Residential Electricity in Uganda

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RESIDENTIAL ELECTRICITY IN UGANDA

Edited by Clarence Tsimpo and Quentin Wodon
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ABSTRACT

This study provides a basic diagnostic of residential electricity coverage and affordability in Uganda and its relationship with poverty using a series of nationally representative household surveys for the period 2002-2013. The study first analyzes trends in residential electricity coverage using both administrative and survey data. Demand-side and supply-side factors reducing the take-up of electricity service by households in areas where the service is available are estimated. The study also documents the extent to which electricity enables household to shift time use away from domestic tasks and towards market work, and the effect that this may have on poverty. The targeting performance to the poor of the subsidies that existed until 2012 is estimated and the results obtained for Uganda are compared with similar estimates for other countries. Finally the study analyzes issues related to affordability, including the impact of the subsidy removal in 2012 on household consumption, poverty, and affordability, as well as the broader economy.

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EXECUTIVE SUMMARY

This study provides a basic diagnostic of residential electricity coverage and affordability in Uganda and its relationship with poverty using nationally representative household surveys for the period 2002-2013. While the analysis is not meant to lead directly to policy recommendations, some of the findings are relevant for policy. The study first analyzes trends in electricity coverage using administrative and survey data (Chapter 2). Demand-side and supply-side factors reducing the take-up of electricity service by households in areas where the service is available are estimated (Chapter 3). The study also documents the extent to which electricity coverage shifts time use within the household away from domestic tasks and towards market work, and the effect that this may have on poverty (Chapter 4). The targeting performance to the poor of large subsidies that existed until 2012 is estimated (Chapter 5) and the results obtained for Uganda are compared with similar estimates for other sub-Saharan African countries (Chapter 6). Finally the study analyzes the impact of the subsidy removal in 2012 on household consumption, poverty, and affordability, as well as on the broader economy (Chapter 7).

The main findings are as follows:

1. Despite an increase in the number of residential connections in recent years, especially after 2009, grid residential coverage remains very low at 11.4 percent of the population in 2012/13. The low coverage despite an increase in connections relates to population growth and a reduction in household sizes. Coverage with all sources of electricity combined including solar panels is 13.9 percent. Coverage is concentrated in urban areas.
2. Lack of residential coverage including in areas with access may be due to either demand or supply-side factors. Some households may live in areas where access to electricity is feasible, but may not be able to afford to connect and pay for the service. Other households may be able to afford the service, but may live too far from the electric grid to connect. In Uganda, lack of supply accounts for a majority of the deficit in coverage.
3. Electricity coverage may help household shift time from domestic to market work. These shifts are indeed observed for women with a connection, but not men. In areas where electricity is available, a connection for households not yet connected would enable women to increase market work by two hours and thereby reduce poverty by one point.
4. The electricity subsidies that existed until 2012 were very badly targeted to the poor, essentially because so few households in poverty were connected to the grid. In 2009/10, less than half a percent of the electricity subsidies reached the poor. But simulations suggest that connection subsidies could potentially be better targeted.
5. In comparison to 17 other sub-Saharan countries, with the exception of Rwanda, Uganda had the lowest targeting performance to the poor of its electricity subsidies.
6. The impact on households of the removal of the subsidies in 2012 and the associated increase in tariffs has been small. The impact on poverty has been virtually inexistent, again because so few poor households are connected. There has been a small negative impact on consumption, but by and large electricity remains broadly affordable for households connected to the grid. The impact on the economy has also been very small.
7. These findings suggest that the removal of the subsidies was the right policy decision, but also that efforts should be undertaken to expand residential electricity coverage.

CHAPTER 1
INTRODUCTION

Clarence Tsimpo and Quentin Wodon

Many governments in developing countries provide subsidies for residential electricity. These subsidies are often poorly targeted to those in need. In 2012, the government of Uganda eliminated these subsidies, which generated a substantial increase in tariffs. The motivation for this study is to provide a basic diagnostic of electricity and its relationship to poverty in Uganda, including in terms of the targeting performance of past subsidies and the impact of their removal. Other topics such as the benefits arising from an electricity connection in terms of time use and potential related earnings for households are also discussed. The study is based on data from nationally representative household surveys. It consists of six chapters.

Chapter 2 documents the trend in connection rates to the electricity network. Administrative data suggest that UMEME's distribution network has grown over the last few years, especially after 2009. But household surveys indicate that residential coverage remains very low due to limited access rates at the neighborhood or village level and limited take-up by households of the service when access is (at least in principle) available in the area where they live. In 2012-13 only 11.4 percent of households were connected to the grid, with most connections being in urban areas. There has been a recent increase in alternative forms of electricity coverage, such as through solar generation, but overall coverage rates still remain low.

Lack of coverage may be due to demand or supply factors. On the demand side, some households may live in areas where access to electricity is feasible, but may not be able to afford to connect and pay for the service. On the supply side, households may be able to afford the service but may live too far from the grid to connect. Given that policy options for dealing with demand as opposed to supply-side constraints are fairly different, it is important to try to measure the contributions of both types of factors in preventing better coverage of electricity, especially in areas with access. Chapter 3 shows how this can be done empirically using household survey data and provides results on the magnitude of both types of factors in explaining the coverage deficit for electricity services. In Uganda, supply-side factors clearly dominate as constraints.

There are many potential benefits for households from a connection to the electricity grid. Chapter 4 discusses one of those benefits using the time use module of the last round of the Uganda National Household Survey for 2012/13 Electricity coverage may help household shift time from domestic to market work. These shifts are observed for women with a connection, but not men. In areas where electricity is available, a connection for households not yet connected would enable women to increase market work by about two hours and reduce the share of the population in poverty by one percentage point.

Until 2012 large subsidies were provided under the national budget to maintain low electricity tariffs for residential and other customers. These subsidies were eliminated in 2012. Who used to benefit from the subsidies? Chapter 5 uses a simple framework to analyze the targeting performance of the subsidies. While most indicators of targeting performance are silent as of why subsidies are targeted the way they are (they only give an idea of whether the subsidies reach the poor or not and to what extent), the framework allows for analyzing "access" and "subsidy design" factors that affect targeting performance. Access factors are related to the availability of electricity service in the area where a household lives and to the household's choice to connect to the network when service is available. Subsidy factors relate to the tariff structure and the rate of subsidization of various types of customers. In Uganda, because of access factors, less than one half of a percent of the subsidies benefited the poor in 2009/10. Connection subsidies by contrast have the potential to be better targeted to the poor.

Electricity subsidies in Uganda used to be very poorly targeted. But how did Uganda compare to other sub-Saharan countries? Using the same framework as in chapter 5, chapter 6 compares the targeting performance of the electricity subsidies embedded in tariff structures in 18 countries, including Uganda. The influence of access factors on targeting performance is again such that the subsidies tend to be poorly targeted in general. However, except for the case of Rwanda, Uganda had the lowest targeting performance to the poor of its subsidies among all the countries in the sample, simply again because so few households in poverty are connected to the water network in the country. The chapter then considers the potential performance of connection subsidies under various scenarios – these subsidies would in all likelihood be better targeted to the poor than the consumption subsidies, as already observed in the case of Uganda.

In 2012, electricity subsidies were abolished by the government. This resulted in a substantial increase in tariffs for all classes of customers. Chapter 7 assesses the impact of this increase in tariffs on households and the broader economy using micro- and macroeconomic analysis techniques. The macro simulations also consider the potential impact of efficiency gains in the sector. The results suggest that that the removal of the subsidies did not affect poverty in any substantial way. There has been a small negative impact on consumption, but by and large electricity remains broadly affordable for households connected to the grid. The impact on the economy has also been very small. While some sectors like manufacturing may have been affected negatively, this should have been compensated by gains in other sectors. If efficiency gains were achieved in the sector, this would generate clear gains for all.

These findings suggest that the removal of the subsidies was the right policy decision, but also that additional efforts should be undertaken to expand the residential coverage of electricity.

PART I
RESIDENTIAL ELECTRICITY COVERAGE

CHAPTER 2
TREND IN RESIDENTIAL ELECTRICITY COVERAGE

Clarence Tsimpo and Quentin Wodon

This chapter provides an analysis of trends in residential coverage rates to electricity in Uganda using both administrative and household survey data. The analysis suggests that while UMEME's distribution network has grown over the last few years, residential coverage rates remain very low due to limited access rates at the neighborhood or village level, and limited take-up by households of the service when access is (at least in principle) available in the area where they live. In 2012-13 only 11.4 percent of households were connected to the grid, with most connected households living in urban areas. There has been a recent increase in alternative forms of electricity coverage, especially through solar generation, but overall coverage rates still remain very low.

1. Introduction

Uganda is a country where thanks to substantial hydro potential, electricity could in principle be generated and distributed at relatively low cost to a large share of the population. Unfortunately, connection rates in the country remain low and power shortages have been commonplace. These shortages have been exacerbated in the last decade not only by a severe drought in 2006 but also by rapid economic growth. As shown in Figures 2.1 and 2.2, until recently and for about two decades, the country experienced rapid growth thanks in part to sound macroeconomic policy and good governance. Over the last few years concerns have been raised about the management of public resources, inflation has picked up, donors have reduced aid, and growth has slowed substantially. Still, real GDP per capita in 2013 was at twice its level of 1990 and according to official poverty measures shown in table 2.1, the share of the population in poverty has been reduced from 56.4 percent in 1992 to 19.5 percent in 2012/13 (on the broader economic context, see the latest Uganda Economic Update of the World Bank, 2014).

Figure 2.1: Real GDP Growth (%)

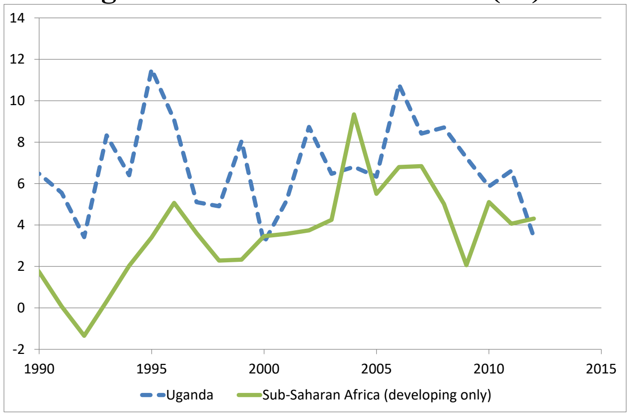
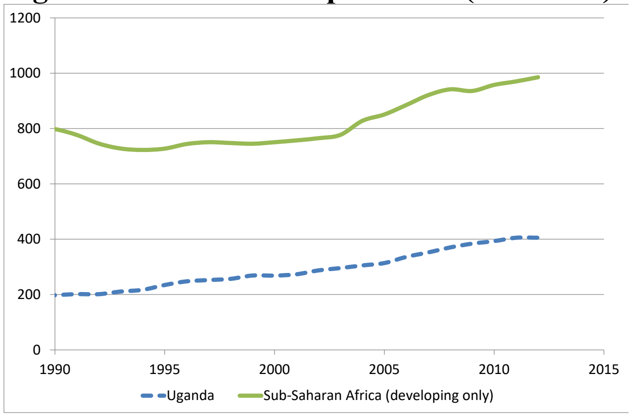


Figure 2.2: Real Per Capita GDP (US$ 2005)



Source: World Bank Development Indicators.

Table 2.1: Trend in Poverty Measures (National Poverty Line)

	1992	1996	2002/03	2005/06	2009/10	2012/13
Poverty Incidence (%)	56.4	44.4	38.8	31.1	24.5	19.5
Depth of Poverty (%)	20.9	13.7	11.9	8.8	6.8	5.2

Source: WDI data (1992-2002) and UNHS (2005/06-2012/13).

The last two decades of growth have fueled a higher demand for electricity from all types of customers, whether residential, commercial, or industrial. The country is responding to this high demand through large generation projects, but these will take some time to materialize. The question for this chapter is whether in the last decade, the provision of electricity to the population (that is, domestic or residential customers) has kept pace with the improvements in the economy and living standards. In other words, has access to electricity improved for the population in the same way that poverty has been reduced and other services have improved?

Unfortunately, as in many other sub-Saharan African countries (see for example Banerjee et al., 2009, 2010; Foster and Briceno-Garmendia, 2010; and Estache and Wodon, 2014), household survey data suggest that only very limited progress has been achieved in the last decade towards higher residential electricity coverage. The objective of this chapter is to document the trend in coverage over the period 2002-2013. The chapter is structured as follows. Section 2 first provides administrative data on the trend in the number of customers and the sales of UMEME, the national distribution company which enjoys a near monopoly on the distribution of electricity. Section 3 then relies on four successive and nationally representative household surveys to measure residential coverage rates to the national electricity grid, and decompose gains in coverage into gains in access rates at the neighborhood or village level, and gains in take-up rates of electricity among households with access (at least in principle) in the area where they live. While sections 2 and 3 are focused on the grid from which most households get their electricity, section 4 briefly discusses other forms of access to electricity. A conclusion follows.

2. Utility Data on Coverage

For many years, the performance of the national integrated utility–the Uganda Electricity Board or UEB, was poor and the utility became financially unsustainable. In 1999 the sector was fundamentally reformed. The UEB was dissolved and the Electricity Act was adopted to provide a more favorable regulatory environment for private sector participation in the power sector. The Electricity Regulatory Authority (ERA) was created as an independent regulatory agency in 2000. In 2001 the Uganda Electricity Board was unbundled into three separate entities for generation, transmission, and distribution[1]. The management of the assets of the generation company - the Uganda Electricity Generation Company or UEGCL – was granted in 2003 under a 20 year concession to Eskom Uganda, a subsidiary of Eskom of South Africa. Similarly, the management of the assets of the distribution company - the Uganda Electricity Generation Company or UEGCL – was granted to UMEME Ltd under a 20 concession in 2005, a first for a distribution network in Africa (for useful information on the operations of the utility, see UMEME, 2014). The transmission company - the Uganda Electricity Transmission Company or UETCL, has remained publicly operated. It provides bulk power to UMEME. Until recently, UETCL sold bulk electricity to UMEME at tariffs well below cost-recovery, thereby requiring large government subsidies, but (most) of these subsidies were removed in 2012, leading to a

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[1] On Uganda's power sector reforms and the current state of the sector, see Gore (2009), Mawejje et al. (2013), and Kapika and Eberhand (2013), and Whitley and Tumushabe (2014).

substantial tariff increase whose impact is analyzed later in this study. To promote rural electrification, a Rural Electrification Agency was established in 2003.

Have these reforms helped to expand access to electricity? To some extent, they have. Discussing the link between the reforms and coverage rates is beyond the scope of this study, but as shown in Figures 2.3 and 2.4, there has been an expansion of the number of clients and sales of UMEME especially in the last few years. Between the first quarter of 2009 and the third quarter of 2013, the number of domestic clients of UMEME increased by 65 percent (an annual growth rate of 14.2 percent). The growth in other types of clients – commercial, medium industrial, and large industrial, has been even faster. Sales in MWh have grown almost at the same pace, with for example an increase of 52 percent for domestic customers since 2009 (an annual growth rate of 11.8 percent). The amounts consumed per customer have remains somewhat stable over time, as expected (slight growth in some cases, slight decrease in others). At the same time, as shown in Figure 2.5, the UMEME network remains mostly urban, and a large share of the population lives to far away from the grid to be able to connect to it.

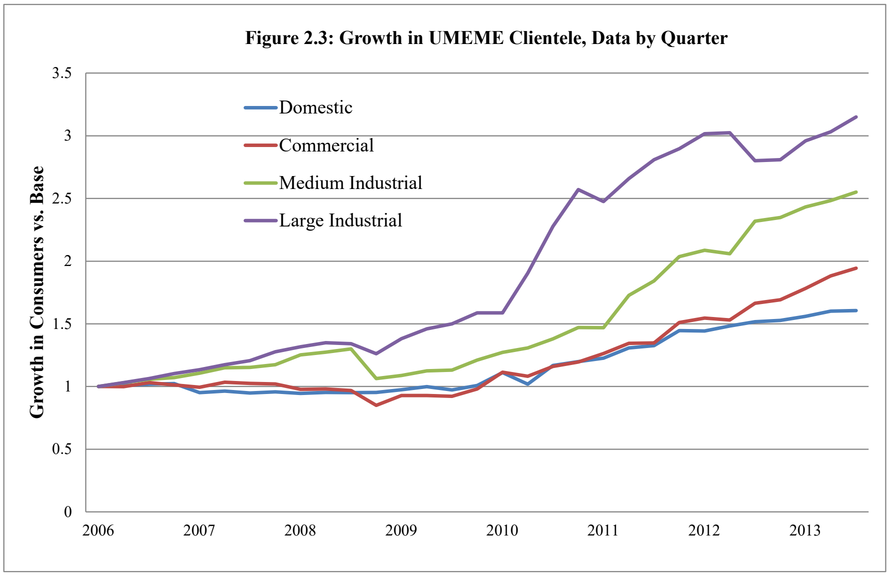
Figure 2.3: Growth in UMEME Clientele, Data by Quarter

Source: Authors, based on UMEME and Electricity Regulatory Authority data.

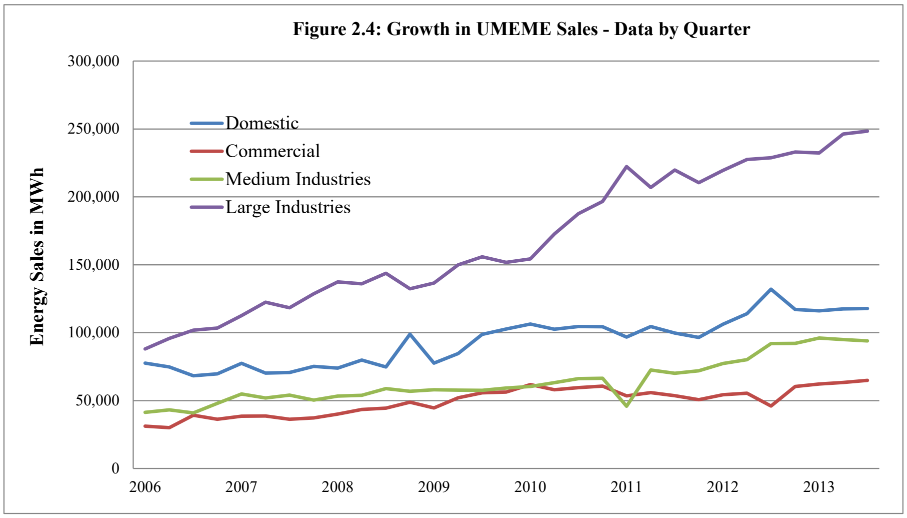
Figure 2.4: Growth in UMEME Sales - Data by Quarter

Source: Authors, based on UMEME and Electricity Regulatory Authority data.

Table 2.2: Trends in UMEME Clients, Sales (MWh), and Average Sales per Client

Year and Quarter	**Domestic**	**Commercial**	**Medium Industrial**	**Large Industrial**
	Number of clients			
2006-1	289,874	24,109	812	126
2007-1	275,947	23,980	899	143
2008-1	274,106	23,553	1,017	166
2009-1	282,520	22,382	884	174
2010-1	322,109	26,870	1,033	200
2011-1	355,568	30,469	1,193	312
2012-1	418,215	37,280	1,695	380
2013-1	452,276	42,991	1,975	373
2013-2	464,098	45,394	2,017	382
2013-3	465,463	46,866	2,071	397
Growth 2009-13	1.65	2.09	2.34	2.28
Annual growth rate 2009-13	14.2%	21.8%	25.5%	24.6%
	Sales (MWh)			
2006-1	77,525	31,131	41,356	88,077
2007-1	77,421	38,552	54,860	112,594
2008-1	73,915	40,055	53,314	137,415
2009-1	77,524	44,522	57,918	136,574
2010-1	106,300	61,808	60,354	154,379
2011-1	96,784	53,483	45,813	222,230
2012-1	106,217	54,306	77,357	219,420
2013-1	116,123	62,141	96,023	232,288
2013-2	117,498	63,342	94,920	246,272
2013-3	117,719	64,898	93,972	248,337
Growth 2009-13	1.52	1.46	1.62	1.82
Annual growth rate 2009-13	11.8%	10.6%	13.8%	17.3%
	Average sales per client (MWh)			
2006-1	0.27	1.29	50.93	699.02
2007-1	0.28	1.61	61.02	787.37
2008-1	0.27	1.70	52.42	827.80
2009-1	0.27	1.99	65.52	784.91
2010-1	0.33	2.30	58.43	771.90
2011-1	0.27	1.76	38.40	712.28
2012-1	0.25	1.46	45.64	577.42
2013-1	0.26	1.45	48.62	622.76
2013-2	0.25	1.40	47.06	644.69
2013-3	0.25	1.38	45.38	625.53
Growth 2009-13	0.95	1.07	0.89	0.89
Annual growth rate 2009-13	-1.5%	1.9%	-3.0%	-2.9%

Source: Authors, based on UMEME and Electricity Regulatory Authority data.

Note: the growth rate for the period 2009-13 is computed on 3.75 years.

Figure 2.5: UMEME Network, 2013

Source: UMEME web site.

3. Household Survey Data on Coverage

This study relies on four rounds of the Uganda National Household Surveys (UNHS) for the periods 2002/03, 2005/06, 2009/10, and 2012/13. The surveys are nationally representative, and should provide valid estimates of trends in residential electricity coverage for the population as a whole as well as for various sub-groups as long as those are not too narrowly defined. It is however important to check whether the data from the household surveys match the administrative data available from UMEME and presented in the previous section. Since surveys are based on random samples, one should not expect a perfect match, but a reasonably good one.

Table 2.3 provides the comparison. The UMEME number of residential clients increased from 290,799 in 2005-06 to 451,852 in 2012-13, yielding an annual rate of growth of 2.4 percent over the period. In the surveys, the number of households with coverage of electricity is substantially higher, at 809,257 in 2013, but this is due in part to the fact that several households may share a connection. The annual growth rate in the number of households with access is at 3.2 percent, which is higher than the rate observed with the administrative data, but of a similar order of magnitude. The same is observed with the number of households in the survey actually paying for electricity (again, that number is higher than the number of connections recorded by UMEME, but this may be due to households sharing connections and thereby the electricity bill). In terms of the comparison of the sales data from UMEME and the consumption by households as it can be computed from expenditures on electricity and the tariff structure at the time of each survey, on average there is very good correspondence between the survey and the UMEME data, although the UMEME data suggest a higher rate of growth in sales than the survey data. Overall, there is a reasonably good correspondence between the administrative and survey data.

Table 2.3: Comparison of Administrative and Household Survey Data, 2005-13

Year/Survey	Clients			Sales (MWh)	
	UMEME	**Survey Access**	**Survey Paying**	**UMEME**	**Survey**
2005-06	290,799	549,057	413,100	304,514	343,050
2009-10	288,872	691,156	504,357	410,524	456,146
2012-13	451,852	809,257	645,986	482,828	437,135
Average	343,841	683,157	529,543	390,092	393,671
Ratio 2012-13 to 2005-06	1.18	1.24	1.28	1.28	1.15
Annual growth rate	2.4%	3.2%	3.6%	3.6%	2.0%

Source: Authors, based on UMEME and UNHS data.

Note: For 2005-06, the number of clients of UMEME is the average for the first two quarters of 2006. For 2013-14, only three quarters of data are available, so that the growth rate is not computed for a full year.

Having established the validity of the household surveys, Figure 2.6 provides data on the trend in household coverage rates from 2002/03 to 2012/13 to the electricity grid (other forms of coverage will be discussed later). Over the last decade coverage rates have increased only slightly, from 9.6 percent in 2002/03 to 11.4 percent in 2012/13. As expected, and as shown in Figure 2.7, coverage rates are much higher among households in the top deciles of the distribution of consumption per capita than among poorer households. In fact, connection rates are virtually inexistent in the bottom half of the population in terms of welfare levels[2]. Figure 2.8 provides a visualization of access, take-up, and coverage or connection rates by geographic area.

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[2] Each decile accounts for ten percent of all households in the country taking household weights in the survey into account, from the poorest (decile 1) to the richest (decile 10). Deciles are based on the consumption aggregates used to construct official poverty measures.

