. These higher profits of connected firms can be observed both among service and manufacturing firms.

Table 50: Profits (in GH¢) – Difference in Means

| | Total | Service | Manufacturing |
|---|---|---|---|
| Connected firms | 224.68 | 176.31 | 285.14 |
| Non-connected firms | 166.98 | 115.47 | 231.70 |
| Difference | 57.70 | 60.84 | 53.44 |

### 5.3. Ordinary Least Squares

Simply comparing the mean values of the two groups, of course, does not account for heterogeneity between firms. Therefore, using an OLS model, we regress profits on the connection dummy and a suite of control variables. Results are presented in *Table 51*: as the first column shows, the coefficient of the connection dummy is not significantly different from zero. Besides this insignificance, the difference in profits between connected and non-connected firms turns negative, controlling for BDS and micro-finance usage, capital and labour input, entrepreneurial experience, education of the firm owner and gender. Connected firms earn 11 GH¢ less than non-connected firms. However, this negative difference is not statistically significant. In addition, we included a dummy for the sector in order to distinguish between service and manufacturing firms. Female firm owners exhibit significantly higher profits than their male counterparts. Firms that use credits have substantially higher profits, a result that is statistically significant. BDS use, in contrast, has a negative effect, although the coefficient is not significant.

While capital usage has a significantly positive impact on profits, labour input is negative (but non-significant), which is in line with our descriptive and qualitative findings.

It comes as a surprise that better educated firm owners have lower profits (see secondary education dummy). Also, the correlation between profits and experience of the owner (measured by years s/he has been working in the firm) is negative, although nonsignificant. One possible explanation is that experience also captures firm age and recently created firms can be supposed to be more dynamic and closer to the market's needs.

The GIZ project in the survey region as well as many practitioners assume that bundled services, i.e. electricity, BDS and micro-finance, are more effective than individually provided services. To examine this assumption we interact the grid connection dummy with BDS and micro-finance usage, respectively. Results on these OLS regression in *Table 51* show some puzzling correlations. While the interacted connection-BDS variable that measures the effect for cases in which both services are used by a firm has a strong but nonsignificant positive effect on firm profits, both the individual BDS and connection variables are negative (but nonsignificant). This would suggest that BDS and a grid connection only have a positive effect if enjoyed together. Otherwise, they rather harm the firm's profits. This might support the pre-conceived notions of those practitioners who keep on spreading the anecdotal message that services have to be provided in a bundled way (Motta and

Reiche 2001, Peters, Harsdorff and Ziegler 2009). The interaction term on credit usage and grid connection is also positive and would likewise advocate in favour of bundled services. Comparing the credit coefficients in the two OLS models indicates that the strong effect of credit usage observed in the first OLS model is to a great extend due to firms that use credits and are connected to the grid at the same time. It has to be noted, however, that both coefficients – the individual credit dummy and the interaction term – are nonsignificant.[45]

Furthermore, it has to be highlighted that results on BDS or credit usage are also likely to be biased upward, since participation in such programmes is prone to selection and simultaneity and the respective variables are, hence, likely to be endogenous.

Table 51: Monthly Firm Profit – Ordinary Least Squares and Two Stage Least Squares egression (p-values in parentheses)

| | OLS | | 2SLS |
|---|---|---|---|
| Grid connection | -11.11<br>(0.91) | -128.85<br>(0.301) | 376.08<br>(0.127) |
| BDS | -36.26<br>(0.739) | -109.2<br>(0.526) | -7.6<br>(0.947) |
| Grid connection*BDS | | 131.83<br>(0.55) | |
| Credit | 233.66<br>(0.030) | 49.48<br>(0.789) | 188.44<br>(0.099) |
| Grid connection*credit | | 276.6<br>(0.225) | |
| Capital stock | 0.04<br>(0.000) | 0.04<br>(0.000) | 0.04<br>(0.000) |
| Working hours | -0.28<br>(0.223) | -0.33<br>(0.151) | -0.28<br>(0.239) |
| Secondary education | -193.02<br>(0.078) | -197.33<br>(0.071) | -268.15<br>(0.027) |
| Experience owner | -27.37<br>(0.84) | -38.1<br>(0.779) | -31.46<br>(0.822) |
| Male owner | -176.81<br>(0.121) | -183.08<br>(0.109) | -167.17<br>(0.156) |
| Manufacturing | 71.33<br>(0.452) | 69.65<br>(0.462) | 71.35<br>(0.467) |
| Constant | 368.2<br>(0.186) | 477.73<br>(0.097) | 202.12<br>(0.505) |
| R2 | 0.151 | 0.161 | 0.09<br>(centred R2) |
| Adjusted R2 | 0.117 | 0.119 | 0.06 |
| F-test | 4.39<br>(0.000) | 3.84<br>(0.000) | 4.36<br>(0.000) |
| F-test on IVs | | | 22.91 |
| Anderson LR-statistic | | | 39.84<br>(0.000) |
| Hansen J-statistic | | | 4.863<br>(0.027) |
| Number of observations | 232 | 232 | 232 |

45) Running F-tests on the joint significance of the individual dummies and the interaction terms cannot reject the null hypothesis of no joint influence, respectively.