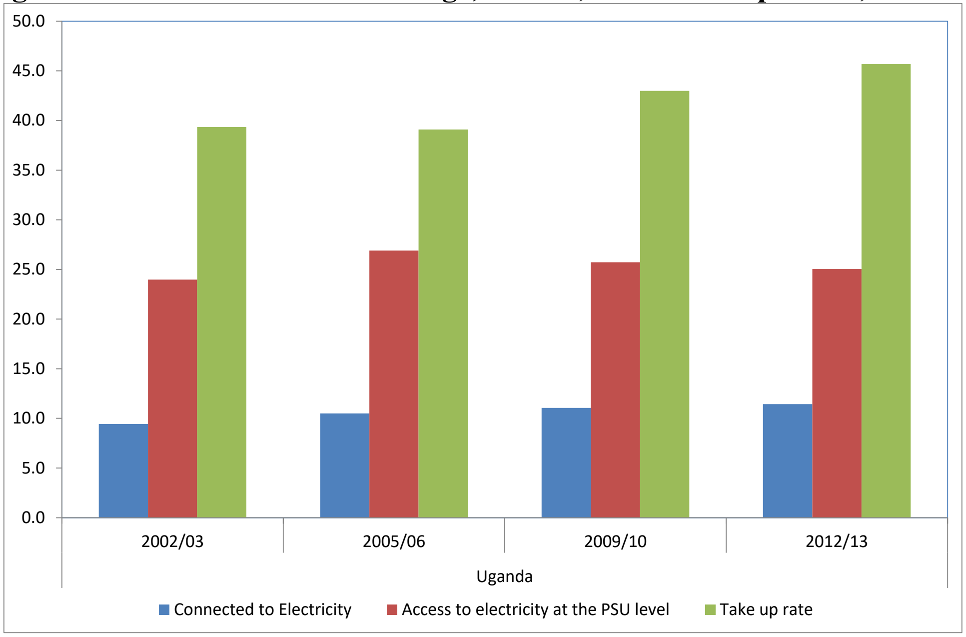
More detailed data are available in tables 2.4 through 2.7. In those tables, as well as in Figure 2.6, coverage or connection rates, denoted as *C*, are decomposed as the product of access rates at the neighborhood level, denoted by *A*, and take-up rates among households who have access, denoted by *U*, so that $C = A \times U$. In the survey, we consider that a household has access to electricity in its neighborhood or village if at least one households living in the same primary sampling unit (PSU) of the survey has access to the grid. In other words, neighborhoods are identified in the household surveys through the PSU to which households belong. These PSUs a are typically based on an administrative units according to census data, from which households are randomly selected to be included in the survey (when designing a sampling frame for a survey, it is customary to first select randomly some PSUs among all PSUs in the country, or by strata within the country, and then to select households randomly within the selected PSUs).

In urban areas, access rates are much higher than in rural areas, but coverage or connection rates are still relatively low with slightly less than half of the urban population being connected (37.7 percent in 2012/13). In rural areas, the situation is much less favorable, with only 1.9 percent connected to the electricity grid in 2012/13. Neither in urban areas, nor in rural areas were substantial gains achieved over time in connection rates, but the migration of households from rural to urban areas where connection rates are higher helped increase coverage.

The data show that in both urban and rural areas connection rates increase with the decile to which a household belong. But the gradient or steepness of this effect is much larger in urban than in rural areas, simply because in rural areas many better off households still live in areas where access is not available. Tables 2.4 through 2.7 suggest that take-up rates in urban areas are at about half among households with access (54.6 percent in 2012/13), while they are much lower in rural areas at about a fifth (20.9 percent in 2012/13). This may reflect an affordability issue, but it may also reflect a geographic access issue, in that PSUs are typically larger in rural areas, so the fact that one households has access in the PSU does not necessarily imply that all other households truly also have access. In the surveys, especially in rural areas, what is captured as lack of take-up may in some cases reflect a lack of access, even if the survey does not provide a way to identify this well given that access for all households in the PSU is defined as available if at least one household in the PSU has access, however far the other households may be located from that particular household or group of households. A more detailed analysis of supply constraints (lack of access) and demand constraints (lack of take up when households in principle have access) in coverage rates is provided in chapter 3.

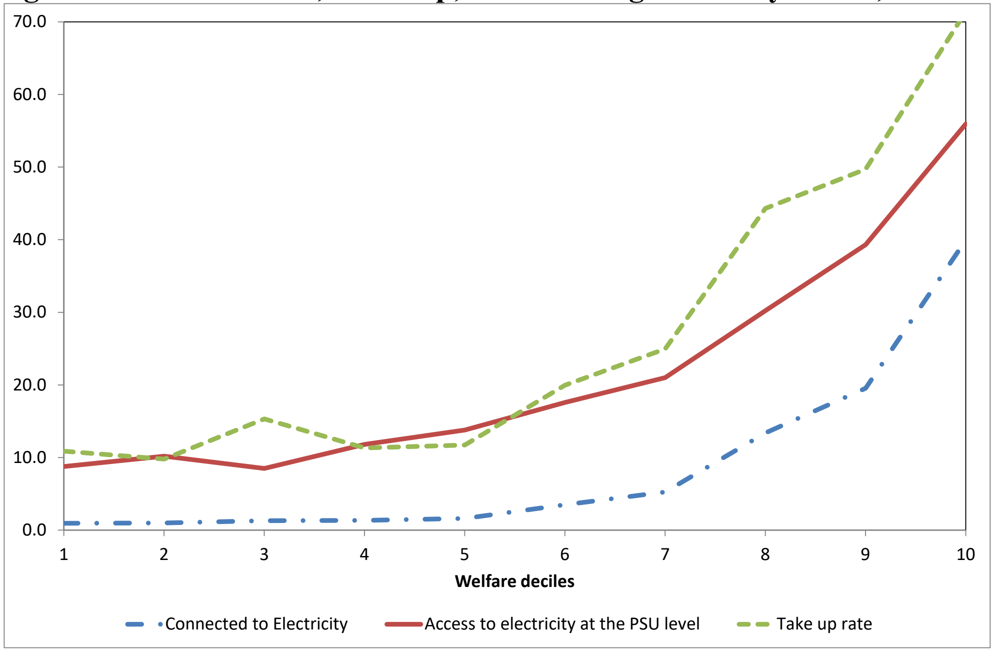
Why are coverage rates progressing so slowly in the household surveys despite substantial growth in the residential customer base of UMEME? A large part of the answer comes from population growth. In 2002/03, the population size in the country as measured through the weights available in the household survey was at about 25.2 million people. In 2012/13, that population size had increased to 35.3 million people, a gain of more than a third in just one decade. But in addition, as noted by Diallo and Wodon (2007), the decrease in the average household size is also at play. In 2002/03, the average household size was 5.1, versus 4.8 in 2012/13. As a result, the number of households in the country increased more rapidly than the population, from 4.9 million households in 2002/03 to 7.1 million in 2012/13, an increase of 44 percent. Said differently, the average reduction in household size in the country over the decade was responsible for about a fifth of the overall growth in the number of households, with the rest of that growth coming from population growth. Under such conditions, even rapid growth in connections from the utility company may translate in only slow growth in coverage rates.

Figure 2.6: Trend in Grid Coverage, Access, and Take-Up Rates, 2002-13



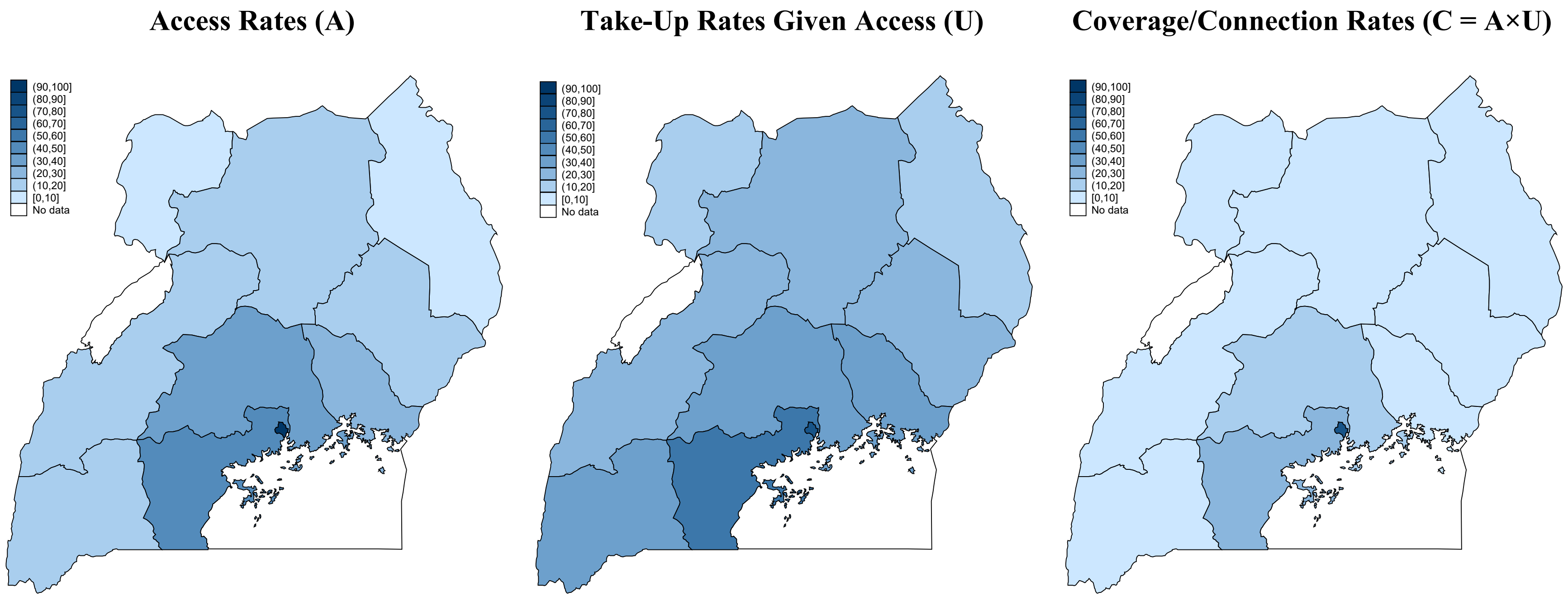
Source: Authors using Uganda 2002/03, 2005/06, 2009/10 and 2012/13 UNHS surveys.

Figure 2.7: Grid Access, Take-Up, and Coverage Rates by Decile, 2012-13



Source: Authors using Uganda 2012/13 UNHS survey.

Figure 2.8: Grid Access, Take-Up, and Coverage Rates by Geographic Area, 2013



Access Rates (A)

Take-Up Rates Given Access (U)

Coverage/Connection Rates (C = A×U)

Source: Authors using 2012/13 UNHS survey.

Table 2.4: Grid Residential Electricity Coverage and Consumption, 2002/03

Deciles	Number of households	Average Kwh consumed per month per household (Qn>0)	Total Kwh (Qn>0)	Electricity coverage	Share paying for electricity	Access to electricity at the PSU level	Take up rate
			National				
1	494129.4	6.0	6197.6	0.2	0.2	35.0	0.7
2	493430.9	29.8	2168.2	0.1	0.0	27.2	0.4
3	494488.3	35.0	70338.7	0.8	0.4	29.9	2.6
4	493225.3	43.6	148349.0	1.2	0.7	32.7	3.7
5	493914.6	32.3	226591.7	2.1	1.4	38.2	5.6
6	494652.6	49.3	650039.1	3.5	2.7	42.4	8.3
7	492760.5	38.4	650535.9	5.6	3.4	45.1	12.3
8	494118.9	46.0	1941675.6	10.2	8.6	49.3	20.6
9	495390.8	68.5	6432698.4	24.3	19.0	62.4	39.0
10	491685.2	102.7	19465523.9	47.8	38.6	78.7	60.7
Uganda	4937796.0	80.1	29594118.0	9.6	7.5	44.1	21.7
			Urban				
1	84481.5	45.6	92494.5	5.1	2.4	95.4	5.3
2	84886.5	38.5	339875.6	12.6	10.4	96.2	13.1
3	85142.4	39.1	499761.2	18.9	15.0	99.0	19.1
4	83204.3	42.0	640622.2	23.8	18.3	97.0	24.5
5	84111.6	56.5	1453000.4	38.0	30.6	98.5	38.6
6	84608.7	77.6	2630037.3	51.0	40.1	99.2	51.4
7	84146.5	60.6	2114687.0	50.7	41.5	98.6	51.4
8	84962.5	70.3	3322604.7	66.4	55.7	99.8	66.6
9	84339.6	92.8	4525862.1	67.0	57.9	98.5	68.0
10	83684.3	134.9	7562749.8	79.8	67.0	99.3	80.3
Total Urban	843567.9	81.2	23181694.6	41.3	33.9	98.1	42.1
			Rural				
1	410037.8	6.0	6197.6	0.3	0.3	13.5	1.9
2	408872.3	-	-	0.0	0.0	12.8	0.0
3	410765.9	-	-	0.3	0.0	12.4	2.4
4	408047.5	43.8	119758.2	0.7	0.7	14.1	4.7
5	410212.3	21.4	62409.9	1.4	0.7	19.4	7.4
6	408625.8	126.7	129198.9	0.8	0.3	20.9	3.7
7	410341.6	42.5	221064.6	2.1	1.3	22.5	9.1
8	408948.2	29.4	167988.8	2.7	1.4	23.9	11.2
9	409720.3	55.0	1239655.2	6.0	5.5	26.7	22.4
10	408656.8	104.8	4466150.1	16.2	10.4	37.2	43.6
Total Rural	4094229.0	76.5	6412423.4	3.0	2.1	20.3	14.9

Source: Authors using Uganda 2002/03 UNHS survey.

Table 2.5: Grid Residential Electricity Coverage and Consumption, 2005/06

Deciles	Number of households	Average Kwh consumed per month per household (Qn>0)	Total Kwh (Qn>0)	Electricity coverage	Share paying for electricity	Access to electricity at the PSU level	Take up rate
				National			
1	523,240	-	-	0.0	0.0	5.8	0.7
2	522,963	72.9	76,911.4	0.7	0.2	9.0	8.1
3	522,600	113.1	23,175.2	0.7	0.0	12.0	5.7
4	522,942	36.6	143,717.9	2.3	0.8	14.5	15.6
5	523,482	43.9	280,418.5	2.9	1.2	19.8	14.9
6	522,748	39.2	723,721.1	5.4	3.5	22.0	24.6
7	522,628	37.0	672,696.0	5.4	3.5	24.2	22.4
8	523,042	49.3	3,149,536.3	13.8	12.2	38.7	35.7
9	522,943	58.3	5,249,933.4	20.8	17.2	50.9	40.9
10	522,529	86.6	18,267,383.3	53.2	40.4	72.4	73.5
Uganda	5,229,119	69.2	28,587,493.1	10.5	7.9	26.9	39.1
				Urban			
1	91,704	79.2	27,243.0	0.6	0.4	46.2	1.3
2	90,867	35.3	243,437.5	12.6	7.6	61.5	20.4
3	91,387	38.2	456,162.0	23.5	13.1	73.0	32.2
4	90,983	39.8	756,013.0	28.1	20.9	77.7	36.1
5	91,517	52.8	1,498,495.8	33.0	31.0	85.0	38.9
6	90,987	51.2	1,922,789.2	44.9	41.3	90.1	49.9
7	91,543	67.0	2,018,794.2	41.0	32.9	92.3	44.4
8	90,818	71.2	2,833,253.6	63.4	43.9	96.0	66.1
9	91,086	70.8	3,955,794.1	75.9	61.3	95.5	79.5
10	90,865	114.2	6,901,738.8	89.8	66.5	97.6	92.1
Total Urban	911,757	71.0	20,613,721.0	41.2	31.9	81.5	50.6
				Rural			
1	432,441	-	-	0.0	0.0	4.7	0.0
2	431,841	-	-	0.6	0.0	5.8	11.2
3	431,586	79.6	72,843.6	0.7	0.2	7.9	8.9
4	431,314	96.3	51,352.7	1.5	0.1	10.4	14.2
5	431,888	35.7	60,659.1	1.3	0.4	11.3	11.4
6	431,611	43.5	119,230.3	1.6	0.6	15.7	9.9
7	431,489	39.1	287,887.1	2.0	1.7	13.9	14.6
8	431,997	35.4	381,558.5	3.3	2.5	16.8	19.7
9	431,737	49.9	1,052,602.8	7.3	4.9	26.3	27.7
10	431,458	76.6	5,947,638.0	22.2	18.0	41.2	53.7
Total Rural	4,317,361	64.9	7,973,772.1	4.0	2.8	15.4	26.3

Source: Authors using Uganda 2005/06 UNHS survey.

Table 2.6: Grid Residential Electricity Coverage and Consumption, 2009/10

Deciles	Number of households	Average Kwh consumed per month per household (Qn>0)	Total Kwh (Qn>0)	Electricity coverage	Share paying for electricity	Access to electricity at the PSU level	Take up rate
			National				
1	622,965	-	-	0.0	0.0	3.9	0.0
2	623,007	5.0	4,810.4	2.3	0.2	7.2	31.6
3	622,654	22.0	70,105.0	1.5	0.5	13.6	11.3
4	622,814	41.2	263,532.5	1.5	1.0	11.5	12.6
5	622,537	31.0	114,944.9	1.2	0.6	11.6	9.9
6	623,600	35.6	609,596.8	3.4	2.7	20.4	16.7
7	621,783	39.6	1,135,742.7	6.2	4.6	28.6	21.9
8	621,996	42.5	2,211,107.1	12.4	8.4	36.0	34.6
9	623,071	58.7	7,259,715.1	26.8	20.2	48.7	55.1
10	622,204	99.7	26,342,610.9	55.3	43.0	76.0	72.7
Uganda	6,226,630	76.0	38,012,165.4	11.1	8.1	25.7	43.0
			Urban				
1	120,004	20.5	81,052.3	12.8	3.3	65.6	19.6
2	114,979	46.3	450,243.9	11.4	8.5	71.9	15.9
3	117,296	30.0	594,910.4	20.6	16.9	85.7	24.0
4	117,664	63.8	1,119,795.8	25.5	14.9	91.2	28.0
5	118,258	34.5	1,131,511.2	36.8	27.7	89.3	41.2
6	115,802	54.4	2,890,386.7	57.5	45.9	92.8	61.9
7	117,838	57.1	2,681,500.6	62.3	41.0	97.4	64.0
8	117,925	72.2	4,419,420.3	68.3	51.9	97.0	70.4
9	116,400	95.5	6,558,147.2	84.0	60.3	97.5	86.2
10	117,168	113.9	9,301,633.7	86.8	69.7	99.7	87.0
Total Urban	1,173,334	73.9	29,228,602.1	46.5	34.0	88.8	52.4
			Rural				
1	505,660	-	-	0.0	0.0	3.1	0.0
2	505,236	5.0	4,810.4	0.4	0.2	3.1	13.4
3	505,551	24.6	32,066.8	1.1	0.3	6.0	18.6
4	505,085	-	-	0.9	0.0	8.4	10.6
5	505,909	31.1	60,392.5	0.4	0.4	5.2	7.4
6	504,772	57.1	54,886.5	0.5	0.2	7.5	6.9
7	505,771	24.8	137,012.3	1.3	1.1	10.0	12.5
8	505,280	24.6	146,255.2	1.5	1.2	14.2	10.8
9	505,453	49.5	856,797.4	4.8	3.4	14.7	32.7
10	504,579	106.1	7,491,342.2	17.3	14.5	38.6	44.8
Total Rural	5,053,297	84.0	8,783,563.4	2.8	2.1	11.1	25.5

Source: Authors using Uganda 2009/10 UNHS survey.

Table 2.7: Grid Residential Electricity Coverage and Consumption, 2012/13

Deciles	Number of households	Average Kwh consumed per month per household (Qn>0)	Total Kwh (Qn>0)	Electricity coverage	Share paying for electricity	Access to electricity at the PSU level	Take up rate
			National				
1	710,398	-	-	1.4	0.0	9.8	14.3
2	709,685	15.7	11,562.1	0.6	0.1	6.5	8.8
3	710,172	29.6	68,576.0	1.5	0.3	11.1	13.6
4	710,157	29.5	108,593.7	1.0	0.5	11.5	8.2
5	708,994	30.9	309,902.4	2.0	1.4	14.4	14.1
6	710,060	25.1	610,689.7	4.5	3.5	22.6	20.1
7	710,052	31.9	1,881,372.1	10.0	8.6	26.2	38.0
8	709,876	36.2	3,461,114.9	17.6	13.9	37.1	47.4
9	709,802	50.3	7,455,770.8	26.3	21.8	46.0	57.1
10	709,549	77.6	22,520,299.9	49.6	40.9	65.3	76.0
Uganda	7,098,744	57.5	36,427,881.5	11.4	9.1	25.1	45.7
			Urban				
1	190,117	15.7	25,336.5	4.5	0.9	32.5	13.7
2	189,529	32.0	204,942.3	5.8	3.4	45.8	12.6
3	189,842	27.8	465,335.4	11.1	8.8	57.3	19.4
4	189,233	27.3	953,722.0	23.1	19.6	61.2	37.7
5	189,543	37.2	2,327,255.0	37.0	33.3	75.7	48.9
6	188,978	40.2	2,381,186.5	45.5	33.0	74.7	60.9
7	189,356	53.8	3,923,918.9	47.6	40.2	80.7	59.0
8	189,612	56.6	4,987,657.4	60.7	47.4	86.6	70.1
9	189,118	71.0	6,785,027.2	64.2	50.6	87.8	73.1
10	189,402	91.2	11,518,690.4	78.0	66.7	89.1	87.5
Total Urban	1,894,728	59.5	33,573,071.6	37.7	30.4	69.1	54.6
			Rural				
1	521,039	-	-	0.4	0.0	4.5	8.3
2	521,098	-	-	1.0	0.0	8.2	12.6
3	519,230	-	-	0.4	0.0	4.1	9.4
4	520,695	44.5	42,410.4	1.2	0.2	6.8	17.0
5	520,995	-	-	0.0	0.0	6.4	0.0
6	519,863	21.2	52,252.8	1.0	0.5	6.1	16.2
7	523,687	29.7	123,496.9	1.0	0.8	10.8	9.6
8	517,770	24.2	214,137.1	2.3	1.7	11.3	20.0
9	519,417	26.1	279,083.8	2.3	2.1	13.0	17.5
10	520,222	50.7	2,143,429.1	9.3	8.4	18.9	49.2
Total Rural	5,204,015	41.2	2,854,810.0	1.9	1.4	9.0	20.9

Source: Authors using Uganda 2012/13 UNHS survey.

Another interesting statistics in tables 2.4 to 2.7 is the share of households paying for their electricity. That share is systematically lower than the share of household who declare using electricity. This may be an indication of illicit connections, but it may also reflect late payment or other issues. The differences between those using electricity and those paying for it are not minor. Nationally, in 2012/13, 11.4 percent of households are connected to the grid, but only 9.1 percent are paying for electricity, generating a 2.3 percentage point gap between coverage and payment. In 2009/10 the gap was at 3.0 percentage points; in 2005/06 it was at 2.6 percentage points and in 2002/03 it was at 2.1 percentage points. Thus, as a share of the coverage rate, the gap has decreased slightly, especially in recent years, from about 27 percent in 2009/10 to 20 percent in 2012/13. This may suggest an improvement in the ability of UMEME to collect payments from residential customers in recent years, although more detailed analysis would be needed to establish this trend, and the differences in payment rates are not very large over time.

4. Quality of the Grid and Other Sources of Electricity

Finally, while the national electricity grid is the main source of electricity for households, other sources of electricity are also used – mainly generators and small (often individual) solar stations. The data are provided in table 2.8 in terms of the sources of lighting used by households (there is a very slight difference in the grid coverage rate for 2012/13 versus the estimate in table 2.6 due to the fact that this relies on a different part of the survey). What is interesting is the fact that there has been a substantial uptake in small solar station in the last few years, including by households in lower quintiles. Overall, electricity coverage in the country in 2012/13 is estimated at 13.9 percent when all sources of electricity are combined. This is slightly below the estimate in the 2011 Demographic and Health Survey, where coverage was estimated at 14.6 percent.

As shown in Figures 2.9 and 2.10 which provides concentration curves for various sources of lighting, while the use of private generators is really concentrated in the top quintile, the use of solar panels is more progressive than access to the grid, especially in the last year of data where substantial growth in access through solar electricity is observed. In other words solar stations are a useful alternative to connect households living far from the grid.

The attraction of alternative sources of electricity to households may relate in large part to the fact that the grid is simply not available where they live. But part of the attraction may also relate to the fact that households connected to the grid are subject to power cut. Data from a separate survey, the 2010/11 round of the Uganda panel survey, are provided in table 2.9 on electricity coverage, the number of hours of service per day, and the payment mechanism used by households. The coverage rate is very similar to that observed in the 2012/13 survey. In terms of quality of service, electricity seems to be available only for 16 hours a day on average.

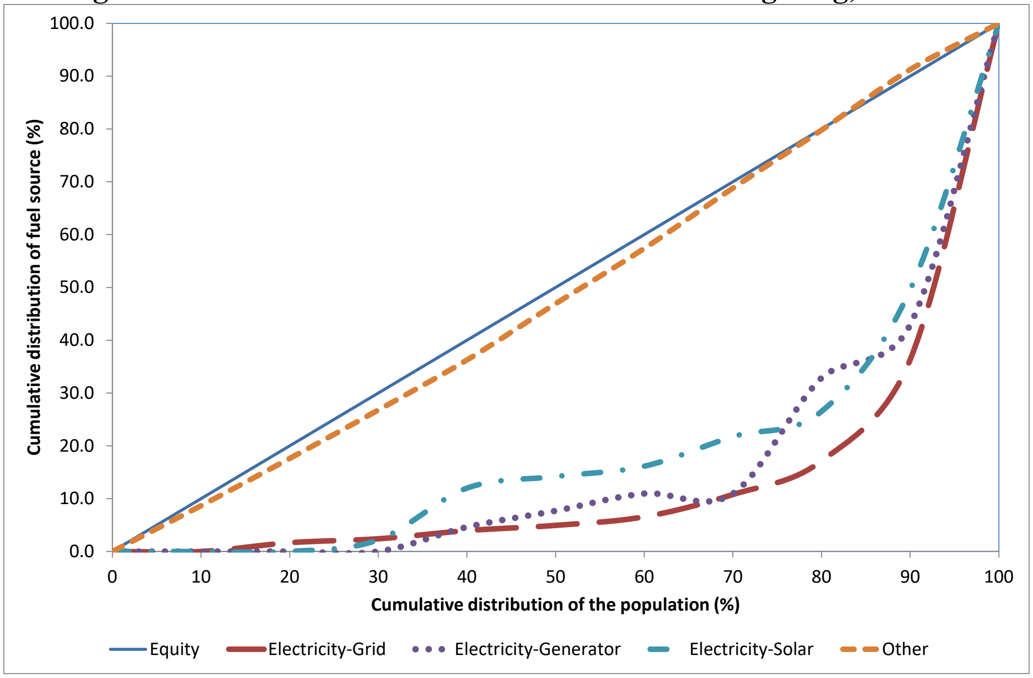
As to the payment mechanisms used by households, while most households pay their bill to the utility, whether directly or through their rent when they are renting their dwelling, a non negligible share of households connects through a neighbor to whom they pay a fee, or do not pay at all when their connection is free or illegal (this is the case for 3.1 percent of households).

Table 2.8: Modes of Lighting, 2009/10 and 2012/13

	Residence		Welfare Quintile					Total
	Urban	Rural	Q1	Q2	Q3	Q4	Q5	
				2009/10				
Grid	46.8	2.7	1.2	1.5	1.5	5.5	32.9	11.0
Generator	1.0	0.3	0.0	0.1	0.2	0.5	1.1	0.5
Solar	0.2	0.7	0.0	0.5	0.1	0.3	1.7	0.6
Others	52.0	96.2	98.8	97.9	98.2	93.7	64.2	87.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				2012/13				
Grid	37.8	1.9	0.9	1.2	2.0	7.9	32.6	11.5
Generator	0.3	0.1	0.0	0.0	0.0	0.0	0.4	0.1
Solar	2.0	2.2	0.3	0.6	1.8	2.4	4.1	2.1
Community/Thermal plant	0.4	0.1	0.2	0.1	0.1	0.1	0.4	0.2
Others	59.6	95.8	98.6	98.2	96.1	89.5	62.5	86.1
Total	101.0	100.0	102.0	103.0	104.0	105.0	106.0	107.0

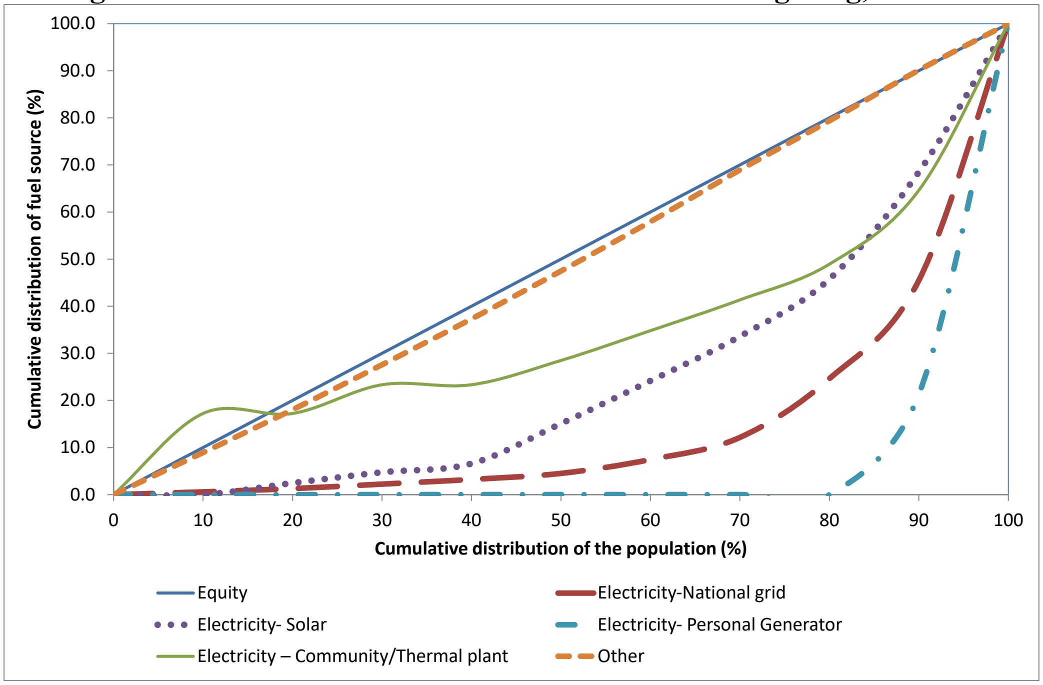
Source: Authors using Uganda 2009/10 and 2012/13 UNHS surveys.

Figure 2.9: Concentration Curves for Sources of Lighting, 2009/10



Source: Authors using Uganda 2009/10 UNHS surveys.

Figure 2.10: Concentration Curves for Sources of Lighting, 2012/13



Source: Authors using Uganda 2012/13 UNHS surveys.

Table 2.9: Quality of the Electricity Supply and Mode of Payment, 2010/11

	Location			Region				Welfare quintile					Total
	Kampala	Other town	Rural	Central	Eastern	Northern	Western	Q1	Q2	Q3	Q4	Q5	
	Does this house have electricity?												
Yes	64.8	38.7	4.6	33.1	5.5	2.2	3.4	0.1	0.9	3.5	11.0	42.8	11.6
No	35.2	61.3	95.4	66.9	94.5	97.9	96.6	99.9	99.1	96.5	89.0	57.2	88.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	How many hours per day do you usually have power, in a season like this?												
Mean	16.0	16.5	16.0	16.7	17.4	12.1	11.2	22.9	19.9	18.8	16.6	15.8	16.2
Median	20	18	19	20	20	12	10	24	20	24	20	18	20
Min	0	1	1	0	6	3	1	21	18	5	1	0	0
Max	24	24	24	24	24	24	24	24	24	24	24	24	24
	How does the household pay for the electricity it uses?												
Bill from power company	35.0	41.4	48.7	40.0	29.8	33.0	85.7	37.4	34.5	58.1	26.9	44.3	41.7
Provide in rent	45.0	36.4	24.7	38.0	34.7	32.8	8.0	0.0	65.5	22.8	31.2	36.8	35.3
Free use/illegal connections	2.4	4.4	2.3	2.3	10.6	1.9	0.0	0.0	0.0	0.0	4.4	3.1	3.1
Pay fee to neighbor	12.5	10.3	19.7	14.1	14.5	29.6	4.8	62.7	0.0	19.1	26.1	10.8	14.1
Operating cost of own generator	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	5.1	7.5	4.6	5.7	10.5	2.8	1.5	0.0	0.0	0.0	11.4	5.0	5.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Authors using Uganda 2010/11 Panel survey.

5. Conclusion

This chapter has provided a basic diagnostic of access, take-up, and coverage rates for residential electricity in Uganda using administrative data as well as nationally representative household surveys. The analysis suggests a fairly good correspondence between the administrative and household survey data. Despite an expansion of the distribution network in the last few years, connection rates remain very low due in large part to population growth, but also a reduction in household size, so that the number of households is growing faster than the population. In 2012/13, grid residential electricity coverage reached 11.4 percent, a small increase versus the rate of 9.6 percent observed a decade earlier in 2002/03.

Consumption of electricity in kWh was also estimated using the surveys, as was the share of household that declare being connected to the network but apparently not paying for the service. That share decreases slightly in 2012/13, but was still relatively high, at about 20 percent of the households connected.

In addition, some households do get electricity from other sources than the national grid, including generators, community/thermal plants, and especially solar panels. There has been an increase in the share of households with electricity from solar panels in recent years. Overall, electricity coverage in the country in 2012/13 Uganda National Household Survey is estimated at 13.9 percent when all sources of electricity are combined.

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CHAPTER 3
DEMAND AND SUPPLY CONSTRAINTS TO ELECTRICITY COVERAGE

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As shown in the previous chapter, a large majority of Uganda's population is not connected to the electricity grid. In rural areas coverage remains extremely low despite recent efforts at rural electrification, and in urban areas coverage is well below 50 percent. Lack of network coverage may be due to demand or supply-side factors. Some households may live in areas where access to electricity is feasible, but may not be able to afford to connect and pay for the service. Other households may be able to afford the service, but may live too far from the electric grid to connect. Given that policy options for dealing with demand as opposed to supply-side constraints are fairly different, it is important to try to measure the contributions of both types of factors in preventing better coverage of infrastructure services in the population. This chapter shows how this can be done empirically using household survey data and provides results on the magnitude of both types of factors in explaining the coverage deficit for electricity services in Uganda.

1. Introduction

Many households are not connected to network-based infrastructure services such as electricity in sub-Saharan Africa (Komives et al., 2005; Banerjee et al., 2008; Estache and Wodon, 2014). This is the case even in urban areas (Clarke and Wallsten, 2003; Wodon et al., 2009), and especially in Uganda where less than half of the urban population is connected to the grid. Yet it is not *à priori* clear whether this lack of coverage is due mainly to demand-side or supply-side factors. On the demand-side, because many in the population are poor or near-poor, some households may simply not be able to afford to pay for electricity even when connection to the network is feasible because the household lives close enough to the grid. The lack of affordability of the service, or more generally of demand for the service, may be due to different reasons. A key reason could be that tariffs are too high for many households, or that connection charges are too high for getting access to the network (Franceys, 2005; Kayaga and Franceys, 2007). Other demand-side issues may relate to lack of land titles or illegal tenure, which makes it difficult for the utility company to accept the household as a client. Still another demand-side issue (from the point of view of the household) could be related to poor quality of service, so that some households may prefer to use alternative ways of satisfying their lighting and other needs rather than by using a network connection, at least when such alternatives – using for example generators or renewable sources of electricity are available.

On the supply-side, many households simply live in rural areas or urban neighborhoods that do not have access to electricity. In addition, even when there is access somewhere in the neighborhood, many households may still live too far from the grid to have an opportunity to connect. Even if some households would like to connect, there may be a lack of capacity within the utility company to provide such connections, for example due to lack of manpower or other resources, or simply because generation capacity is too low. In some cases, a policy may be in place in the utility company not to extend the network, because the utility already faces capacity constraints to properly serve existing consumers. In many sub-Saharan countries, power cuts are frequent, as the generation, transmission, and distribution capacity of utilities is limited and insufficient to meet the existing demand. There may also be financial factors affecting the capacity or willingness of the utilities to expand their network, especially if tariffs and fees are too low to permit cost recovery.

As noted among by a number of authors (Estache et al. 2002; Komives et al., 2005; and Estache and Wodon, 2014), the policies that need to be implemented in order to promote higher coverage rates are very different depending on the nature of the obstacles to increase coverage. If the main obstacle is low demand due to a lack of affordability, utilities or governments may consider implementing special tariffs or subsidies for the poor, whether this is done for reducing the cost of the consumption of households once they are connected, or for reducing the cost of connecting itself. If the main problem is low supply, the first line of answer lies in finding the necessary resources in order to strengthen the network – whether in terms of generation, transmission, or distribution, in order to better reach those who do not have access. Given that the policy options for dealing with demand as opposed to supply-side constraints are fairly different, it is important to try to measure the contributions of both demand and supply-side factors to low coverage of infrastructure services. The aim of this chapter is to show how this can be done empirically in a simple way using household survey data for Uganda.

The importance of assessing the role of demand as opposed to supply-side factors in residential electricity coverage has been recognized among others by Foster and Araujo (2004, hereafter F&A) in their study of the impact of infrastructure reforms on the poor in Guatemala. These authors proposed a simple statistical method for assessing the contribution of pure demand-side problems, pure supply-side problems, and combined demand and supply-side problems to coverage deficits. If a household living in an area with access to electricity service was not connected, this was taken as a sign that the service was not affordable for the household (pure demand-side problem). In practice, the authors assessed whether households lived in an area with access simply by checking if any other household living in the same primary sampling unit of the survey had access. This can be done with household surveys since their samples rely on geographically defined primary sampling units which tend to be well delimited areas. To the extent that the primary sampling units are not too large, access by one household in the primary sampling unit could be considered as indicating potential access for all the households in that primary sampling unit.

F&A then defined the magnitude of supply-side problems as the part of the lack of coverage that was not due to the pure demand-side problem. In addition, they decomposed supply-side problems into two components. The authors noted that even if there were access to the service in neighborhoods currently without access, some households would still not connect to the network. They argued that in areas without access, there was for some households a combined of lack of demand and supply. For those households who would probably connect to the network if there were access in their neighborhood to the service, the authors argued that there was a genuine pure supply-side problem. Overall, the authors thus decomposed the lack of coverage of the network in the sum of a pure demand-side problem, a pure supply-side problem, and a combined demand and supply-side problem. Others, including Angel-Urdinola et al. (2006), Angel-Urdinola and Wodon (2007, 2012) and Komives et al. (2005, 2007) have expanded on the work of F&A in order to analyze factors determining not only who connects or not to the network, but also who benefits (or is likely to benefit) from various utility subsidies.

However, a weakness with the simple statistical approach used by F&A lies in the fact that there are limitations in the surveys used to assess empirically the magnitude of demand-side and supply-side problems, and that this may lead to biases in the estimates of demand as opposed to supply-side problems. Some households may live in an area where there is access to the service, but may still be located too far from the grid to be able to connect (or perhaps the capacity of the grid to support more households is limited). Under the simple empirical procedure for estimating demand-side and supply-side problems proposed by F&A, these households would be considered as suffering from a demand-side problem, while the true nature of the issue may be a supply-side constraint. To some extent, this type of biases can be dealt with by using regression techniques, as shown by Wodon et al. (2009). The objective of this chapter is to apply the Wodon et al. (2009) methodology to electricity coverage in Uganda, and compare the results obtained with those from the F&A approach.

The chapter is structured as follows. In section 2, we describe the approach used by F&A for assessing the relative role of demand and supply-side problems to account for the lack of coverage of modern infrastructure services. That section also presents the alternative econometric approach proposed by Wodon et al. (2009). The results obtained with both approaches for Uganda are then provided in section 3. A conclusion follows.

2. Methodology

In this chapter, we look at whether the main barrier to higher connection rates among households not connected to the network (this could be for piped water or electricity, for example) is likely to be due to demand or supply-side factors. We start by presenting in mathematical notation the approach proposed by F&A (2004) for assessing demand and supply-side problems limiting coverage of network services, and continue with the method proposed by Wodon et al. (2009) to improve on such assessments.

Coverage rate is defined as the product of the access rate in a neighborhood (*A*) and the take-up or uptake rate (*U*) rates where access is available ($C=AxU$). The share of the population not served by the network is $1\text{-}C$. The objective is to assess whether the unserved population is not served due to a demand-side problem (the service is available, but not taken up by the households, probably because it is not affordable, but perhaps also because it is of low quality) or a supply-side problem (the service is simply not available to households). F&A (2004) define the pure demand-side gap (PDSG) as:

$$PDSG = A - C = A \times (1 - U)$$

This definition implies that when there is access in the area where a household lives, if a household does not take-up the service, it is symptomatic of a demand issue. Thus, lack of demand is responsible for all of the difference between the neighborhood access rate *A* and the actual coverage rate *C*. Next, the authors define the supply-side gap as follows:

$$SSG = (1 - C) - PDSG = (1 - A \times U) - A \times (1 - U) = 1 - A$$

In other words, the supply gap is the difference between the neighborhood access rate and the coverage rate. Said differently, the sum of the pure demand-side gap, the supply-side gap, and the coverage rate is equal to one:

$$PDSG + SSG + C = 1$$

However, in areas that are not covered by the network, and are responsible for the supply gap above, it is likely that even if supply were available, some households would not take up the service due to affordability issues. If one assumes that the take-up rate in non-served areas would be similar to the take-up rate in areas where there is service now, the additional coverage that we would obtain by providing access to these areas would be equal to the supply-side gap times the take-up rate where there is access. This is defined as the pure supply-side gap:

$$PSSG = SSG \times U = (1 - A) \times U$$

The difference between the pure supply-side gap and the supply-side gap can then be deemed to represent a combined demand and supply-side gap, since first there is no access to the service, and second even if there were access, some households would not be connected. F&A defined this as the mixed demand and supply-side gap, defined as follows:

$$MDSSG = SSG \times (1 - U)$$

Given the above definitions, the proportion of the deficit in coverage that is attributed to demand-side factors is defined as the ratio of the pure demand-side gap to the unserved population. The proportion of deficit attributable to supply-side factors is the ratio of the pure supply-side gap divided by the unserved population. Finally, the proportion of deficit attributable to both demand and supply-side factors is the ratio of the mixed demand and supply-side gap divided by the unserved population. The sum of the three proportions is equal to one.

A weakness of this statistical approach is that all households not connecting to the network where there is access are assumed to suffer from a demand-side problem, which may lead to an overestimation of the proportion of deficit coverage that is attributed to demand-side factors. Wodon et al. (2009) proposed an alternative econometric method to try to better identify demand and supply-side problems. Their method is used here. We estimate for each country a regression of the determinants of the take-up of the household as a function of the following variables: a set of dummies for the quintile of well-being to which the household belongs, and the leave-out mean take-up rate in the primary sampling unit where the household lives. In the case of Uganda, since we have consumption data, that is the variable used to assess welfare.

The regressions on take-up of service are estimated only on the samples of households who live in neighborhoods where there is access at the neighborhood level, and the estimation follows a simple probit procedure. The regressions are not presented here, as there are many of them, but they are rather straightforward. The leave-out-mean access rate is meant to capture the general conditions of the neighborhood (including factors such as the average distance from the electric grid), while the quintiles of welfare are used to deal with the affordability issue.

Once the regressions have been estimated, we simulate what the access rate would be if all households living in areas where there is access would be lifted in terms of well-being from wherever they are in the distribution of well-being to the top quintile of well-being. That is, we simulate what the take-up rate would be for all households living in primary sampling units where there is access based on what the behavior of the households would be if they were in the top quintile, which corresponds implicitly to an assumption of no affordability problem, since the households in the top quintile should be able to afford electricity services. When aggregating the results for an area as a whole, we denote by U^* the alternative take-up rate obtained in this way ($U^* > U$). We then define the adjusted pure demand-side gap (APDSG) as:

$$APDSG = A \times (U^* - U)$$

This definition means that we consider as a demand-side or affordability issues the difference between the observed take-up rate and the simulated take-up rate when all households are given the wealth of the richest households in the country. We next define the adjusted supply-side gap as follows:

$$ASSG = (1 - C) - APDSG = (1 - A \times U) - A \times (U^* - U) = 1 - AU^*$$

The adjusted supply-side gap is thus the difference between full coverage and the coverage that would be achieved taking into account first the current level of availability of the network in areas (the A variable), and second the take-up rate expected when there is no affordability issue. As before, the sum of the adjusted pure demand-side gap, the adjusted supply-side gap, and the coverage rate is equal to one:

$$APDSG + ASSG + C = 1$$

The third step is to decompose the adjusted supply-side gap into two components. First, the adjusted pure supply-side gap is defined as follows:

$$APSSG = ASSG \times U^* = (1 - AU^*) \times U^*$$

Finally, the adjusted mixed demand and supply-side gap is defined as follows:

$$AMDSSG = ASSG \times (1 - U^*) = (1 - AU^*) \times U^*$$

The proportions of the deficit in coverage due to demand-side, supply-side, and combined problems can then be computed using the above adjusted definitions, with the sum of the three proportions still being equal to one.

3. Empirical Results

The estimations using both the statistical and econometric approaches are implemented with the Uganda National Household Surveys for 2009/10 and 2012/13. The use of two different surveys for the analysis is useful to ensure robustness of the findings, which should turn out similar in both years given that access, take-up, and coverage rates have not changes substantially between the two years. The results from the estimations carried with both the F&A (2004) method and the alternative proposed by Wodon et al. (2009) are provided in tables 3.1 and 3.2 for the 2009/10 survey, and in tables 3.3 and 3.4 for the 2012/13 survey. In those tables results are also provided by region (Central, Eastern, Northern, and Western), stratum in the surveys (Kampala, Central 1, Central 2, East Central, Eastern, Mid-Northern, North-East, West-Nile, Mid-Western, South-Western), and finally by urban and rural areas in each of the four regions.

Table 3.1: Statistical Estimation of Demand and Supply-side Constraints to Coverage (F&A approach), 2009/10

	Access	Take-up	Coverage	Unserved Population	Pure demand side gap	Supply side gap	Pure supply side gap	Mixed demand and supply side gap	Proportion of deficit attributable to demand side factors only	Proportion of deficit attributable to supply side factors only	Proportion of deficit attributable to both supply and demand side factors
Uganda											
National	25.7	43.0	11.1	88.9	14.7	74.3	31.9	42.3	16.5	35.9	47.6
Urban	88.8	52.4	46.5	53.5	42.2	11.2	5.9	5.3	79.0	11.0	10.0
Rural	11.1	25.5	2.8	97.2	8.3	88.9	22.6	66.3	8.5	23.3	68.2
Region											
Central	55.3	50.8	28.1	71.9	27.2	44.7	22.7	22.0	37.9	31.5	30.6
Eastern	11.4	26.6	3.0	97.0	8.4	88.6	23.6	65.1	8.6	24.3	67.1
Northern	6.5	19.8	1.3	98.7	5.2	93.5	18.5	75.0	5.3	18.8	76.0
Western	17.6	29.2	5.2	94.8	12.5	82.4	24.1	58.3	13.2	25.4	61.4
Stratum											
Kampala	100.0	64.7	64.7	35.3	35.3	0.0	0.0	0.0	100.0	0.0	0.0
Central 1	51.0	44.8	22.8	77.2	28.1	49.0	22.0	27.1	36.5	28.5	35.1
Central 2	33.3	36.0	12.0	88.0	21.3	66.7	24.0	42.7	24.2	27.3	48.5
East Central	12.7	25.5	3.2	96.8	9.4	87.3	22.3	65.0	9.8	23.0	67.2
Eastern	10.4	27.6	2.9	97.1	7.5	89.6	24.7	64.9	7.7	25.4	66.8
Mid-Northern	8.9	13.7	1.2	98.8	7.7	91.1	12.5	78.6	7.8	12.7	79.5
North-East	0.0	-	-	-	-	-	-	-	-	-	-
West-Nile	6.5	31.0	2.0	98.0	4.5	93.5	29.0	64.6	4.6	29.5	65.9
Mid-Western	16.1	17.0	2.7	97.3	13.4	83.9	14.2	69.7	13.7	14.6	71.6
South-Western	19.0	38.5	7.3	92.7	11.7	81.0	31.2	49.8	12.6	33.7	53.7
Region urban/rural											
Central rural	29.4	28.8	8.5	91.5	20.9	70.6	20.3	50.3	22.9	22.2	54.9
Central urban	97.7	61.6	60.1	39.9	37.5	2.3	1.4	0.9	94.2	3.6	2.2
East rural	4.5	23.4	1.1	98.9	3.4	95.5	22.3	73.2	3.5	22.6	73.9
East urban	74.9	28.4	21.2	78.8	53.7	25.1	7.1	18.0	68.1	9.0	22.8
North rural	2.1	12.4	0.3	99.7	1.8	97.9	12.1	85.8	1.8	12.2	86.0
North urban	46.5	22.8	10.6	89.4	35.9	53.5	12.2	41.3	40.1	13.7	46.2
West rural	8.8	18.9	1.7	98.3	7.1	91.2	17.2	74.0	7.2	17.5	75.2
West urban	91.9	37.5	34.5	65.5	57.4	8.1	3.0	5.1	87.6	4.7	7.7

Source: Authors using 2009/10 UNHS survey. All variables are expressed as percentages (%).