### 5.4. Two Stage Least Squares

While OLS is an effective way to control for observable heterogeneity in the sample, unobservable variables that affect both right hand side variables and the outcome variable on the left hand side induce endogeneity problems. In this case, the treatment variable is particularly suspected to be endogenous. One reason is that omitted variables like motivation or managerial ability both influence the decision to connect and firm profits and might not be sufficiently captured by other control variables. In addition, we assume that the relation between the connection variable and profit is simultaneous. Therefore, a causal interpretation of the OLS results in *Table 52* is not warranted.

In order to deal with this endogeneity, we apply a 2SLS approach. While finding appropriate identifying variables is in many cases a prohibitive challenge, we draw upon two binary variables that fulfill the necessary conditions. The first variable indicates whether an enterprise is located in an industrial zone and the second indicates whether it is located in a dispersed area. Both are negatively correlated with the decision to connect. This can be partly explained by the fact that reliability of the grid is rather low in some industrial zones where transformers have often been originally established for residential users and, consequently, are overburdened by enterprise usage. Enterprises in dispersed areas are less likely to connect, simply because the distance to the grid is higher than in populated or market areas. At the same time, these two variables are not correlated with the firm's profits. Insights during the field visit support this thesis. Moreover, also information that approximates the profit level of the firms, namely the number of consumers per day, shows no significant differences. Also, a correlation with unobservable motivation characteristics of the owner is not to be expected.

These two variables are used as IV in a 2SLS regression. We conducted various tests to check the validity of the model.[46] The application of the 2SLS approach confirms the results in all control variables, whose coefficients are only altered slightly. With regards to the treatment variable, the 2SLS estimation confirms the OLS results partly: there is no significant effect of being connected. What is surprising, however, is that the OLS result in *Table 51* suggested that profits of connected firms are 11 GH¢ lower than those of non-connected ones. Purging (at least parts of) the selection and simultaneity bias turns the estimated coefficient of the connection status positive and up to almost 380 GH¢. One would expect an upward bias triggered by the self-selection process and the simultaneity described above. Accordingly, it would be intuitive if the usage of IV reduces the estimated impact of the connection treatment.

Lassen (2005), who documents similarly counterintuitive findings of studies using instrumental variables (Dee 2004, Milligan, Moretti and Oreopoulos 2003, see also Miguel, Satyanath and Sergenti 2004), speculates that one cause may be classical measurement errors in the independent variables, which can induce attenuation bias in the estimate. To the extent that the predicted values used in an IV analysis typically have less variability than the actual variables and thereby mitigate the effects of measurement errors, the estimates would be expected to increase. An alternative explanation for the divergence between the OLS and IV estimates, noted by Angrist and Krueger (2001), is that the instruments reduce omitted variable bias by capturing only that part of the variability in the connection indicator that is uncorrelated with the omitted variables. The overall direction of this bias, however, is difficult to infer, as it will depend on both the net effect of the omitted variables on the dependent variable and on their correlation with the explanatory variable of interest.

### 5.5. Robustness of Results

In order to check the sensitiveness of the results with regards to the decision to drop the outliers described at the beginning of *Section 5.2* we check the robustness of results by including them again. It can be seen in *Table 52* that the results on average profits are highly sensitive to the treatment of these outliers. The comparison of mean

46) With respect to the identification of the models, three tests are reported at the bottom of *Table 52*. The first of these is a F-test of the joint significance of the instruments from the first stage regressions. It easily rejects the null hypothesis of no joint effect in both models. The second statistic, the Anderson canonical correlations likelihood ratio statistic, provides an additional test of whether the excluded instruments are relevant. The null hypothesis is that the equation is under-identified. Again, in both models the null hypothesis is rejected at the one percent level. The final test reports the Hansen J-statistic. The null hypothesis here is that the instruments are uncorrelated with the error term and that the excluded instruments are correctly excluded from the estimated equation. The null hypothesis is not rejected indicating that the instruments are good ones. Hence, altogether, technically the selected IV fulfil all conditions.

values for the whole sample averages shows that profits among manufacturing and service grid-connected firms on average are 53 GH¢ higher than among non-connected firms. While this difference does not deviate very much from the difference when excluding the outliers, a closer look at service and manufacturing sector suggests an increasing heterogeneity between sectors. The positive difference in the service sector gets substantially larger. Manufacturing firms, in contrast, now have considerably higher profits if they are *not* connected.