Table 3.2: Econometric Estimation of Demand and Supply-side Constraints to Coverage (Wodon et al. Approach), 2009/10

	Access	Take-up	Adjusted take-up rate given access	Coverage	Unserved Population	Adjusted pure demand-side gap	Adjusted supply-side gap	Adjusted pure supply-side gap	Adjusted mixed demand and supply-side gap	Adjusted proportion of deficit attributable to demand-side factors only	Adjusted proportion of deficit attributable to supply-side factors only	Adjusted proportion of deficit attributable to both supply and demand-side factors
Uganda												
National	25.7	43.0	58.7	11.1	88.9	4.0	84.9	49.9	35.0	4.6	56.1	39.4
Urban	88.8	52.4	66.9	46.5	53.5	12.9	40.6	27.2	13.4	24.0	50.8	25.1
Rural	11.1	25.5	41.2	2.8	97.2	1.7	95.4	39.3	56.2	1.8	40.4	57.8
Region												
Central	55.3	50.8	63.0	28.1	71.9	6.8	65.1	41.1	24.1	9.4	57.1	33.5
Eastern	11.4	26.6	60.7	3.0	97.0	3.9	93.1	56.5	36.6	4.0	58.3	37.7
Northern	6.5	19.8	35.3	1.3	98.7	1.0	97.7	34.5	63.2	1.0	35.0	64.0
Western	17.6	29.2	47.3	5.2	94.8	3.2	91.7	43.3	48.3	3.4	45.7	51.0
Stratum												
Kampala	100.0	64.7	73.2	64.7	35.3	8.5	26.8	19.6	7.2	24.1	55.5	20.3
Central 1	51.0	44.8	57.1	22.8	77.2	6.3	70.9	40.5	30.4	8.1	52.4	39.5
Central 2	33.3	36.0	46.4	12.0	88.0	3.5	84.5	39.2	45.3	3.9	44.5	51.5
East Central	12.7	25.5	56.5	3.2	96.8	3.9	92.8	52.5	40.4	4.1	54.2	41.7
Eastern	10.4	27.6	64.1	2.9	97.1	3.8	93.3	59.9	33.5	3.9	61.6	34.5
Mid-Northern	8.9	13.7	-	1.2	98.8	-	-	-	-	-	-	-
North-East	0.0	-	-	-	-	-	-	-	-	-	-	-
West-Nile	6.5	31.0	76.7	2.0	98.0	3.0	95.0	72.9	22.2	3.0	74.4	22.6
Mid-Western	16.1	17.0	34.2	2.7	97.3	2.8	94.5	32.3	62.2	2.9	33.2	63.9
South-Western	19.0	38.5	55.5	7.3	92.7	3.2	89.4	49.7	39.8	3.5	53.6	42.9
Region urban/rural												
Central rural	29.4	28.8	39.6	8.5	91.5	3.2	88.3	35.0	53.3	3.5	38.3	58.3
Central urban	97.7	61.6	72.5	60.1	39.9	10.7	29.1	21.1	8.0	26.9	53.0	20.1
East rural	4.5	23.4	62.0	1.1	98.9	1.7	97.2	60.3	36.9	1.8	60.9	37.3
East urban	74.9	28.4	59.6	21.2	78.8	23.4	55.4	33.0	22.4	29.7	41.9	28.4
North rural	2.1	12.4	-	0.3	99.7	-	-	-	-	-	-	-
North urban	46.5	22.8	33.1	10.6	89.4	4.8	84.6	28.0	56.6	5.4	31.4	63.3
West rural	8.8	18.9	33.0	1.7	98.3	1.2	97.1	32.0	65.1	1.3	32.6	66.2
West urban	91.9	37.5	56.3	34.5	65.5	17.3	48.3	27.2	21.1	26.4	41.5	32.2

Source: Authors using 2009/10 UNHS survey. All variables are expressed as percentages (%).

Table 3.3: Statistical Estimation of Demand and Supply-side Constraints to Coverage (F&A approach), 2012/13

	Access	Take-up	Coverage	Unserved Population	Pure demand side gap	Supply side gap	Pure supply side gap	Mixed demand and supply side gap	Proportion of deficit attributable to demand side factors only	Proportion of deficit attributable to supply side factors only	Proportion of deficit attributable to both supply and demand side factors
Uganda											
National	25.0	45.7	11.4	88.6	13.6	75.0	34.2	40.7	15.4	38.7	46.0
Urban	69.1	54.6	37.7	62.3	31.4	30.9	16.9	14.0	50.4	27.1	22.5
Rural	9.0	20.9	1.9	98.1	7.1	91.0	19.0	72.0	7.3	19.4	73.4
Region											
Central	49.9	57.4	28.7	71.3	21.2	50.1	28.8	21.3	29.8	40.3	29.9
Eastern	16.9	28.8	4.9	95.1	12.1	83.1	24.0	59.1	12.7	25.2	62.1
Northern	8.9	21.8	2.0	98.0	7.0	91.1	19.9	71.2	7.1	20.3	72.6
Western	16.7	31.6	5.3	94.7	11.4	83.3	26.4	56.9	12.0	27.8	60.1
Stratum											
Kampala	100.0	78.7	78.7	21.3	21.3	0.0	0.0	0.0	100.0	0.0	0.0
Central 1	45.9	51.2	23.5	76.5	22.4	54.1	27.7	26.4	29.3	36.2	34.5
Central 2	32.2	38.4	12.3	87.7	19.8	67.8	26.0	41.8	22.6	29.7	47.7
East Central	24.6	30.1	7.4	92.6	17.2	75.4	22.7	52.7	18.5	24.5	56.9
Eastern	11.3	26.8	3.0	97.0	8.3	88.7	23.8	64.9	8.6	24.6	66.9
Mid-Northern	12.1	25.1	3.0	97.0	9.1	87.9	22.0	65.8	9.4	22.7	67.9
North-East	5.5	18.4	1.0	99.0	4.5	94.5	17.4	77.1	4.5	17.6	77.9
West-Nile	5.1	10.6	0.5	99.5	4.6	94.9	10.1	84.8	4.6	10.2	85.3
Mid-Western	17.2	28.1	4.8	95.2	12.4	82.8	23.3	59.5	13.0	24.4	62.5
South-Western	16.2	35.1	5.7	94.3	10.5	83.8	29.4	54.4	11.1	31.2	57.6
Region urban/rural											
Central rural	17.8	23.5	4.2	95.8	13.6	82.2	19.3	62.9	14.2	20.1	65.7
Central urban	89.8	65.8	59.1	40.9	30.7	10.2	6.7	3.5	75.1	16.4	8.5
East rural	8.8	20.4	1.8	98.2	7.0	91.2	18.6	72.6	7.1	19.0	73.9
East urban	54.5	35.1	19.1	80.9	35.3	45.5	16.0	29.5	43.7	19.8	36.5
North rural	3.3	10.2	0.3	99.7	3.0	96.7	9.9	86.8	3.0	9.9	87.1
North urban	35.9	27.1	9.7	90.3	26.2	64.1	17.3	46.8	29.0	19.2	51.8
West rural	6.5	20.3	1.3	98.7	5.2	93.5	19.0	74.5	5.3	19.3	75.5
West urban	52.1	36.6	19.1	80.9	33.1	47.9	17.5	30.4	40.8	21.6	37.5

Source: Authors using 2012/13 UNHS survey. All variables are expressed as percentages (%).

Table 3.4: Econometric Estimation of Demand and Supply-side Constraints to Coverage (Wodon et al. Approach), 2012/13

	Access	Take-up	Adjusted Take-up rate given access	Coverage	Unserved Population	Adjusted pure demand-side gap	Adjusted supply-side gap	Adjusted pure supply-side gap	Adjusted mixed demand and supply-side gap	Adjusted proportion of deficit attributable to demand-side factors only	Adjusted proportion of deficit attributable to supply-side factors only	Adjusted proportion of deficit attributable to both supply and demand-side factors
Uganda												
National	25.0	45.7	60.1	11.4	88.6	3.6	84.9	51.0	33.9	4.1	57.6	38.3
Urban	69.1	54.6	67.3	37.7	62.3	8.8	53.5	36.0	17.5	14.2	57.8	28.1
Rural	9.0	20.9	37.7	1.9	98.1	1.5	96.6	36.4	60.2	1.5	37.1	61.3
Region												
Central	49.9	57.4	69.6	28.7	71.3	6.1	65.3	45.4	19.9	8.5	63.7	27.8
Eastern	16.9	28.8	44.4	4.9	95.1	2.6	92.5	41.1	51.4	2.8	43.2	54.1
Northern	8.9	21.8	44.2	2.0	98.0	2.0	96.1	42.4	53.6	2.0	43.3	54.7
Western	16.7	31.6	44.5	5.3	94.7	2.1	92.6	41.2	51.4	2.3	43.5	54.3
Stratum												
Kampala	100.0	78.7	84.2	78.7	21.3	5.5	15.8	13.3	2.5	25.7	62.6	11.8
Central 1	45.9	51.2	64.3	23.5	76.5	6.0	70.5	45.4	25.1	7.9	59.3	32.8
Central 2	32.2	38.4	55.5	12.3	87.7	5.5	82.2	45.6	36.6	6.3	52.0	41.7
East Central	24.6	30.1	41.6	7.4	92.6	2.8	89.8	37.4	52.4	3.1	40.3	56.6
Eastern	11.3	26.8	55.9	3.0	97.0	3.3	93.7	52.3	41.4	3.4	54.0	42.6
Mid-Northern	12.1	25.1	44.4	3.0	97.0	2.3	94.6	42.0	52.6	2.4	43.3	54.3
North-East	5.5	18.4	80.7	1.0	99.0	3.4	95.6	77.2	18.4	3.5	77.9	18.6
West-Nile	5.1	10.6	-	0.5	99.5	-	-	-	-	-	-	-
Mid-Western	17.2	28.1	42.4	4.8	95.2	2.5	92.7	39.3	53.4	2.6	41.3	56.1
South-Western	16.2	35.1	46.4	5.7	94.3	1.8	92.5	42.9	49.6	1.9	45.5	52.6
Region urban/rural												
Central rural	17.8	23.5	40.2	4.2	95.8	3.0	92.8	37.4	55.5	3.1	39.0	57.9
Central urban	89.8	65.8	76.3	59.1	40.9	9.4	31.5	24.0	7.5	23.0	58.7	18.3
East rural	8.8	20.4	26.6	1.8	98.2	0.5	97.7	26.0	71.7	0.6	26.5	73.0
East urban	54.5	35.1	51.5	19.1	80.9	8.9	71.9	37.1	34.9	11.1	45.8	43.1
North rural	3.3	10.2	-	0.3	99.7	-	-	-	-	-	-	-
North urban	35.9	27.1	49.4	9.7	90.3	8.0	82.3	40.7	41.6	8.9	45.0	46.1
West rural	6.5	20.3	39.6	1.3	98.7	1.3	97.4	38.6	58.8	1.3	39.1	59.6
West urban	52.1	36.6	46.5	19.1	80.9	5.2	75.8	35.2	40.5	6.4	43.5	50.1

Source: Authors using 2012/13 UNHS survey. All variables are expressed as percentages (%).

Note: For the Mid-Northern stratum and the North rural region, the estimations did not provide appropriate results due to limited sample size with coverage.

Summary results nationally and for urban and rural areas are provided in table 3.5. The results obtained with both the statistical and econometric approaches are very similar in the two years, as expected. Consider the results for 2012/13. In the statistical approach demand-side factors account for 15.4 percent of the coverage gap at the national level, while supply-side factors account for 38.7 percent of the gap. The rest of the coverage gap (46.0 percent) is due to combined demand- and supply-side factors. With the econometric approach, supply-side factors account for a majority of the gap (57.6 percent), followed by combined factors (38.3 percent) and demand-side factors (only 4.1 percent). The results in terms of the relative size of the demand versus supply factors limiting take up thus change significantly when using the econometric as opposed to the statistic al approach. Similar findings are observed for urban and rural areas.

Table 3.5: Summary Results on Demand and Supply-side Constraints to Coverage

	2009/10			2012/13		
	Demand side factors (%)	Supply side factors (%)	Combined factors (%)	Demand side factors (%)	Supply side factors (%)	Combined factors (%)
Statistical Approach						
National	16.5	35.9	47.6	15.4	38.7	46.0
Urban	79.0	11.0	10.0	50.4	27.1	22.5
Rural	8.5	23.3	68.2	7.3	19.4	73.4
Econometric Approach						
National	4.6	56.1	39.4	4.1	57.6	38.3
Urban	24.0	50.8	25.1	14.2	57.8	28.1
Rural	1.8	40.4	57.8	1.5	37.1	61.3

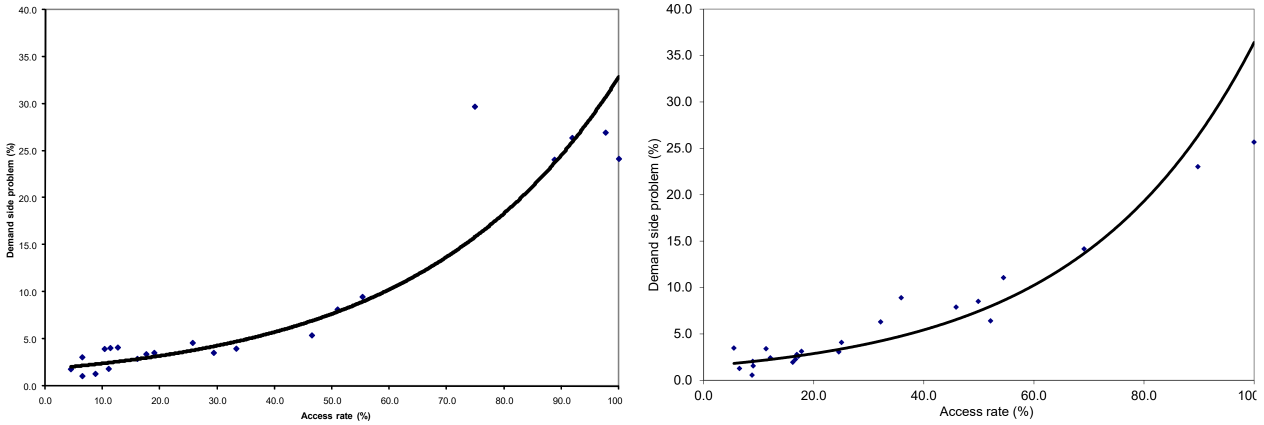
Source: Authors using 2009/10 and 2012/13 UNHS survey. All variables are expressed as percentages (%).

The analysis was also carried according to Ugandan’s regions/areas and by urban-rural areas within regions/areas, as well as by strata. This provides a set of 22 observations. The relative importance of demand-side constraints, supply-side constraints, and combined constraints with the econometric is visualized in Figure 3.1. In each panel of the Figure, we have a scatter plot with on the horizontal axis the average neighborhood access rate in the region/area, and on the vertical axis the estimates from the econometric method of the proportions of the coverage deficit due respectively to demand-side factors, supply-side factors, and combined factors. The curves through the scatter plots have been fitted in Excel for visual purposes.

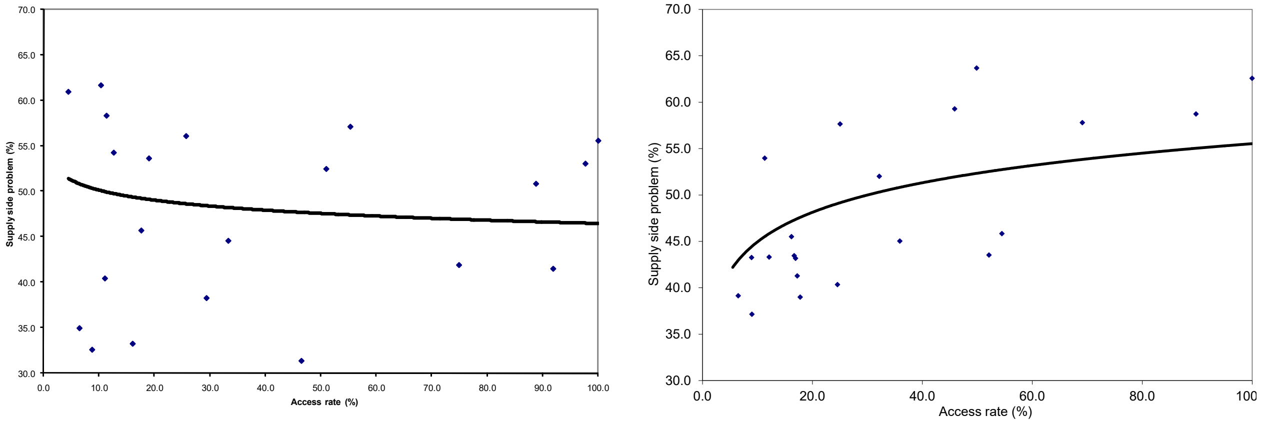
Clearly, demand-side factors are more important in areas where access is already high, as expected. Supply-side factors are less important in areas with higher access, also as expected. The relationship between combined factors and access rates is less significant, and depends on the year considered. Still, overall, the key conclusion from the exercise is that supply-side issues are clearly more important than demand-side issues in Uganda to explain coverage gaps. In order to provide additional visualization of the results, Figures 3.2 and 3.3 provide maps of Uganda with the intensity of the shading reflecting the relative size of demand, supply, and combined factors in accounting for the residential electricity coverage gap in each geographic area. This is done for the statistical approach in Figure 3.2, and for the econometric approach in Figure 3.3.

Figure 3.1: Demand and Supply Constraints to Electricity Coverage

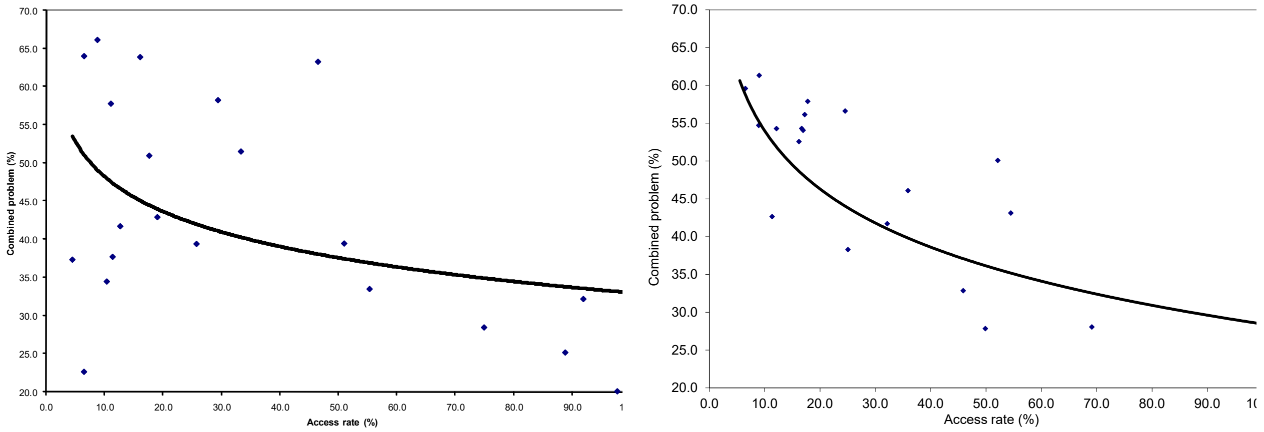
Supply, 2010 Supply, 2013



Demand, 2010 Demand, 2013

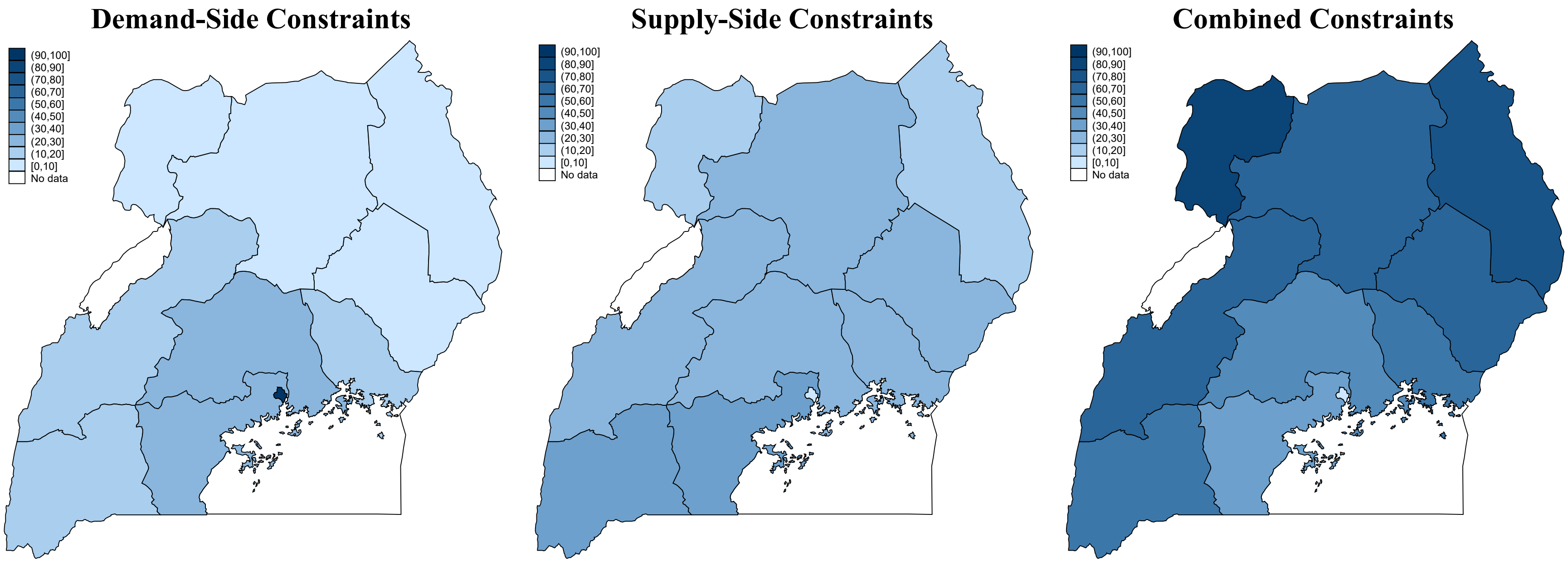


Combined, 2010 Combined, 2013



Source: Authors using Uganda 2009/10 and 2012/13 surveys.

Figure 3.2: Demand, Supply, and Combined Constraints According to the Statistical Approach, 2012/13

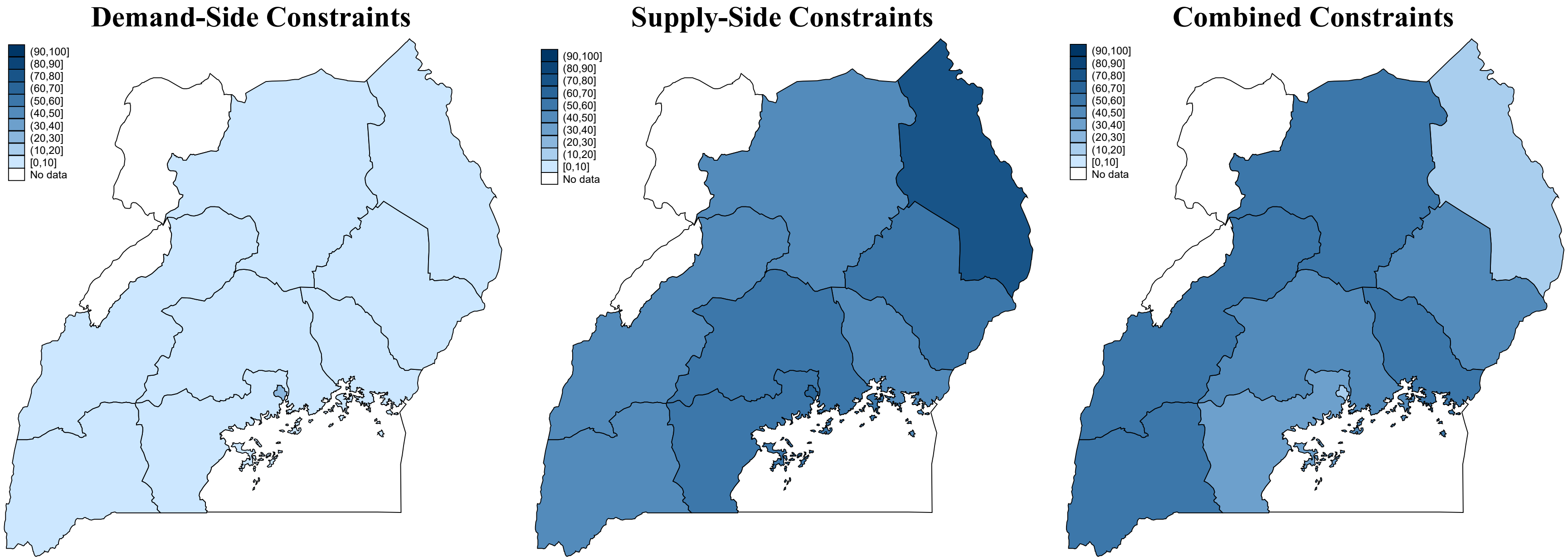

Demand-Side Constraints

Supply-Side Constraints

Combined Constraints

Source: Authors using 2012/13 UNHS survey.

Figure 3.3: Demand, Supply, and Combined Constraints According to the Econometric Approach, 2012/13



Demand-Side Constraints

Supply-Side Constraints

Combined Constraints

Source: Authors using 2012/13 UNHS survey.

4. Conclusion

Many African countries are aiming to improve coverage of network-based infrastructure services such as electricity in the population. Yet in order to inform appropriate policies to do so, it is important to first understand whether lack of coverage is due primarily to demand-side or affordability issues, to a lack of supply, or to a combination of both. Some households may live in areas where access to electricity is in principle available, but may not be able to pay for those services. Other households may be able to pay for the services, but may live too far from the grid to be able to connect.

In this chapter, using the last two household surveys for Uganda, we have used two different methods for decomposing the lack of coverage observed in various areas into three components: pure demand-side constraints, pure supply-side constraints, and combined demand- and supply-side constraints. The results obtained with the statistical method suggest that demand-side constraints account for a substantial share of the coverage gap. But the results obtained from the econometric method, which is arguably more reliable, suggest that lack of supply appears to be by far the main issue, as one might expect in a country like Uganda.

The method used here could be refined for more detailed policy work. For example, one could check the robustness of the econometric simulations to alternative estimation techniques, or alternative specifications of the regressions. One could also rely on census data in order to obtain estimates of demand as opposed to supply-side constraints for smaller geographic areas. The results obtained from survey or census data could also be combined with additional information from willingness to pay studies or focus group discussions. But overall, even though this may not be too surprising for Uganda, it is useful to know that the data confirm the prominence of supply over demand constraints in explaining low coverage rates in the country.

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CHAPTER 4
ELECTRICITY COVERAGE, TIME USE, AND POVERTY

Clarence Tsimpo, Quentin Wodon, Faisal Buyinza, and Willy Kagarura

What are the benefits for households from a connection to the electricity grid? This chapter considers one such benefit, looking at time use and its impact on household welfare. Using the last round of the Uganda National Household Survey for 2012/13, the chapter estimates the impact of a connection to electricity on domestic and productive work time. Simulations are provided about the gains in welfare and the reduction in poverty that might be generated from an expansion of electricity coverage. The results suggests that in areas where electricity is available, a connection for households not yet connected may enable women to reduce domestic work and increase market work by about two hours and is likely to reduce poverty by about one percentage point.

1. Introduction

The way people allocate their time matters for productivity, poverty reduction, and economic growth. Women and children may spend considerable time on collecting water and fuel to meet domestic needs (Blackden and Wodon, 2006; UNICEF and WHO, 2008). Hours spent on these chores are not necessarily productive and take time away from more productive activities such as acquiring human capital or working in the labor market or on the household farm. Therefore the availability of electricity and network (piped) water may help in reducing time spent on domestic chores, and increase economic opportunities and earnings, especially for women, ultimately reducing poverty.

Time use decisions depend on household structure. Illahi (2000) notes that the presence of young children significantly affects women's time use as they withdraw from labor markets or reduce the amount of time they work outside their homes. Namkhumi (2004) shows that with other adult female members in a household, the time each one must allocate to domestic work is reduced and the likelihood of participating in market work is increased. But time allocations also depend on the availability of basic infrastructure services and the impact of such services on time use can be substantial. In Kenya Whittington et al. (1990) note that the time household members spend collecting water amounts to the wage rate of an unskilled worker. Ilahi and Grimard (2000) show that lack of access to water reduces the time that women devote to market work and increases their total work time. Water provision encourages a move towards market work among women and increases time available for leisure. In South Africa Dinkelman (2008) suggests that electricity roll-outs increase women's employment rate by 14 points, whereas men's employment was not significantly affected. Grogan and Sadanand (2008) show that women's earnings increased by 60 percent in Guatemala with improved access to electricity thanks to an increase in market work. Availability of basic infrastructure may also benefit children since many spend hours fetching water or collecting wood (Blackden and Wodon, 2006).

Several studies (Khandker, 1996; Martins, 2005; World Bank, 2008; Asian Development Bank, 2010) point to the role of rural electrification in improving welfare, quality of life, and growth[3]. Khandker et al. (2013) find that power connections have positive impacts on income,

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[3] On various aspects of rural electrification in Uganda, see for example Ezor (2009), Hazal and Tedgren (2009), Muhoro (2010), Berg (2011), and especially Government of the Republic of Uganda (2012).

expenditures, and schooling. Electricity benefits income-generation activities through business operations being able to stay open longer. A reliable supply of electricity also creates opportunities for many small entrepreneurial activities which can take place within the household, increasing its non-wage income. Srivastava and Rehman (2005) note presence of a strong negative correlation between people leaving below the poverty line and the level of electrification. Better lighting can benefit other activities, such as sewing by women, social gatherings after dark, studying by children. Access to piped water may help prevent water-borne diseases, thereby reducing risks of infant and under-five mortality as well as child malnutrition (Fay et al., 2005), and it may also reduce the cost of water provision (Bardasi and Wodon, 2008). Some cooking methods also have negative effects on health and thereby productivity (Pal, 2010), with again potential gains from access to basic infrastructure. Access to basic infrastructure is likely to reduce time poverty (Bardasi and Wodon, 2010), and when children and women need to walk far away from home to fetch water or wood, they may be exposed to crime risks.

This chapter estimates the extent to which electricity coverage could help household shift time from domestic to market work in Uganda. Section 2 presents basic statistics on time use. Section 3 estimates the impact of electricity on time use, and the consumption gains that connections may generate together with the resulting reduction in poverty. A conclusion follows.

2. Basic Statistics

The analysis is based on data from the Uganda National Household Survey (2012/13), a nationally representative survey collected by the Uganda Bureau of Statistics (UBOS, 2013). The UHNS employs a two stage sampling framework and it covers approximately 7,000 households. The socioeconomic module provides information on household sources of energy, including electricity, gas, firewood, and biogas, among others. A household is considered as having access to electricity if the household uses electricity for lighting, cooking or both. The labor force questionnaire provides information on the activity status of individuals in terms of hours worked in market activities and domestic work (mostly chores). Information is available on domestic work related to fetching water, cooking, collecting firewood, and looking after or taking care of children and the elderly. Other variables of interest include among others information on the structure of the household, its location, its welfare status, the education level of its members.

Table 4.1 provides data on time use in terms of the number of hours allocated to different activities by different categories of individuals. Given that the simulations entail providing access to electricity to households, the estimations are conducted on households who live in an area where access is in principle feasible because other households already are connected. In those areas, some households are connected to the grid, while others are not. The sample is further restricted to individuals who are working at least some time on market activities (that typically provide earnings) and domestic chores. The idea is to assess the extent to which electricity results in a shift in working hours from domestic to productive activities, and if this is the case, the extent to which this may help in reducing poverty through higher earnings. The reason to restrict the estimation to those individuals who already are working at least some time on both market and domestic activities is that it makes the estimation easier, because issues related to some individuals entering market work after getting access to infrastructure services do not need to be modelled separately. Since most adult individuals in the household do some market and domestic work, the restriction to that sample is not problematic. Once the effect on time use of electricity (and piped water) is estimated, simulations of poverty impact can be conducted.

Table 4.1: Basic Statistics on Time Use (Number of Hours per Week per Activity), 2012/13

	All households					With electricity					Without electricity				
	Market	Collecting firewood	Fetching water	Cooking	Children & elderly care	Market activities	Collecting firewood	Fetching water	Cooking	Children & elderly care	Market activities	Collecting firewood	Fetching water	Cooking	Children & elderly care
Gender															
Female	37.6	3.8	5.4	15.5	13.5	51.6	1.0	1.9	14.4	12.2	35.8	4.1	5.8	15.6	13.6
Male	39.8	1.9	4.2	2.5	3.5	50.7	0.5	2.4	2.6	3.3	38.7	2.1	4.4	2.5	3.5
Residence Area															
Kampala	62.9	0.1	1.0	11.5	6.4	62.5	0.1	0.8	11.9	6.7	64.2	0.0	1.5	10.5	5.2
Other urban	45.9	1.8	3.8	11.4	10.3	53.1	0.4	1.6	10.5	10.4	42.9	2.4	4.7	11.7	10.2
Rural area	36.0	3.5	5.3	10.5	9.8	42.6	1.9	3.5	10.2	9.3	35.7	3.5	5.4	10.5	9.9
Region															
Central	44.7	1.4	2.7	10.0	9.0	54.6	0.3	1.0	10.0	8.8	41.4	1.8	3.3	10.0	9.1
Eastern	33.2	5.3	7.5	9.7	12.2	43.8	2.4	4.4	10.1	10.7	32.6	5.4	7.7	9.7	12.3
Northern	36.4	2.5	5.6	12.6	9.8	42.5	1.3	4.3	14.7	10.5	36.1	2.6	5.6	12.5	9.8
Western	40.0	2.6	3.6	11.2	7.7	50.6	1.2	2.8	11.9	9.7	39.2	2.7	3.6	11.1	7.5
Welfare quintile															
Q1	33.4	4.5	6.1	10.4	10.7	21.5	2.3	5.6	10.5	7.9	33.7	4.5	6.1	10.4	10.8
Q2	33.9	4.0	6.0	10.3	10.5	38.5	6.4	6.9	11.7	12.3	33.8	4.0	6.0	10.3	10.5
Q3	35.2	3.4	5.3	10.9	10.3	42.2	1.2	3.0	10.0	11.9	34.9	3.4	5.4	10.9	10.2
Q4	40.4	2.5	4.2	11.0	9.5	51.0	1.1	3.1	10.9	11.6	39.3	2.7	4.4	11.0	9.3
Q5	47.4	1.5	3.4	10.8	8.4	54.5	0.4	1.3	10.6	8.5	44.0	2.0	4.3	10.9	8.3
Industry															
Agriculture	33.3	3.7	5.5	10.8	9.7	33.0	2.1	3.5	11.2	9.8	33.3	3.8	5.6	10.8	9.7
Mining/utilities	54.9	1.1	3.1	10.3	9.8	59.5	0.4	1.6	11.0	9.6	52.8	1.4	3.7	10.0	9.8
Manuf./Const.	46.4	1.3	4.1	6.6	10.1	69.8	0.0	0.7	3.4	18.9	41.3	1.5	4.9	7.3	8.2
Services	57.3	0.2	1.8	6.8	3.5	54.2	0.0	0.9	5.9	3.8	60.3	0.4	2.6	7.6	3.2
Public Adm.	59.1	0.3	0.9	4.5	8.2	51.4	0.0	1.0	4.2	4.5	67.2	0.5	0.9	4.9	12.0
Missing	36.5	4.1	5.9	13.6	16.8	49.6	0.3	1.5	7.8	7.5	35.0	4.5	6.4	14.2	17.8
Total	38.4	3.1	4.9	10.7	9.8	51.3	0.9	2.1	10.7	9.4	36.9	3.4	5.3	10.7	9.9

Source: Authors using 2012/13 UNHS survey.

In table 4.1, statistics on time use are provided for the sample as a whole (again, households living where access is available), those households connected to the grid, and those households not connected. Individuals from households connected to the grid (or having another source of electricity) tend to have higher market working times than individuals not connected, and lower domestic work time for collecting wood and fetching water. Differences in domestic work time allocated to cooking and care of children and the elderly do not differ fundamentally between those with and those without a connection. Much of the domestic work is, as expected, done by women (and children) versus adult men. Women work longer hours than men. The poor tend to have less working hours, probably because of limited opportunities for productive work. None of those findings are surprising, as they have been well documented in the literature (see for example the country studies and reviews in Blackden and Wodon, 2006). The question is the extent to which having electricity grid reduces domestic work and increases market work.

3. Econometric Analysis and Simulations

To assess the extent to which a connection to the electricity grid reduces domestic work and increases market work, simple regressions are estimated for the logarithm of the number of hours worked by individuals on market and domestic tasks. The independent variables include whether the household has electricity (and piped water), as well as a range of controls. The regressions are somewhat parsimonious in their specification to avoid endogeneity issues – for example, we do not include household level quintiles of welfare as independent variables because these clearly depend on the time worked by household members. The models are:

$$\ln MT_i = \alpha_0 + \alpha_1 E_i + \alpha_1 PW_i + \alpha_2 HM_i + \alpha_5 HH_i + CH_i + \varepsilon_i$$
$$\ln DT_i = \beta_0 + \beta_1 E_i + \beta_1 PW_i + \beta_2 HM_i + \beta_5 HH_i + CH_i + \nu_i$$

where MT_i and DT_i are the market and domestic working time for individual i, E_i and PW_i denote the access of the household to electricity and piped water, HM_i and HH_i are vectors of characteristics for the household (HH) and for the household member (HM), HC_i is a vector of location variables, and ε_i and υ_i are normally distributed error terms with usual properties.

The results of the regressions are provided in table 4.2. Many of the controls are statistically significant, but the focus here is on the impact of an electricity connection on the number of hours allocated to domestic and market work by men and women. A connection to the grid reduces domestic work for men by 22 percent (albeit from a lower base than for women), and for women by 12 percent. A connection to electricity also increases market work for women by nine percent, but the effect for men is not statistically significant. For piped water, the effects for market and domestic work are not significant for men, but there is an increase in market work hours for women even if the decrease in domestic work hours is not statistically significant. Thus both electricity and piped water tend to increase the time allocated to market work by women. By comparing predicted working time with and without electricity on the basis of the regressions in table 4.2, it can be shown that in the case of a connection to electricity for a household previously not connected but living in an area with access, the average gain for women in market working time is 1.9 hours.

Table 4.2: Correlates of the Logarithm of Market and Domestic Work

	Domestic Work		Market Work	
	Men	Women	Men	Women
Access to infrastructure				
Has electricity	-0.2181***	-0.1198**	-0.0262	0.0887***
Has piped water	-0.0599	-0.0113	0.0447	0.0797**
Location (Ref.: Urban)				
Urban without Kampala	0.1272	0.1234*	-0.1108**	-0.2028***
Rural area	0.1325	0.1635**	-0.1337***	-0.2413***
Region (Ref.: Southern)				
Eastern region	0.3938***	0.4492***	-0.1970***	-0.1309***
Northern region	-0.1910***	0.2096***	-0.0773**	0.0043
Western region	-0.1650***	0.0588*	-0.0185	0.1131***
Age and Education				
Age	0.0073	0.0125*	0.0826***	0.0565***
Age squared	-0.0001	-0.0003***	-0.0011***	-0.0008***
Primary education	-0.1519**	0.0046	-0.0238	-0.0155
Secondary or higher education	-0.2765***	-0.0949***	-0.0656*	-0.0580**
Household structure				
Polygamous marriage	0.3436***	-0.1934***	-0.1987***	0.0061
Monogamously married	0.0564	-0.4863***	-0.2166***	-0.2038***
Infants aged 0-5	0.0449	0.2491***	-0.0575**	-0.0365***
Infants aged 0-5, squared	-0.0137	-0.0318***	0.0083	0.0030
Boys aged 6-17	-0.0310	-0.0276	-0.1084***	-0.0268*
Boys aged 6-17, squared	0.0076	0.0049	0.0153***	0.0050
Girls aged 6-17	-0.0230	-0.1121***	-0.0242	-0.0275*
Girls aged 6-17, squared	-0.0064	0.0124**	0.0017	0.0024
Adults aged 18-59	-0.1683***	-0.0942***	-0.0460	0.0065
Adults aged 18-59, squared	0.0237***	0.0046	0.0103**	0.0009
Seniors aged 60+	0.0036	-0.0159	0.0364*	0.0114
Seniors aged 60+, squared	-0.0023	-0.0029	-0.0003	-0.0037
Occupation				
Mining and utilities	-0.2074***	-0.1019***	0.3646***	0.2819***
Manufacture, construction	-0.3013	0.0871	0.1439	-0.0023
ICT, finance, professional services	0.0620	-0.6145***	0.4748***	0.2356*
Public administration	0.1111	-0.5033*	0.3535***	0.3523**
Missing industry	-0.1348	0.0151	0.1707*	0.0275
Constant	2.1872***	3.2628***	2.5704***	2.8103***
Observations	3,143	5,893	3,143	5,893
R-squared	0.088	0.260	0.317	0.215

Source: Authors' estimation using Uganda UNHS 2012/13 survey.
Note: *** p<0.01, ** p<0.05, * p<0.1

The next step consists in estimating the potential increase in household consumption from the shit in time use away from domestic work towards market work associated with an electricity connection. The simulated counterfactual consumption level Y^C of household j is computed as:

$$Y_j^C = Y_j + (\Delta MT_i \times \omega_i) / N_j$$

where Y_j is the observed consumption level of the household (per equivalent adult), ΔMT_i is the increase in market working time for individual i following a connection to the network, ω_i is the expected wage or earnings of this individual (which may take the form for farm households of a higher production for household consumption), N_j is the household size (in equivalent adults) and the summation of the earnings gains is done for all working age individuals in the household.

Given the counterfactual consumption resulting from a connection to the grid, denoting by Z the poverty line, by *n* the population in the sample (in this case, households previously not connected who now get electricity), and by *1* the indicator function (taking a value of one if the condition is observed), the counterfactual poverty measures P^C can be estimated in a straightforward way as:

$$P^C = \frac{1}{n}\sum_{i=1}^{n} 1_{Z>Y_i}\left[\frac{Z - Y_i^C}{Z}\right]^{\alpha}$$

The headcount index of poverty is obtained for α equal to zero, the poverty gap for α equal to one, and the squared poverty gap for α equal to two. While the headcount index provides the share of the population in poverty, the poverty gap takes into account the distance separating the poor from the poverty lines as well as the proportion of the poor in the population, and the squared poverty gap is based on the square of that distance and the share in poverty. More sophisticated methods could be used to measure general equilibrium effect of the shifts in time use that take place from an electricity connection, but the estimations given in this chapter provide a quick "first round" welfare (consumption) and poverty effects from gains in working time with a connection.

A difficult question is what value to assign to ω_i, the expected gains in earnings, wages, or other benefits from working time assigned to individual *i*. One possibility would be to rely on the wages of individuals, and to estimate wage regressions to impute wages for those who do not have a wage. The issue however is that many individuals work without wages (for example on the household's land), so that the estimations may not be precise. An alternative is to make assumptions for likely gains in earnings based on the level of consumption of the household.

Specifically, following Bardasi and Wodon (2006), two alternative assumptions are made. In the first case, the household (as opposed to individual) earnings gain per hour of additional market work is defined as the total household consumption divided by the total working time of its members aged 14-59, including domestic time, assuming that even domestic work may help in generating earnings. In the second case, the earnings gain per hour of additional market work is obtained by dividing total household consumption by the number of hours spent by household members in market work. These two ratios can be considered a form of 'household consumption productivity' because they represent the efficiency of the household in translating each hour of work (or each time of market work) by any of its member into consumption. While the first measure considers all household activities as 'productive' and therefore able to generate consumption, it is true that extra-employment aimed at increasing consumption would be mostly directed at the labor market and/or in farm or family business. Therefore in the second case only market work is considered for the denominator of the measure.

The results of the simulations are provided in table 4.3, with the base data corresponding to the actual situation of households, and the two cases corresponding to the counterfactual with the two assumptions regarding the valuation of the time essentially shifted from domestic to market work. Among households who do not have electricity but live in an area where other households have electricity, the baseline poverty incidence is 12.76 percent. This decreases by about one percentage point with a connection (the decrease is a bit larger with the second than the first assumption). The counterfactual poverty gaps are also provided, and there in proportional terms the gains in poverty reduction from connections to the network are larger (because those who were poor and remain poor are now less poor, an effect that does not appear when considering only poverty incidence measures).

Table 4.3: Impact on Welfare and Poverty of an Electricity Connection

	Consumption per eq. adult			Poverty incidence (%)			Poverty gap (%)		
	Base	With connection		Base	With connection		Base	With connection	
		Case 1	Case 2		Case 1	Case 2		Case 1	Case 2
Residence Area									
Kampala	168,953	169,068	169,086	0.56	0.56	0.56	0.14	0.14	0.14
Other urban	117,442	118,932	120,443	6.96	6.86	6.17	2.20	2.06	1.86
Rural area	70,652	72,224	73,747	17.69	16.56	15.83	4.41	4.09	3.72
Region									
Central	123,026	124,520	125,897	4.80	4.17	3.70	0.96	0.86	0.75
Eastern	64,443	65,303	66,382	18.80	18.15	16.27	3.39	3.17	2.82
Northern	49,801	51,105	52,583	40.23	38.12	37.34	14.10	13.38	12.35
Western	88,676	90,499	92,151	6.31	6.31	6.31	1.18	1.00	0.88
Quintiles									
Q2	21,839	22,410	23,250	-	-	-	-	-	-
Q3	35,065	36,122	37,389	-	-	-	-	-	-
Q4	49,068	50,464	51,992	-	-	-	-	-	-
Q5	71,253	72,843	74,485	-	-	-	-	-	-
Quintile	177,086	178,883	180,333	-	-	-	-	-	-
Total	94,249	95,681	97,083	12.76	12.06	11.41	3.34	3.11	2.82

Source: Authors' estimation using Uganda UNHS 2012/13 survey.

5. Conclusion

There are many potential benefits for households from a connection to the electricity grid. This chapter focused on one of those benefits using the time use module of the last round of the Uganda National Household Survey for 2012/13 Electricity coverage may help household shift time from domestic to market work. These shifts are observed for women with a connection in the data, but not men (for whom electricity reduces domestic work time, but does not increase market work time). Simulations suggest that if electricity were provided to all households living in areas where electricity is available at the neighborhood level, connections for households not yet connected would enable women to increase market work by two hours on average. The poverty incidence in the sample would decrease by about one percentage point, and the impact on the poverty gap would be larger in proportional terms because even when a household remains poor after benefitting from an electricity connection, it becomes less poor thanks to the earning gains associated with the shift from domestic to market work time for women. These gains may not seem large because the poverty measures are low, since the focus is on households living in areas with access – mostly Kampala and other large cities. But for those who may benefit from those gains, these gains in consumption can be very important.

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PART II
TARIFFS, SUBSIDIES, AND AFFORDABILITY

CHAPTER 5
WHO BENEFITED FROM ELECTRICITY SUBSIDIES?

Until 2012 large subsidies were provided under the national budget to maintain low electricity tariffs for residential (and other) customers. These subsidies were eliminated in 2012. Who used to benefit from the subsidies? This chapter uses a simple framework to analyze the targeting performance to the poor of the subsidies. While most indicators of targeting performance are silent as of why subsidies are targeted the way they are (they only give an idea of whether the subsidies reach the poor or not and to what extent), the framework allows for analyzing access and subsidy design factors that affect targeting performance. Access factors are related to the availability of electricity service in the area where a household lives and to the household's choice to connect to the network when service is available. Subsidy factors relate to the tariff structure and the rate of subsidization of various types of customers. In Uganda, due to access factors, less than 0.5 percent of the subsidies benefited the poor. Connection subsidies could be better targeted.

1. Introduction

In many developing countries it is tempting to subsidize residential electricity. Electricity is more and more considered as a basic necessity especially in urban areas. It is perceived to have important externalities for education and health, and it is believed to also contribute to economic growth. For many households in poverty, the full cost of a standard electricity bill may not be affordable. The desire to make electricity affordable to the poor and the population as a whole has led many governments and regulatory agencies to maintain electricity tariffs at low levels by not allowing tariffs to follow increases in generation, transmission or distribution costs. This is for example the case when increases in oil prices are not fully accounted for in thermal energy generation costs. Many governments also maintain increasing block tariff structures to ensure that the cost of electricity consumption is lower for households who consume smaller amounts of electricity. It is hoped that the implicit subsidies embedded in such tariff structures are targeted to the poor because households who consume lower amounts of electricity also tend to be poorer.

While the temptation is high to keep subsidizing electricity for residential customers through low average tariff levels and/or increasing block tariff structures, the cost of doing this may be high if the average level of the tariff is below cost recovery levels for the utility (Foster and Briceno-Garmendia, 2010; International Monetary Fund, 2013; Estache and Wodon, 2014). When subsidies are provided, they are often paid by the state, either directly or indirectly, and therefore compete with other priorities for public investments or social welfare programs. The subsidies may also distort price structures and incentives, and lead to inefficient use of electricity. The subsidies often reduce the ability of the utilities to carry adequate levels of maintenance for their networks and to invest more aggressively into generation capacity and network extension. It is also not clear whether electricity consumption subsidies are well targeted to the poor, given that many among the poor lack access to electricity. It could for example be that alternative subsidies such as connection subsidies would be better for poverty reduction, or that changes in tariff structures could help in reducing overall subsidies while not hurting the poor too much, freeing resources for other policies more conducive to poverty reduction.

In the case of Uganda, large subsidies were for many years by the government to the generation company in order to keep tariffs low. The subsidies increased substantially after the 2005–06 droughts which led to increased used of more costly thermal power. In 2011, the share of the electricity generated by thermal power plants had increased to 39 percent from seven percent in 2005. To offset higher generation costs, budgetary support was provided to the Uganda Electricity Transmission Company (bulk supplier) as well as to thermal power units, reaching 1.1 percent of GDP in fiscal year 2010/11.