Table 52: Monthly Profits – Manufacturing and Service Sector (including outliers)

| | Service and Manufacturing | Service | Manufacturing |
|---|---|---|---|
| Connected firms | 300.45 | 377.89 | 202.77 |
| Non-connected firms | 247.09 | 115.47 | 408.32 |
| Difference | 53.36 | 262.42 | -205.55 |

Since strong outliers deliver biased results in OLS regressions, we apply an alternative approach called quantile regression. Unlike OLS, which assumes normality of the dependent variable, quantile regression models the relationship between an explanatory variable and the conditional quantiles of the dependent variable, making it particularly robust to response outliers. Applying this approach suggests that the impacts of being connected are negative but the estimates are statistically insignificant.

Altogether, robustness checks confirm the insights gained during the previous analysis: the difference between connected and non-connected firms cannot be considered to be clearly positive. All results that suggest a positive difference are statistically not significant. At the same time we even find a negative difference in one case.

## 6. Conclusion

This chapter has examined the use of energy and the performance of micro-enterprises in peri-urban areas in Ghana. Based on 236 firms from the service and manufacturing sector we first descriptively analysed factor inputs, usage of credits, BDS, services and energy. We did not dispose of data from firms in non-electrified areas, as all regions comparable to the survey regions in Ghana are connected to the grid. Therefore, we had to rely on the comparison of connected and non-connected firms in the same region.

We find partly large differences between the two sectors and also between firms that are connected to the electricity grid and those that are not. With 62 % the share of firms that are connected to the grid is relatively elevated. These firms have much higher energy consumption than the non-connected ones – even for traditional energy sources. While lighting is the mostly used application of electricity, many connected firms also use electric equipment. The difference in terms of opening hours and labour input between connected and non-connected firms is not substantial. Capital input, in contrast, is considerably higher among connected firms.

Albeit it is beyond the scope of this study to probe into the details of credit usage, it can be stated that take-up rates are moderate. Clearly, compared to rural areas many firms are making use of available credit access. Yet, in some subgroups only around 30 % of interviewed firms have ever used a credit. Subjective questions indicate that knowledge about credit conditions is limited. Access to credits is given in principle and the firms dispose of relatively considerable amounts of capital and equipment. Hence, it might be worth following up on this result in order to understand the modest take-up rates. Accompanying measures by the GIZ programme might investigate the necessity and opportunities to close the gap between supply of and demand for credits.

Turning to the ultimate impact of electricity usage on firm performance measured by firm profits we find no significant effect. Differences in means indicate that connected firms in both sectors perform better. The result is sensitive, however, to the decision on keeping or dropping four outliers that exhibit extreme profit figures. More importantly, regression analysis employing first a simple OLS approach shows that the effect of

the connection variable is negative but statistically not significantly different from zero. In order to account for the presumably strong simultaneity and selection processes we additionally use a Two Stage Least Squares (2SLS) approach that requires identifying variables being correlated with the endogenous treatment variable and uncorrelated with the dependent variable. 2SLS confirms the non-significance of the difference between connected and non-connected firms.

Furthermore, we examined the joint effect of electricity connection and usage of BDS and micro-credits. The related regressions delivered somewhat puzzling results, assigning a substantial power to the participation in BDS programmes: electricity users seem to perform only better if they – at the same time – use some sort of BDS. These results, however, have to be interpreted with caution. First, most of these coefficients are not significant. In addition, BDS was included simply as a binary variable but has, as a matter of course, various forms from vocational training to close consulting activities. Second, qualitative information gained during field work rather suggests a low quality of obtainable BDS in the region. Therefore, it is likely that the BDS dummy rather captures other firm characteristics that have positive effects on profits. Methodologically, the employed BDS dummy is presumed to be biased due to selection processes as well.

Altogether, our research shows that usage of electricity does not increase generated income by all means. The results have to be interpreted carefully, however. The sample size is relatively small, which might be particularly problematic using an outcome indicator (firm profits) that can be expected to be prone to measurement difficulties. This leads to a high standard deviation – a problem that can be compensated by a higher sample size. In fact, the descriptive findings especially on capital usage – connected firms are using substantially more appliances and machinery – suggest a positive effect of electricity usage.

Future research should follow up on this: first, in the case of the survey region by an ex-post survey after the implementation of the GIZ project. This will particularly improve the understanding of the joint influence of BDS and electricity. Since the GIZ project will intervene an incremental change of service provision can be expected in the meantime making evaluation of their impacts easier. Also, the effect of electrification on investments and capital usage can be studied more profoundly. Second, in general, further studies should be conducted in other countries and set-ups in order to shed light on the circumstance under which electricity provision has stronger effects on firm performance. Not least, the sample size of future studies might be augmented in order to reduce the consequences of potential inaccuracies in the data.

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