These subsidies were eliminated, or at least substantially reduced in 2012, which required a substantial increase in tariffs. The impact of this increase in tariffs on households and especially the poor is discussed in chapter 7 of this study (the impact was small). This chapter assesses the extent to which previous electricity subsidies were targeted to the poor. Section 2 of the chapter describes the methodology. Section 3 provides the empirical results, which suggest that virtually none of the subsidies reached the poor. As an alternative to consumption subsidies, section 4 looks at the potential targeting performance of connection subsidies. A brief conclusion follows.

2. Methodology for Consumption Subsidies

This section outlines the methodology used to assess who benefited from electricity subsidies in Uganda until 2012. The methodology is reproduced from Angel-Urdinola and Wodon (2007; see also Angel-Urdinola et al., 2006, as well as Komives et al., 2005 and 2007, for an application to a large number of countries worldwide).

Define by S_P and S_H the amounts of subsidies granted to the poor and to the population as a whole respectively. The benefit targeting performance indicator Ω is the share of the subsidy benefits received by the poor (S_P/S_H) divided by the proportion of the population in poverty (P/H), where H denotes all households and P denotes the households who are poor. A value that is lower (greater) than one implies that the average subsidy for the poor is lower (greater) than the average subsidy received in the population as a whole. The parameter Ω can be computed from household surveys with data on expenditure on utility service provided that information is also available on the tariff structure. The value of Ω is:

$$\Omega = \frac{S_P}{S_H}\frac{H}{P} = \frac{\sum_{i=1}^{P} q_i(p_i - C)}{\sum_{i=1}^{H} q_i(p_i - C)}\frac{H}{P},$$

where q_i is the quantity consumed by household i and $p_i - C$ is the unit subsidy for household i (i.e., the difference between average unit price for the household and unit cost of service C assumed constant across households.)

The parameter Ω can be decomposed in five key factors affecting its value: access, take-up, targeting, rate of subsidization, and quantity consumed. The first factor is access to the network in the neighborhood where the household lives, denoted by A, with typically access for the poor lower than for the population as a whole ($A_P<A_H$). The second factor is take-up or usage of service when households have access, with often lower usage among the poor than the population as a whole conditional on access ($U_{P|A}<U_{H|A}$). The product of A and U is as before the connection or coverage rate (share of households using the service). The variables A and U affect the targeting performance of subsidies since in order to receive a subsidy households must first

consume the good that is subsidized. The third factor is subsidy targeting (conditional on usage), which takes a value of one for households who receive a subsidy, and zero otherwise. When utility consumption is subsidized for all users we have $T_{P|U}=T_{H|U}=1$. Beneficiary incidence (the probability of receiving or not the subsidy among a specific population group) is:

$$B_H = A_H U_{H|A} T_{H|U}$$

$$B_P = A_P U_{P|A} T_{P|U}$$

To estimate the benefit incidence (as opposed to the beneficiary incidence), two more factors must be taken into account: the rate of subsidization and the quantity consumed among those who benefit from the subsidy. If the average quantity consumed by subsidy recipients in the population as a whole is $Q_{H|T}$, and the average expenditure on the good is $E_{H|T}$, the average rate of subsidization is $R_{H|T} = 1 - E_{H|T} / (Q_{H|T}\ C)$. The average value of the subsidy received among subsidy recipients is then $R_{H|T}\ Q_{H|T}\ C$. For the poor, the average subsidy received among those who benefit from the subsidy is $R_{P|T}\ Q_{P|T}\ C$. Overall, the average subsidy benefits in the population as a whole and among the poor are:

$$\frac{S_H}{H} = B_H R_{H|T} Q_{H|T} C\ .$$

$$\frac{S_P}{P} = B_P R_{P|T} Q_{P|T} C\ .$$

This implies that:

$$\Omega = \frac{A_P}{A_H}\frac{U_{P|A}}{U_{H|A}}\frac{T_{P|U}}{T_{H|U}}\frac{R_{P|T}}{R_{H|T}}\frac{Q_{P|T}}{Q_{H|T}}\ .$$

Thus Ω is the product of five ratios for access, uptake, targeting, rate of subsidization, and quantity consumed. In most cases, the ratio of access rates will be lower than one (the poor tend to live in areas with lower access rates than the population as a whole), and the ratio of usage or take-up rates for the service will also be lower than one (when access is available in a neighborhood or village, the poor are less likely to be connected to the network than the population as a whole due to high costs of connection). Also, the quantities consumed in the population as a whole tend to be larger than those consumed by the poor. This means that the design of the subsidy mechanisms (through the values of T and R for the poor and the population as a whole) must be pro-poor if overall targeting is to be pro-poor (Ω larger than one).

To better understand the design of typical subsidy mechanisms, denote as before by q_i the quantity consumed by a particular household i and by e_i the expenditure for that household. Consider first a benchmark case corresponding to an inverted block tariff (IBT) structure with two price levels Π_A and Π_B with $\Pi_A < \Pi_B$. The reasoning can easily be extended to more blocks. The variable L denotes the consumption threshold (in kilowatt-hours per month) at which the unit price for the good shifts from Π_A to Π_B. In IBTs, L is often considered as a "lifeline", that is a level of consumption needed for a household to meet its basic needs. If we denote by t_i a dummy variable taking a value of one for a household eligible to benefit from the lifeline rate (and a value of zero otherwise), the expenditure of household i is:

[IBT]
$$e_i = \begin{cases} q_i \Pi_A & if \quad q_i \le L \\ L\Pi_A + (q_i - L)\Pi_B & if \quad q_i > L \end{cases}, \text{ with } t_i = 1 \text{ if } \{ q_i > 0 \}.$$

In that equation all households pay a unit price of Π_A per quantity consumed below the lifeline L, and for those who consume more than L, the price per unit consumed above that threshold is Π_B. Household wither higher consumption will pay a higher average price per unit consumed, but since all households with a positive consumption benefit from the lower unit prices for quantities below L, the targeting indicator t_i is equal to one, meaning that every household consuming some quantity benefits from a lower unit price for at least part of the quantity consumed. An alternative tariff structure is to grant the lower price Π_A only to those households consuming less than L. This is referred to as a Volume Differentiated Tariff (VDT):

$$[VDT] \qquad e_i = \begin{cases} q_i \Pi_A & if \quad q_i \le L \\ q_i \Pi_B & if \quad q_i > L \end{cases}, \text{ with } t_i = 1 \text{ if } \{ q_i > 0 \text{ and } q_i \le L \}.$$

In that equation, if total quantity consumed is above L, the unit price is Π_B, and this price applies to the total quantity consumed. In turn, since only the households who consume less than L benefit from the lower price Π_A, the targeting indicator takes a value of one only for those households. These equations enable us to compute subsidy rates for the poor and the population as a whole under alternative tariff designs. If we denote the average subsidy rate for the poor R_P (among poor households who benefit for at least part of their consumption from a lower tariff rate as compared to the average cost for the utility), we have:

$$R_P = \left(1 - \frac{\sum_{i=1}^{P} e_i 1(p_i = 1) 1(t_i = 1)}{C \sum_{i=1}^{P} q_i 1(p_i = 1) 1(t_i = 1)} \right),$$

where p_i takes a value of one for a household in poverty and zero otherwise, and $1(p_i = 1)$ and $1(t_i = 1)$ are indicator functions taking a value of one if the conditions are met (i.e., the household is poor in the first function, and the household benefits from a lower tariff rate on at least part of its consumption in the second function), and zero otherwise. Thus only households verifying these conditions are included in the estimation of the ratio of expenditures to costs. The subsidy rate at the national level R_H is calculated likewise among all households who benefit from the subsidy:

$$R_H = \left(1 - \frac{\sum_{i=1}^{H} e_i 1(t_i = 1)}{C \sum_{i=1}^{H} q_i 1(t_i = 1)} \right).$$

Finally, it is often useful to look at changes in targeting performance over time. Based on the above decomposition of targeting performance, Angel-Urdinola and Wodon (2012) suggest to look at the change in the share of the subsidies benefiting the poor, denoted by γ. By definition, this share is equal to:

$$\gamma = \frac{A_P}{A_H} \frac{U_{P|A}}{U_{H|A}} \frac{T_{P|U}}{T_{H|U}} \frac{R_{P|T}}{R_{H|T}} \frac{Q_{P|T}}{Q_{H|T}} \frac{P}{H}.$$

For notation purposes, define by A, U, T, R, Q, and Pov (for the share of households in poverty) the various ratios in the above equation, so that at time t, we have:

$$\gamma_t = A_t U_t T_t R_t Q_t Pov_t.$$

Then we have:

$$\begin{aligned}\Delta\gamma/\gamma = (\gamma_{t+1}-\gamma_t)/\gamma_t \approx\ & (\ln A_{t+1}-\ln A_t)+(\ln U_{t+1}-\ln U_t)\\ & +(\ln T_{t+1}-\ln T_t)+(\ln R_{t+1}-\ln R_t)\\ & +(\ln Q_{t+1}-\ln Q_t)+(\ln Pov_{t+1}-\ln Pov_t)\end{aligned}.$$

This decomposition enables us to look at why targeting performance changes over time. The same decomposition could also be used in order to assess the drivers of changes in targeting performance that follow from a change in the tariff structure.

3. Targeting Performance of Consumption Subsidies

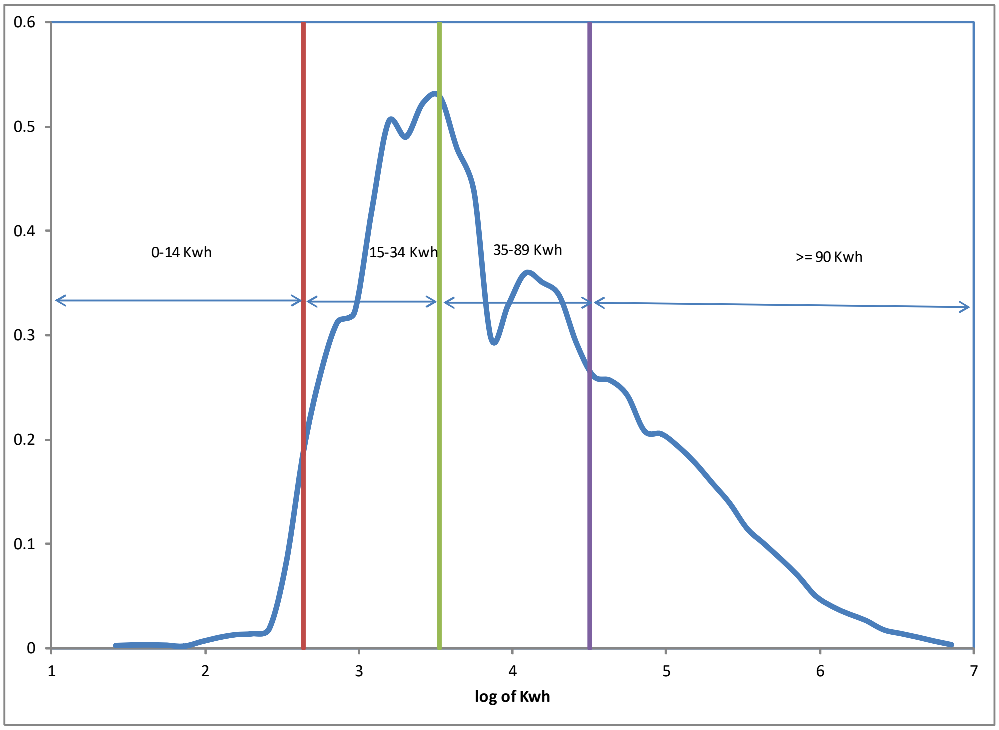
In Uganda as in many other developing countries, the electricity tariff follows an Inverted Block Tariff (IBT) structure, which means that the price per kWh increases with the quantity consumed by households. In 2009/10, before the reform of 2012, the tariff structure was as follows (see table 5.1 which provides the unit tariffs for 2009/10, as well as for the two previous survey years). The unit price was 100 UGx per kWh for consumption between 0 and 14 kWh. The unit price then increased to 385.6 UGx per kWh for the consumption above 14 KWh. There were thus only two blocks in the tariff structure, as was the case in previous years (in addition, a flat service charge is levied). There was an implicit subsidy in the tariff structure because the average level of the tariff was not high enough to fully cover the generation costs. This subsidy benefited all households to some extent since all households paid the lower unit price for the part of their consumption that fell in the lower (lifeline) bracket (consumption up to 15 kWh). Given that the surveys provide data on the amounts paid by households for their electricity, it is feasible to estimate the level of consumption of households using the above tariff structure. Figure 5.1 displays the density function for household electricity consumption in the 2009/10 survey. Fairly few households had a consumption level below the lifeline, but some did.

Table 5.1: Electricity Tariff Structure at the Time of the Household Surveys

2002/03		2005/06		2009/10	
Consumption (kWh)	**Unit Price (UGx)**	**Consumption (kWh)**	**Unit Price (UGx)**	**Consumption (kWh)**	**Unit Price (UGx)**
0-29	168.0	0-15	50.0	0-15	100.0
>30	168.0	>15	298.2	>15	385.6

Source: UMEME.
Note: Service charge not included.

Figure 5.1: Density Function for Residential Electricity Consumption, 2009/10



Source: Authors using Uganda 2009/10 UNHS.

Table 5.2 provides data on electricity consumption for the three survey years at the national, urban, and rural levels by welfare decile. The statistics are provided only for households connected to the network. There is quite a bit of coherence in the data for the three years as the level of consumption in kWh does not change much over time (the same was observed in chapter 2 when using data from UMEME to estimate average consumption levels per customer). In 2009/10 at the national level consumption per month among those connected to the network was on average at 76 kWh (84 kWh in rural areas versus 74 kWh in urban areas). Consumption levels were slightly lower in 2005/06 at 69 kWh on average nationally, and slightly higher in 2002/03 at 80 kWh (in those two years consumption levels among those connected is higher in urban areas than in rural areas). As expected, consumption levels are higher among richer households, with large consumption levels for the top deciles in comparison to the bottom deciles. When taking into account connection rates (which are provided in chapter 2), it can be shown that the top decile typically accounts for about 70 percent of total residential consumption, while the share accounted for by the seven bottom decile is well below 10 percent.

Table 5.2: Electricity Consumption by Decile among Those Connected, 2002-10

	2002/03			2005/06			2009/10		
	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
Decile 1	6.0	45.6	6.0	-	79.2	-	-	20.5	-
2	29.8	38.5	-	72.9	35.3	-	5.0	46.3	5.0
3	35.0	39.1	-	113.1	38.2	79.6	22.0	30.0	24.6
4	43.6	42.0	43.8	36.6	39.8	96.3	41.2	63.8	-
5	32.3	56.5	21.4	43.9	52.8	35.7	31.0	34.5	31.1
6	49.3	77.6	126.7	39.2	51.2	43.5	35.6	54.4	57.1
7	38.4	60.6	42.5	37.0	67.0	39.1	39.6	57.1	24.8
8	46.0	70.3	29.4	49.3	71.2	35.4	42.5	72.2	24.6
9	68.5	92.8	55.0	58.3	70.8	49.9	58.7	95.5	49.5
Decile 10	102.7	134.9	104.8	86.6	114.2	76.6	99.7	113.9	106.1
All	80.1	81.2	76.5	69.2	71.0	64.9	76.0	73.9	84.0

Source: Authors using Uganda 2002/03, 2005/06, and 2009/10 UNHS surveys.

In order to estimate who benefits from the implicit subsidies in the tariff structure, both in terms of the lifeline and the fact that average tariffs did not cover costs before the 2012 tariff increase, we need to make an assumption regarding the cost of service. For simplicity, and in the absence of detailed data on the cost structure of the utility, the price per kWh of the highest bracket in the tariff structure for residential customers is taken to represent full cost of delivery. This would be too low a cost in Uganda at the time, but the estimation of the targeting performance of the subsidies is not at all sensitive in Uganda to the choice of the parameter to represent costs, so this does not affect the results.

The results from the decomposition analysis are provided in table 5.3. The value of Ω is equal to 0.023 at the national level in 2009/10, versus 0.012 in 2005/06, and 0.024 in 2002/03. Changes in targeting performance between the three years are thus rather small. And targeting performance is extremely low essentially because virtually none among the poor are connected to the network due to lack of access and take-up when access is (at least in principle) available. Because of the effect of these “access factors”, the “subsidy design” factors do not play a meaningful role to improve targeting performance. Since the tariff structure is an IBT, the targeting parameters are equal to one for both the population as a whole and the poor. The assumed rates of subsidization are in some years slightly higher for the poor than the population as a whole, but not by much (these rates are underestimated due to the assumption regarding costs as mentioned above, but this does not affect the overall results since it is the ratio of those rates that matters). Finally, the quantities consumed are substantially higher for the population as a whole than the poor, which contributes further to poor targeting performance.

In all three years less than one percent of the subsidies reach the poor (γ parameter with $\gamma = \Omega \times (P/H)$). The official poverty measures for Uganda suggest that the share of households in poverty (P/H) in 2002/03 was 33.3 percent nationally versus 26.5 percent in 2005/06 and 19.3 percent in 2009/10 (the share of the population in poverty is higher, at 38.8 percent in 2002/03, 31.1 percent in 2005/06, and 24.5 percent in 2009/10 because the poor tend to have larger household sizes on average). This results in shares of electricity subsidies benefiting the poor equal to 0.4 percent in 2009/10, 0.3 percent in 2005/06, and 0.8 percent in 2002/03, all below one percent.

Table 5.3: Targeting Performance of Electricity Subsidies, 2002-10

	2002/03			2005/06			2009/10		
	National	**Urban**	**Rural**	**National**	**Urban**	**Rural**	**National**	**Urban**	**Rural**
	Detailed Decomposition Parameters								
A_N	0.208	0.774	0.091	0.223	0.794	0.102	0.228	0.849	0.084
A_P	0.056	0.426	0.036	0.053	0.423	0.027	0.042	0.505	0.014
$U_{N\|A}$	0.374	0.450	0.241	0.355	0.401	0.279	0.356	0.400	0.253
$U_{P\|A}$	0.078	0.1161	0.0538	0.017	0.009	0.027	0.056	0.054	0.062
$T_{N\|U}$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$T_{P\|U}$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$R_{N\|T}$	0.160	0.160	0.160	0.183	0.179	0.195	0.136	0.140	0.122
$R_{P\|T}$	0.160	0.160	0.160	0.160	0.161	0.160	0.538	0.512	0.741
$Q_{N\|T}$	80.12	81.18	76.53	69.18	70.98	64.93	76.02	73.90	84.02
$Q_{P\|T}$	30.41	37.26	24.46	79.46	79.20	79.55	15.08	20.25	5.00
	Ratios								
A	0.270	0.551	0.393	0.236	0.533	0.262	0.184	0.594	0.163
U	0.210	0.258	0.223	0.049	0.022	0.095	0.158	0.134	0.246
T	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
R	1.000	1.000	1.000	0.873	0.898	0.819	3.960	3.662	6.058
Q	0.380	0.459	0.320	1.149	1.116	1.225	0.198	0.274	0.060
	Omega and Gamma								
Ω	0.024	0.063	0.035	0.012	0.012	0.025	0.023	0.080	0.014
γ	0.008	0.006	0.013	0.003	0.001	0.008	0.004	0.005	0.003

Source: Authors using the Uganda 2002/03, 2005/06, and 2009/10 UNHS surveys.

Targeting performance does not change much over time in absolute terms, even if in proportional terms it does, since the value for γ in 2009/10 at 0.0044 is proportionately much lower than the value in 2005/06 at 0.0079. For the sake of completeness table 5.4 provides the results at the national level of the decomposition of the changes in targeting performance nationally between 2002/03 and 2009/10. Between the two years there was a large proportional decrease in the value of γ (there was a similar decrease within urban and rural areas). As shown in table 5.4, several factors contributed to that proportional decrease, but the various access and subsidy design factors in the decomposition tend to cancel each other out. As a result, the decrease in the share of the population in poverty between the two years accounted for much of the decrease in targeting performance over time (the smaller the share of the population in poverty is, the smaller the share of the benefits of a subsidy that reaches the poor will tend to be all other things being equal).

Table 5.4: Decomposition of Changes in National Targeting Performance, 2002-10

Ratios	2002/03	2009/10	Actual changes	2002/03 to 2009/10	Decomposition (approximation)	2002-10
A	0.2695	0.1837	% change in A	-0.3184	$\ln A_{t+1}-\ln A_t$	-0.3833
U	0.2095	0.1581	% change in U	-0.2453	$\ln U_{t+1}-\ln U_t$	-0.2815
T	1.0000	1.0000	% change in T	0.0000	$\ln T_{t+1}-\ln T_t$	0.0000
R	1.0000	3.9048	% change in R	2.9048	$\ln R_{t+1}-\ln R_t$	1.3622
Q	0.4230	0.1984	%change in Q	-0.5310	$\ln Q_{t+1}-\ln Q_t$	-0.7571
P/H	0.3326	0.1935	%change in P/H	-0.4183	$\ln Pov_{t+1}-\ln Pov_t$	-0.5418
Ω	0.0239	0.0225	% change in Ω	-0.0586	$\ln \Omega_{t+1}-\ln \Omega_t$	-0.0604
γ	0.0079	0.0044	% change in γ	-0.4524	$\ln \gamma_{t+1}-\ln \gamma_t$	-0.6022

Source: Authors using the Uganda 2002/03, 2005/06, and 2009/10 UNHS surveys.

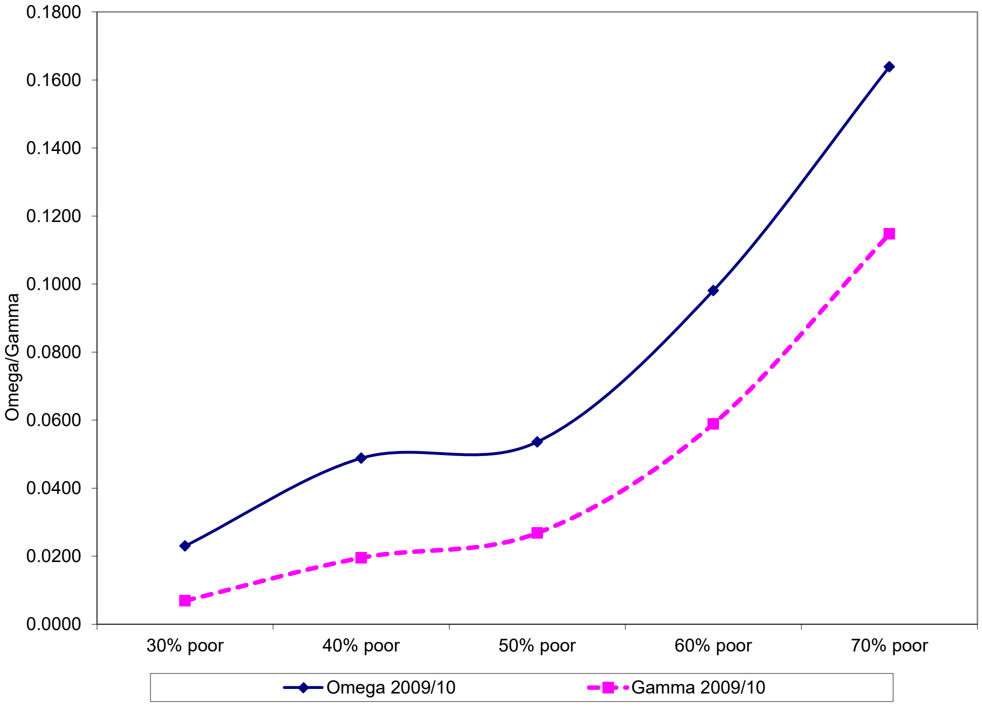
One could argue that electricity subsidies are not meant exclusively for the poor, but also for other vulnerable households. What would happen if the definition of the target group were changed? Would the subsidies be better targeted? To a limited extent they would, but the gains would be small, because so many households connected to the grid are concentrated in the top part of the distribution of consumption. Table 5.5 and Figure 5.2 provide the values of Ω and γ for the 2009/10 survey year under various definitions of the target group, considering "the poor" as representing the bottom 30 percent, 40 percent, 50 percent, 60 percent, and finally 70 percent of households (not population) in terms of consumption. Consider the share of the subsidies γ going to the various target groups so defined. Even when one considers the bottom 70 percent of households as the target group, γ takes on a value of only 11.5 percent, which is still very low.

Table 5.5: Targeting Performance under Alternative Poverty Lines, 2009/10

	30% Poor	40% Poor	50% Poor	60% Poor	70% Poor
Targeting performance Ω	0.0230	0.0488	0.0536	0.0981	0.1639
Share benefitting the poor γ	0.0069	0.0195	0.0268	0.0589	0.1147

Source: Authors using the Uganda 2009/10 UNHS surveys.

Figure 5.2: Omega and Gamma under Various Target Groups, 2009/10



Source: Authors using the Uganda 2009/10 UNHS survey.

What could be done to improve the targeting performance of electricity subsidies? In some countries which have a relatively high lifeline bracket (such as 80 kWh of consumption per month), experience suggests that reducing the levels of the lifeline consumption can improve targeting performance, but only very slightly, while not necessarily reducing substantially the level of spending for subsidies (Komives et al., 2005). In Uganda, reducing further the level of the lifeline would not make much sense, because it is already fairly low. Another alternative explored in other countries to improve targeting performance is to implement volume differentiated tariffs (VDTs) instead of IBTs. As explained earlier, under VDTs only those customers consuming below a certain threshold are subsidized. Thus instead of providing all customers with a subsidized first block of consumption as is the case in IBTs, VDTs provide a subsistence level of consumption at a lower price, but this lower price is accessible only to those who do not consume more than the subsistence level. VDTs typically improve targeting performance, again slightly, and they may also help reduce outlays for subsidies since only a subset of residential consumers are eligible to receive certain levels of subsidies.

In the case of Uganda, given the small share of customers below the lifeline and the fact that the tariff has only two blocks, this again would not make a major difference. The option that was chosen in 2012 was to simply eliminate tariffs (or at least substantially reduce them), and this will be discussed in chapter 7 of the study. It might perhaps make sense to introduce more blocks in the tariff structure (for example, many other countries have three blocks in their tariffs), but this is an issue beyond the scope of this study. What is clear is that in Uganda the consumption subsidies embedded in the tariff structure did not benefit the poor. The next section considers whether connection subsidies might.

4. Potential Targeting Performance of Connection Subsidies

Subsidies provided under the former tariff structures in Uganda did not reach the poor because of a lack of access and take-up rates among them. An alternative could be to provide connection instead of consumption subsidies. There is indeed evidence from willingness to pay studies that many among the poor would like to connect to the network. Unfortunately, initial power connection costs are high, at about US$80 (International Monetary Fund, 2013). Assuming that newly connected households would be on average poorer than households connected to the grid, connection subsidies could lead to substantially higher values for Ω and γ.

To analyze the potential performance of connection subsidies, simple simulations can be implemented with the household surveys. Denote the average subsidy rate for a connection subsidy received by a household in the population benefitting from such subsidies by $R^C_{H|T}$. This rate depends on the difference between the average cost of a connection (C^C), assumed constant for all households for simplicity, and the connection fee actually paid by households (F^C_H). The rate of subsidization $R^C_{H|T}$ is then $R^C_{H|T}=1–F^C_{H|T}/C^C$. For the poor it is $R^C_{P|T} = 1 – (F^C_{P|T}/C^C)$.

Three stylized scenarios for connections subsidies can be considered. First, we assume that connection subsidies are distributed in the same way as existing connections. This is a pessimistic assumption from a distributional point of view since it tends to favor better off households, but it may be realistic when access rates are low. In that case:

$$\Omega^{C1} = \frac{A_P}{A_H} \frac{U_{P|A}}{U_{H|A}} \frac{R^C_{P|T}}{R^C_{H|T}}$$

Secondly, new connections could be distributed randomly among households who are not connected, but live in a neighborhood where access is available. In that case:

$$\Omega^{C2} = \frac{A_P}{A_H} \frac{(1-U_{P|A})}{(1-U_{H|A})} \frac{R^C_{P|T}}{R^C_{H|T}}$$

Thirdly, new connection subsidies could be randomly distributed among all households who do not currently have access (an optimistic assumption given that many of these households do not live in neighborhoods with access). This would lead to:

$$\Omega^{C3} = \frac{(1 - A_P U_{P|A})}{(1 - A_H U_{H|A})} \frac{R^C_{P|T}}{R^C_{H|T}}$$

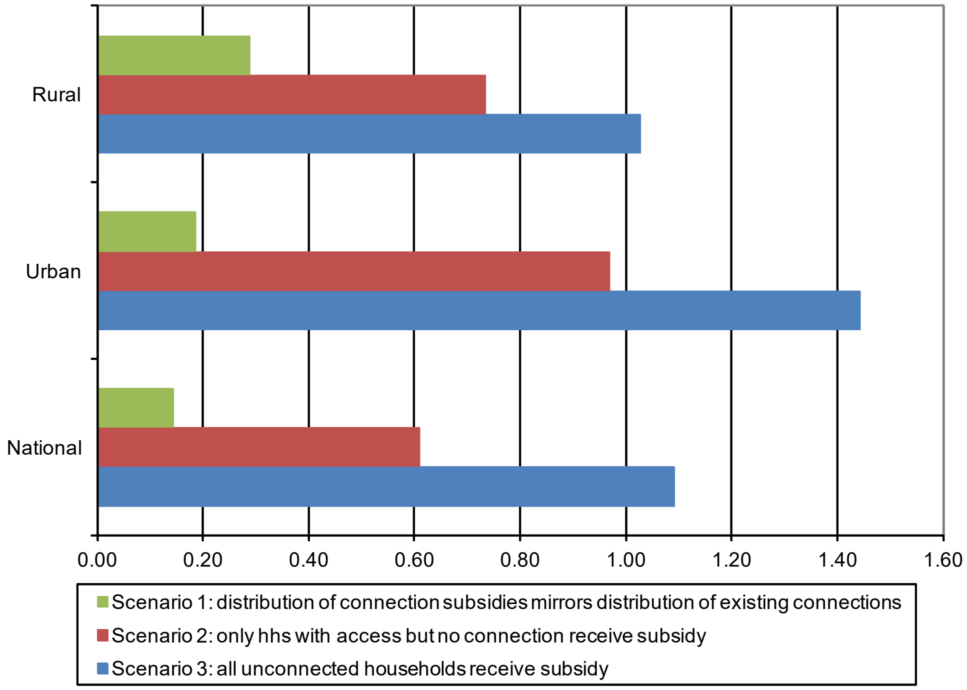
In most cases one would observe that $\Omega^{C1} < \Omega^{C2} < \Omega^{C3}$ although this does not need mathematically to be the case. Table 5.6 provides the results, which are also visualized in Figure 5.3. The simulations are done only with the 2009/10 survey. When connection subsidies are distributed to households similar to those with access, they are still not well targeted. But under the other two scenarios, they are (of course) better targeted than consumption subsidies. In the second scenario which assumes that households who benefit from new connections are selected from currently non-served households living in areas with access, Ω is nationally at a value of 0.610. In the third scenario, which is the least realistic, targeting performance is above one.

Table 5.6: Simulated Targeting Performance of Connection Subsidies, 2009/10

Scenarios	**National**	**Urban**	**Rural**
Case 1: New connection mirror the distribution of existing connections	0.143	0.186	0.289
Case 2: New connections for households with access but no connection	0.610	0.969	0.735
Case 3: New connections to randomly selected households not connected	1.091	1.443	1.027

Source: Authors using Uganda 2009/10 UNHS survey.

Figure 5.3: Simulated Targeting Performance of Connection Subsidies, 2009/10



Source: Authors using Uganda 2009/10 UNHS survey.

While connection subsidies clearly have the potential to be better targeted than consumption subsidies, they should be implemented at scale only when generation capacity is sufficient, and when considered, they need to be implemented well to ensure good targeting and limit costs. This has not always been the case. In their study on social water connections in Abidjan and Dakar, Lauria and Hopkins (2004) explain how social connections were financed through a Water Development Fund paid for through a surcharge on water tariffs. Unfortunately, poor targeting resulted in 90 percent of residential connections in Abidjan being eligible for the subsidy. In fact, some of the connected households paying the surcharge were found to be poorer than many of the households receiving the new social connections. The program suffered from distorted incentives as flat fees paid for each social connection to private operators were an incentive for them to increase the number of subsidized connections while seeking for these "social" connections richer households who were likely to consume more water (so that the utilities would reap higher revenues) and were located closer to the pipes (to minimize the cost of connecting). According to the authors, these distortions may in fact have led to reductions in connection rates (or at least delays in the time needed for connection) among poor households who lived in informal settlements. The fact that the social connections required households to own the land on which their dwelling was located also probably undermined the targeting performance of the program. This example makes it clear that for connection as well as for consumption subsidies, good design of the subsidy mechanism is required for the subsidy to actually reach the poor.

5. Conclusion

This chapter was devoted to an assessment of the targeting performance to the poor of the implicit subsidies embedded in the tariff structure until 2012. The framework for this assessment allowed for measuring both "access" and "subsidy design" factors that affect targeting performance. Due to very low connection rates to electricity among the poor, electricity subsidies were very poorly targeted. Less than one percent of the subsidies reached the poor. Changing some of the parameters of the tariff structure, such as the number of blocks, or relying on VDT s opposed to IBT tariffs would not improve the targeting performance substantially simply because of the weight of access factors. By contrast, providing connection subsidies as opposed to consumption subsidies might increase the share of the subsidies that would be received by the poor. Overall, these results are not surprising, but they provide a useful quantification of basic parameters that can inform policy towards access and affordability of electricity in Uganda. From the point of view of poverty reduction, eliminating the electricity subsidies in 2012 was the right thing to do, simply because virtually none of those subsidies reached the poor.

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CHAPTER 6
TARGETING PERFORMANCE OF ELECTRICITY SUBSIDIES IN AFRICA

Clarence Tsimpo and Quentin Wodon

As shown in the previous chapter, electricity subsidies in Uganda used to be very poorly targeted. How did Uganda compare to other sub-Saharan countries? Using the same framework as in chapter 5, this chapter compares the targeting performance of electricity subsidies embedded in tariff structures in 18 countries, including Uganda. The influence of access factors on targeting performance is such that the subsidies in the various countries tend to be poorly targeted in general. However, except for Rwanda, in no other country were they as poorly targeted than in Uganda. The chapter also considers the potential performance of connection subsidies under various scenarios – these subsidies would in all likelihood be better targeted to the poor than existing consumption subsidies.

1. Introduction

In Uganda, large electricity subsidies were provided until 2012 to all classes of customers – domestic, but also commercial and industrial. These subsidies have now been eliminated, but it is interesting still to compare the targeting performance of the subsidies as they existed until the 2012 tariff increase to subsidies embedded in the tariff structures of other sub-Saharan African countries. This is the purpose of this chapter, which also considers connection subsidies. Even though large electricity subsidies are often poor policy in the African context (Komives et al., 2005; Banerjee et al., 2010; International Monetary Fund, 2013; Alleyne, 2013; Estache and Wodon, 2014), the reasons why many countries subsidize electricity are not hard to understand. Governments aim to make electricity affordable for the population, including the poor. When increases in oil prices led to higher utility costs in many countries that depended in part or entirely on thermal power generation, many did not reflect these higher costs fully in their electricity tariff structures. As a result, many utilities are not able to cover their costs, or if they do, they often cannot afford to properly maintain their network, yet alone expand it (the lack of proper maintenance of, and investments in, existing networks may in fact be an implicit subsidy in itself since customers then do not pay for costs that will have to be paid by others – typically the government, at some point). Increasing tariffs is also politically difficult for governments since such increases are highly visible for customers who will feel it right away, while they may not know much about the medium term cost structures of the utilities and the need for increases. Such increases in tariffs affect urban populations the most, but these are precisely the populations that are most likely to be vocal, maybe even take up to streets against such increases.

While the temptation is high to keep subsidizing electricity tariffs for residential customers (as well as in many cases for commercial and industrial customers, but for other reasons), the cost of doing this is however potentially high, as discussed in chapter 5. The cost of generating, transmitting and distributing electricity is often high in Africa, in part because the populations served by the electricity grid are often small, which prevents to some extent the utilities to reap the full benefit of economies of scale. In addition, many countries are landlocked, with high transportation costs, and limited hydroelectric power, which also contributes to high generation costs due to the need to rely on thermal power. Thus, due in part to high and increasing generation costs, subsidies that may appear to be limited at the household level tend to be very expensive at the macroeconomic level, especially when compared to the limited resources available to governments through taxation and aid. Said differently, under strict budget constraints, subsidizing electricity has a direct cost in terms of crowding out today or in the future (typically through the accumulation of debt for the utilities that are guaranteed by governments) resources for public interventions aimed at poverty reduction and development.

In addition, there is an additional perverse incentive that derives from the inability of utilities to cover their costs due to low tariffs. When utilities are operating at a loss, or at least cannot properly fund their maintenance and investment needs, they have no incentives to expand the network, since expanding the network would probably imply increasing their losses. At the margin, new customers may be poorer than existing customers, thereby increasing the cost of delivery and also increasing the risk of non-payment. Furthermore, when investments are not sufficient, expanding the network to new customers is also problematic because of the limited generation capacity installed, which already translates into service cuts during the day. Finally, adding consumption through an expansion of the network often tends to further increases the average cost of generating electricity, since at the margin, even when countries have access to cheap hydroelectric power, the additional demand must be met through costly fuel generation.

The upshot of the above is that many utilities are trapped in a vicious circle. It can be shown that for the poor, the benefits of network extension are substantially larger than the benefits from the subsidization of electricity consumption. At the same time, without enough revenues to cover their operating and maintenance costs fully, utilities cannot seriously think about network expansions, as this might exacerbate their losses. In addition, poor quality of service, which is in part the consequence of the lack of revenues, limits the willingness of customers to pay a higher price for a service that is considered by them as deficient, due for example to service cuts during the day. As to regulatory agencies and governments, when hit by substantial price increases for oil, and thereby for the cost of generating thermal power, they are under pressure to reduce existing subsidies, especially in the context of their broader commitment to implement poverty reduction and development strategies. But the fear of discontent in the population makes such a reduction in subsidies difficult to implement. All parties are trapped in a situation that does not benefit them, with limited ability to move forward.

In this context, the contribution of this chapter is to try to demonstrate a simple fact: that electricity subsidies are among the least well targeted subsidies that governments can implement, and that therefore the argument regarding the need to preserve these subsidies in order to make the service affordable for the poor, while valid for the small fraction of the poor who may already be connected to the network, does not hold when considering what is required to accelerate poverty reduction and economic development more broadly, including through network expansion. Said differently, even if some poor households would be hurt by a removal or substantial reduction in the electricity subsidies that are prevailing in many countries, the gains that could be achieved by reallocating the resources now allocated to these subsidies could be very large, with many other poor households benefiting, and with a restoration of sustainability and profitability in the sector also conducive to growth itself.

The structure of the chapter is as follows. Section 2 introduced the methodology used for the analysis as well as the data sources. In section 3, the data are used estimate the targeting performance of consumption subsidies embedded in the residential tariff structures for electricity. The framework for the analysis is the same as that used in chapter 5, and it demonstrates clearly not only that electricity subsides are poorly targeted, but also why in terms of access and subsidy design factors. Section 4 discusses, again as done in chapter 5 for Uganda, the potential targeting performance of connection subsidies. A brief conclusion follows.

2. Methodology and Data

This chapter applies the subsidy decomposition framework presented in chapter 5 to household survey data from 18 African countries. In terms of methodology, as a brief reminder (this was already discussed in chapter 5), define by S_P and S_H the amounts of subsidies granted to the poor and to the population as a whole respectively. The benefit targeting performance indicator Ω is the share of the subsidy benefits received by the poor (S_P/S_H) divided by the proportion of the population in poverty (P/H), where H denotes all households and P denotes the households who are poor. A value that is lower (greater) than one implies that the average subsidy for the poor is lower (greater) than the average subsidy received in the population as a whole. The targeting parameter Ω can be decomposed in five key factors affecting its value: access, take-up, targeting, rate of subsidization, and quantity consumed.

The first factor is access to the network in the neighborhood where the household lives, denoted by A, with access for the poor often lower than for the population as a whole (typically $A_P<A_H$). The second factor is take-up or usage of service when households have access, with often lower usage among the poor than the population as a whole conditional on access (typically $U_{P|A}<U_{H|A}$). The product of A and U is as before the connection or coverage rate (share of households using electricity from the grid). The variables A and U affect the targeting performance of subsidies since in order to receive a subsidy households must first consume the good that is subsidized. The third factor is subsidy targeting (conditional on usage), which takes a value of one for households who receive a subsidy, and zero otherwise. When utility consumption is subsidized for all users as is the case with a traditional inverted block tariff structure, we have $T_{P|U}=T_{H|U}=1$. The last two factors are the rate of subsidization of electricity among those benefiting from subsidies versus the cost of providing the service (typically $R_{P|T}>R_{H|T}$) and the quantity consumed among those who benefit from the subsidy (typically $Q_{P|T}<Q_{H|T}$). The value of the targeting parameter Ω can be shown to be equal to:

$$\Omega = \frac{A_P}{A_H}\frac{U_{P|A}}{U_{H|A}}\frac{T_{P|U}}{T_{H|U}}\frac{R_{P|T}}{R_{H|T}}\frac{Q_{P|T}}{Q_{H|T}}.$$

As already mentioned, in most cases, the ratio of access rates will be lower than one (the poor tend to live in areas with lower access rates than the population as a whole), and the ratio of usage or take-up rates for the service will also be lower than one (when access is available in a neighborhood or village, the poor are less likely to be connected to the network than the population as a whole due to high costs of connection). The quantities consumed in the population as a whole tend to be larger than those consumed by the poor. This means that the design of the subsidy mechanisms (through the values of T and R for the poor and the population as a whole) must be highly pro-poor if overall targeting is to be pro-poor (Ω larger than one), and this is very rarely (if not ever) the case with existing tariffs in sub-Saharan African countries.

As was the case in chapter 5, we also simulate connection subsidies as an alternative to consumption subsidies. Three stylized scenarios are considered. First, we assume that connection subsidies are distributed in the same way as existing connections, leading to a first estimate of potential targeting performance Ω^{C1}. This is a pessimistic assumption from a distributional point of view since it tends to favor better off households, but it may be realistic when access rates are low. Second, we assume that new connections are distributed randomly among households who are not connected, but live in a neighborhood where access is available (Ω^{C2} estimate). Third, we assume that new connection subsidies are randomly distributed among all households who do not currently have access (Ω^{C3} estimate, which is optimistic assumption given that many of these households do not live in neighborhoods with access). In most cases we would expect that $\Omega^{C1} < \Omega^{C2} < \Omega^{C3}$ although this does not need to be the case. If we assume that the connection costs and connection subsidies are the same for all households, the three estimates are defined as:

$$\Omega^{C1} = \frac{A_P}{A_H}\frac{U_{P|A}}{U_{H|A}} \qquad \Omega^{C2} = \frac{A_P}{A_H}\frac{(1-U_{P|A})}{(1-U_{H|A})} \qquad \Omega^{C3} = \frac{(1-A_P \times U_{P|A})}{(1-A_H \times U_{H|A})}$$

In terms of data we rely on household surveys which for most countries are from the middle of the last decade, because this work was initially done in 2008 for a report on infrastructure needs in Africa. In the case of Uganda however, we use the results from the 2009/10 survey presented in the previous chapter. While for the other countries more recent surveys are often available, as was shown in the analysis for Uganda for the period 2002 to 2010 in chapter 5, the value of the targeting parameter Ω does not actually change very much from one year to the next because access and take-up rates do not change too much either, and the structure of the tariff structures does not tend to be altered much either (the elimination of subsidies in Uganda in 2012 was an exception). This implies that at least for illustrative and comparative purposes of the targeting of Uganda's subsidies (when they were implemented) with the subsidies in other sub-Saharan African countries, the results essentially remain valid.

The surveys provide information on how much households spend on electricity. The tariff structures prevailing at the time of the survey are used to obtain the level of consumption of the household in terms of kWh per month. For standardization, in the absence of detailed data on the cost structure of the utilities, the price per kWh of the highest bracket in the tariff structure for residential customers is assumed to represent cost. Typically, the estimation of the targeting performance of the subsidies is not very sensitive to the choice of the parameter to represent costs. Given that in most cases, the average price paid by customers is well below the cost of provision, the use of the highest bracket as an approximation for costs seems reasonable.

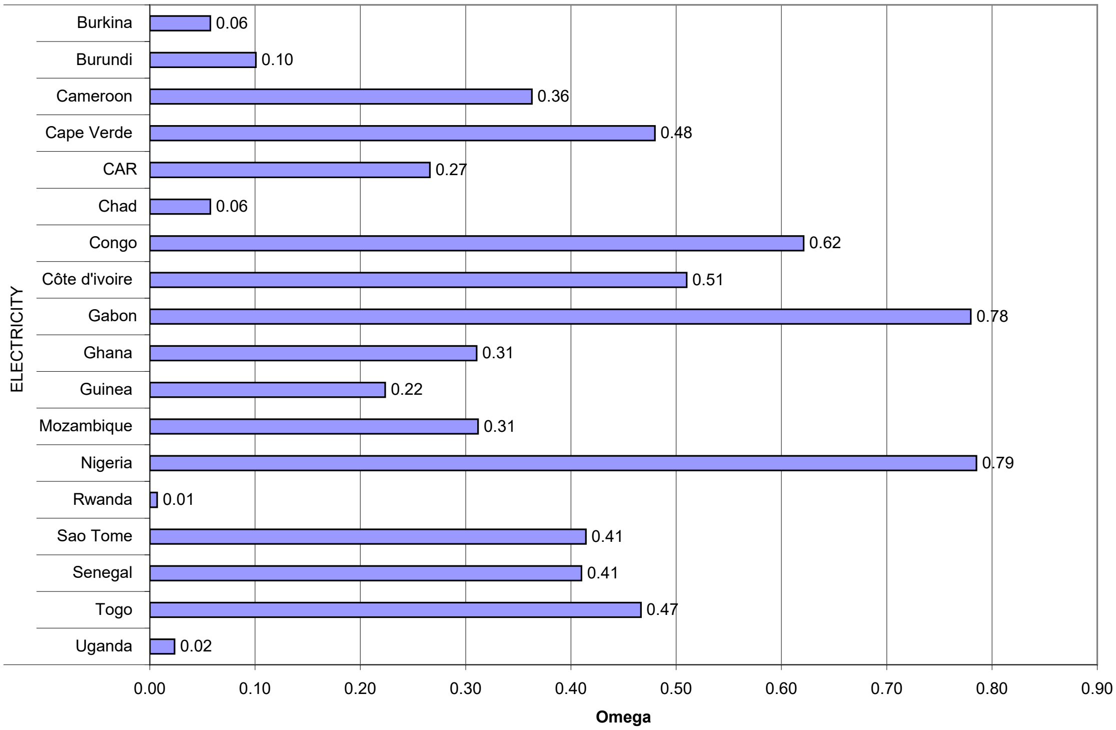
The list of countries included in the estimation and the corresponding household survey year for each country is as follows: Burkina Faso (2003); Burundi (2006); Cameroon (2001); Cape Verde (2006); Central African Republic (2007); Chad (2003); Congo (Republic of, 2005); Cote d'Ivoire (2001); Gabon (2005); Ghana (2006); Guinea (2003); Mozambique (2003); Nigeria (2005); Rwanda (2001); Sao Tome (2005); Senegal (2001); Togo (2005); Uganda (2009/10). The tariff structures in most countries were traditional inverted block tariff structures (see Briceño-Garmendia and Shkaratan, 2011, for a description of the tariff structures in those and other African countries). More precisely, in ten countries in our sample including Uganda, residential customers consuming a lower amount of kWh per month paid a lower price per kWh than customers consuming higher amounts, with typically three to four blocks in the tariff structure. In three countries, larger consumers paid the lowest price and in another two countries, the middle level consumers paid the lowest price per kWh. Finally, in three countries, all consumers paid the same price regardless of their consumption level.

3. Consumption Subsidies

In order to facilitate the visualization of the results, we rely in this chapter on graphical representations of the estimates instead of tables. Figure 6.1 gives the values of Ω for the consumption subsidies embedded in the tariff structures of the 18 countries. In all cases, the value of Ω is much lower than one, suggesting that on average the benefits from the subsidies going to the poor are much lower than for the population as a whole. Nigeria and Gabon are the countries with the highest values of Ω (0.79 and 0.78 respectively), followed by the Republic of

Congo with a value for Ω of 0.62, and Côte d'Ivoire, with a value of 0.51. For the other countries, the values are below 0.50 so that on average the subsidy received by a poor household is less than half that received by a randomly selected household in the overall population. The values of Ω in some countries are extremely low (especially in Rwanda and Uganda, as well as Burkina Faso, Burundi, and Chad,). In a third of the countries, the values are between about a third and half (Cameroon, Cape Verde, Ghana, Mozambique, Sao Tome, Senegal and Togo).

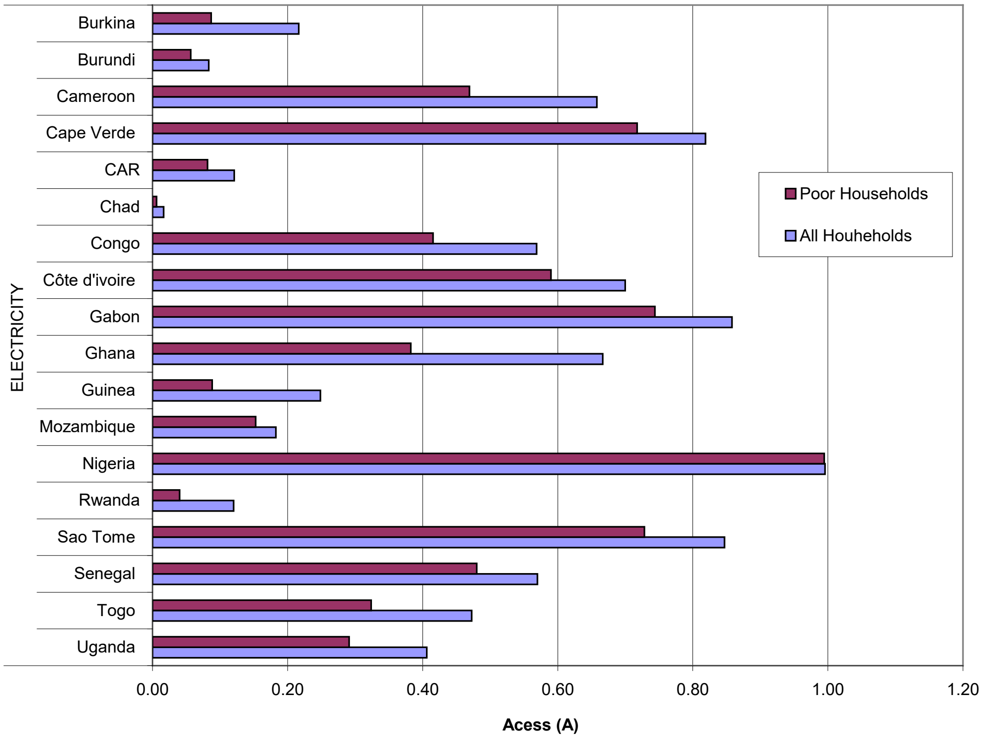
Figure 6.1: Targeting Performance (Ω) of Electricity Subsidies, Selected Countries

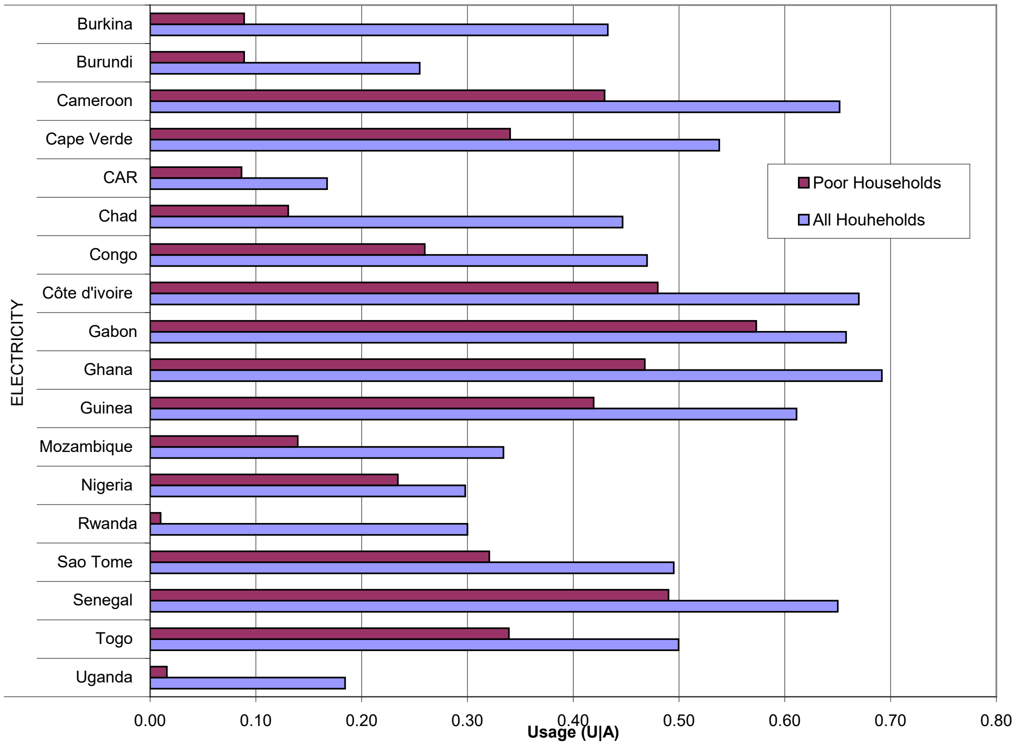


Source: Authors.

Access rates as well as take-up rates when access is available are key factors that contribute to weak targeting performance for existing subsidies. First, access is often not available, especially in the areas where the poor live ($A_P < A_H$). Furthermore, poor households having at least in principle access to the grid in there are also less likely than the average household living in an area with access to use the service, whether this is because they may not be able to afford to pay for electricity, or because even if access is available in the area, the grid may still be located too far away from their dwelling. In terms of the methodological framework this means that $U_{H|A} < U_{P|A}$. The combination of the values obtained for A and U|A gives the actual connection or coverage rates in the population as a whole and among the poor. Figure 6.2 displays the values of A and U|A for the population as a whole and for the poor.

Figure 6.2: Access To and Usage of Electricity Services, Selected Countries



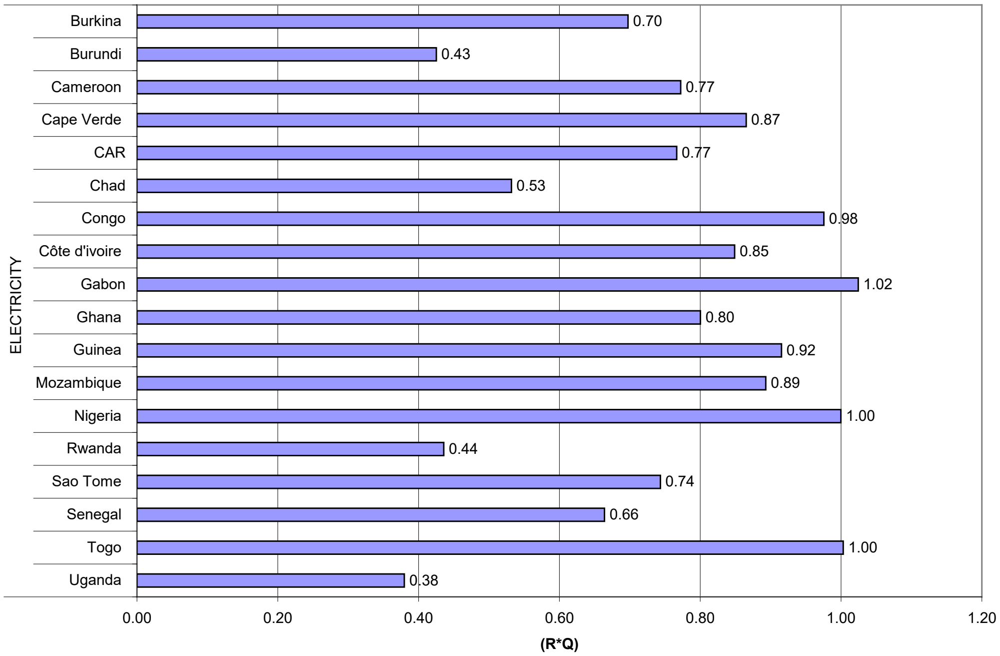


Source: Authors.

Beyond differences in access and take-up rates between the poor and the overall population, poor subsidy design also limits the targeting performance of consumption subsidies. The subsidies are meant to benefit the poor. This is supposed to be the case for IBT tariffs, assuming that the poor have much lower levels of consumption than the population as a whole. But since IBTs enable all residential customers to benefit from subsidies in the lower brackets of consumption, they also benefit households who are better off, unless the upper tariffs in the IBT schedule are such that the subsidy provided to the better off in lower consumption brackets is reduced by a surcharge for the consumption in the higher brackets, but this is rarely the case in Sub-Saharan Africa because tariffs rarely achieve full cost recovery. Thus, under an IBT structure, all households typically benefit from at least some level of subsidy, and the targeting parameter T|U is equal to one for both the population as a whole and the poor.

What about the rates of subsidization and the quantities consumed, namely the parameters R|T and Q|T in the framework? Figure 6.3 displays the product of these two parameters in the 18 countries. In many countries, the parameter R|T is higher for the poor than the population as a whole (noting that this parameter is estimated under strong assumptions), but this is more than compensated for parameters Q|T, which is substantially higher for the population as a whole than the poor. Taking account the assumed rate of subsidization, the quantity consumed by the beneficiaries of the subsidy determines the total value of the subsidy received. Figure 6.3 displays the product of the last two ratios in the estimation of Ω. The figure suggests that although rates of subsidization are higher for the poor than the overall population (because the poor consume less on average, hence pay tariffs associated with lower blocks of the IBT schedules), the differences are not large enough to compensate for the higher consumption levels among the overall population than the poor. In all countries the product of the three subsidy design factors takes a value below one, contributing to poor targeting.

Figure 6.3: Product of the Subsidy Design Factors, Selected Countries



Source: Authors, assuming T|U is equal to one for all households.

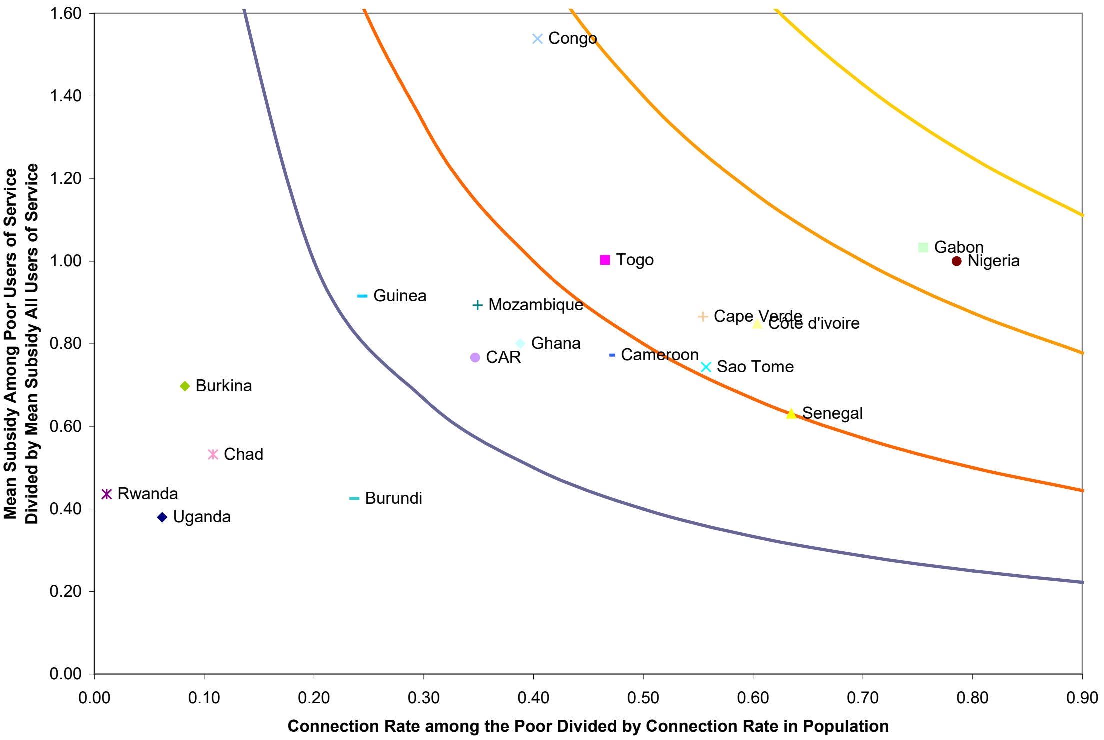
Figure 6.4 summarizes the evidence provided in the previous Figures by providing a scatter plot of the access and subsidy design factors affecting targeting performance, so that Ω = (Access Factors) x (Subsidy Design Factors). The two access factors are whether a household lives in an area served by the grid and when this is the case, whether the household is actually connected to the gird (i.e., whether the household actually "takes up" the service). The value of the access factors variable is thus the rate of connection or coverage among the poor to the grid (which depends on access and uptake when there is access) divided by the rate of connection in the population as a whole. This variable is presented on the horizontal axis in Figure 6.4, and as expected, it is much lower than one for all countries simply because the poor have much lower connection rates than the population as a whole on average.

The second aggregate variable affecting targeting performance is related to subsidy design and takes into account who benefits from subsidies among households connected to the grid and how large the subsidies are, which itself depends on the rate of subsidization and the quantity consumed. What the vertical axis represents is thus the ratio of the average subsidy among all poor households who are connected to the network, divided by the average subsidy among all households connected to the network, whether poor or non-poor. Again, in all countries, the products of the subsidy design factors take on values below one. The reason is that while the rate of subsidization of the poor who are connected (i.e., the discount versus the full cost of service) is often larger than for the population connected as a whole, the quantities consumed by all the poor who connected tend to be lower than those consumed by the overall connected population. Therefore the average subsidy received by the poor who are connected is lower than for the overall connected population (note that in all countries, we have $T|U$ equal to one for the poor and the overall population connected).

The countries placed lowest on the scatter plot in Figure 6.4 (the bottom left corner) have the worst targeting performance, and this include Uganda as discussed earlier. The curves through the scatter plot indicate equal values for the targeting performance parameter Ω.

What could be done to improve targeting performance? As discussed in chapter 5, the experience suggests that reducing the levels of consumption for the first bracket of the tariff structure (the "lifeline") in countries with an inverted block tariff (IBT) structure does not lead to a large gain in targeting performance. One alternative is to implement instead volume differentiated tariffs (VDTs). Under VDTs only those customers consuming below a certain threshold are subsidized. Thus instead of providing all customers with a subsidized first block of consumption as is the case in IBTs, VDTs provide a subsistence level of consumption at a lower price, but this lower price is accessible only to those who do not consume more than the subsistence level. VDTs typically do improve targeting performance, although in most cases not by much, but their main benefit is that they may help in reducing the overall cost of subsidies. Another alternative is connection subsides, which are discussed next.

Figure 6.4: Access and Subsidy Design Factors Affecting Targeting Performance

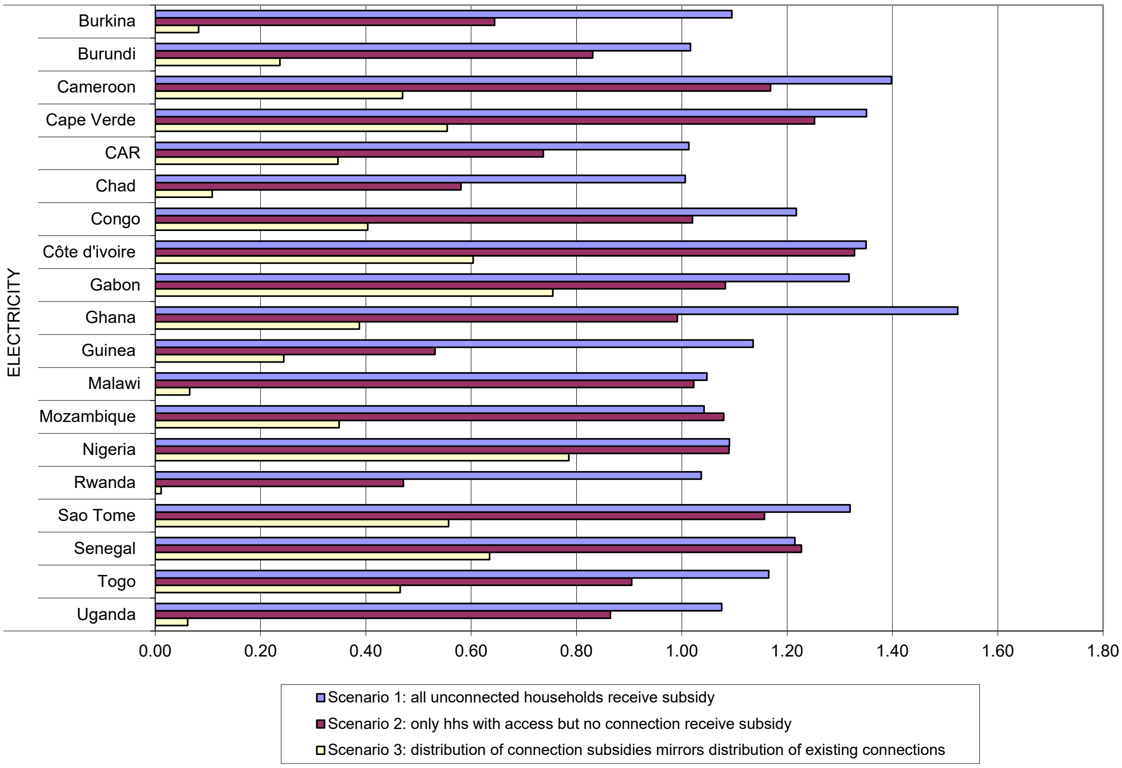


Source: Authors.

4. Connection Subsidies

Changing subsidy design factors has the potential to improve targeting performance, but probably not to satisfactory levels. This is because the subsidies provided under the tariff structures do not solve the underlying issue of a lack of access and take-up rates among the poor. Using geographic targeting or proxy means-testing may also bring better results in terms of targeting performance, but these targeting systems are not practical to implement in many sub-Saharan African countries. One other alternative to improve targeting performance could be to provide connection instead of consumption subsidies. Assuming than newly connected households are poorer than households already benefiting from connections, this could lead to higher values for Ω. Figure 6.5 provides estimates of potential targeting performance for connection subsidies under the three scenarios considered in the methodological discussion in section 2. As expected, the value of Ω is largest under the assumption that new connections benefit households who are selected randomly from the population without a connection. In all cases, Omega is larger than one under that assumption. Yet the assumption is not realistic, because many of those households are located in areas that are not yet served by the network. The second scenario assumes that households who benefit from new connections are selected from currently non-connected households living in areas where there is already access to the grid. The values of Omega in that case, while often lower than one, are still much better than the targeting performance of existing consumption subsidies. In the third scenario, new connections are distributed in a similar way to existing connections, in which case targeting remains poor.

Figure 6.5: Potential Targeting Performance of Connection Subsidies



Source: Authors.

As was the case in chapter 5, it should be noted however that while connection subsidies have potential, they need to be implemented well to ensure good targeting and limit costs. In their study on social water connections in Abdijan and Dakar, Lauria and Hopkins (2004) show that connection subsidies for piped water in Côte d'Ivoire were not well targeted. The program suffered from distorted incentives as flat fees paid for each "social" connection to private operators led them to maximize subsidized connections especially among households who did not need them (targeting better off households helped the utilities reap higher revenues with lower connection costs as those households tend to be located closer to the network). These distortions may have led to a reduction in connections for the poor living in informal settlements. This example makes it clear that for connection subsidies as well, proper design is important.

5. Conclusion

Several clear messages emerge from the analysis of the targeting performance of electricity subsidies and the decomposition of this targeting performance into key factors driving it. Overall, consumption subsidies for electricity appear to be very poorly targeted in African countries, including Uganda. Several reasons explain this poor performance. First, access factors are important in determining the potential beneficiaries of consumption subsidies. When poor households live in areas without service, it is impossible for them to connect to the grid. Even when there is potential access to the service where the poor live, many among the poor remain not connected, either because they live still too far from the grid or because the cost of connecting and purchasing the equipment needed to use electricity may be too high. In order to compensate for the negative impact of access and take-up factors on targeting performance, good subsidy design mechanisms are required. Unfortunately, traditional inverted block tariff structures tend to be poorly targeted. They spread subsidies across all households connected to the network, since even those who consume high amounts of electricity benefit from some level of subsidy for the part of their consumption that belongs to the lower level blocks of the tariff structure. In addition, the lower blocks in many countries (not in Uganda where the lifeline is low) are often too high in terms of consumption levels in kWh per month to target the poor well.

One alternative to improve the targeting performance of electricity subsidies is to move from traditional IBTs to Volume Differentiated Tariff structures, whereby the lower prices for smaller consumption levels can be obtained only by those households who consume very little and are more likely to be poor. Although this was not shown in this chapter, in most cases, this would have only a limited impact on targeting performance, but it would help in reducing the amount of subsidies allocated by governments to electricity consumption. Another alternative would be to provide connection as opposed to consumption subsidies, assuming that the generation, transmission, and distribution capacity is sufficient to expand the network. The simulations implemented in this chapter suggest that this alternative could have a larger impact on targeting performance than simply changing at the margin the characteristics of tariffs.

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CHAPTER 7
IMPACT OF THE ELECTRICITY SUBSIDY REMOVAL

Clarence Tsimpo, Quentin Wodon, and John M. Matovu

Large subsidies used to be provided by Uganda's government to keep electricity prices low. In 2012, these subsidies were abolished, which resulted in a substantial increase in tariffs for all classes of customers. This chapter assesses the impact of this increase in tariffs on households and the broader economy using micro- and macroeconomic analysis techniques. The macro simulations also consider the potential impact of efficiency gains in the sector. The results suggest that that the removal of the subsidies did not affect poverty in any substantial way, and that it probably also had only a minimal impact on the economy. While some sectors like manufacturing may have been affected negatively, this should have been compensated by gains in other sectors. If efficiency gains were achieved in the sector, this would generate clear gains for all.

1. Introduction

Energy has long been an integral part of the Ugandan Government's National Development Plan which includes references to the link between energy and poverty reduction. The Government has set targets in a range of areas, including rural electrification and renewable energy. Electricity and the broader energy sector are meant to play a key role in the development of the economy. Increased investments in the sector are needed to meet growth in demand, and the cost recovery model that persisted with its large subsidies until 2012 was not sustainable.

Governments often support the production or consumption of energy in several ways. Apart from direct subsidies, these include supporting generation, providing guarantees and tax incentives, or providing grants or low interest rate loans. The full extent of the subsidies in the case of Uganda is not well documented. Notwithstanding their exact value, the subsidies for keeping electricity prices low that could be well documented by the time they were abolished in 2012 were large. They had grown from 2.5 percent of the government's budget in 2005/06 to 4.3 percent in 2009/11 and over 1.1 percent of GDP. The subsidies were meant to cover part of the costs of generation, which was well above the relatively low tariff rates. This growth in subsidies for the sector limited fiscal space for other sectors and it contributed to the fiscal deficit.

When electricity subsidies were introduced in Uganda in 2005, this was part of an effort to increase power supply through thermal power generation, which was more expensive than hydropower[4], without correspondingly increasing tariffs for households and firms, so as not to affect social welfare and economic development. But the subsidies increased over time and competed with funding for other essential services. They probably discouraged supply-side and demand-side efficiency improvements, promoted non-economic consumption of energy, and made new forms of renewable energy less competitive. Virtually none of the subsidies for residential customers reached the poor because the poor were not connected to the grid.

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[4] Uganda's long-run marginal costs could be substantially lower than current average costs, but this will require substantial investment. By developing its hydro-power potential the country can reduce generation costs from US$0.16 to around US$0.12 per kWh (Ranganathan and Foster, 2012). The Bujagali power project was the first step in that direction, and a number other major hydro projects are undertaken that could double generation capacity.

As noted by the International Monetary Fund (2013), previous attempts at cost recovery were not successful. Tariffs were raised in June and November 2006 (this tariff increase was considered as acceptable by households, as noted by Sendegeya et al., 2009), but they remained flat between 2007 and 2009 despite rising generation costs due to a depreciating currency, higher fuel prices, and delays in. When tariffs were increases again in January 2010, they reached only two thirds of the cost of supply. When subsidies were eliminated in January 2012, the average tariff had to increase by more than 40 percent, and it is expected to cover cost only when the Bujagali project becomes operational. Tariffs for industrial users were increased more than for residential users in an effort to reduce cross-subsidization from households to industry. A life-line tariff for residential customers for consumption was kept, but the fixed charge increased, so that the increase in overall unit costs was larger for smaller than larger residential customers. The new tariff structure includes an automatic adjustment mechanism (Electricity Regulatory Authority, 2014), so that in principle, higher or lower costs would result in tariff adjustments that would not require additional subsidies from the government anymore in case of cost increases.

What has been the impact of the increase in electricity tariffs on households and the broader economy? This chapter assesses this impact using micro- as well as macroeconomic analysis techniques. The micro simulations are based on data from the 2012/13 Uganda national household survey. The macro simulations rely on a CGE model, and they also consider the potential impact of efficiency gains in the sector. The results from both types of analysis suggest that that the removal of the subsidies did not affect poverty in any substantial way, and that it probably had only a minimal impact on the economy. While some sectors like manufacturing may have been affected negatively, this should have been compensated by gains in other sectors. If efficiency gains were achieved in the sector, this would generate clear gains for all.

The chapter is organized as follows. Section 2 provides results from the microeconomic analysis. Section 3 discusses the results from the macroeconomic analysis. A conclusion follows.

2. Microeconomic Analysis

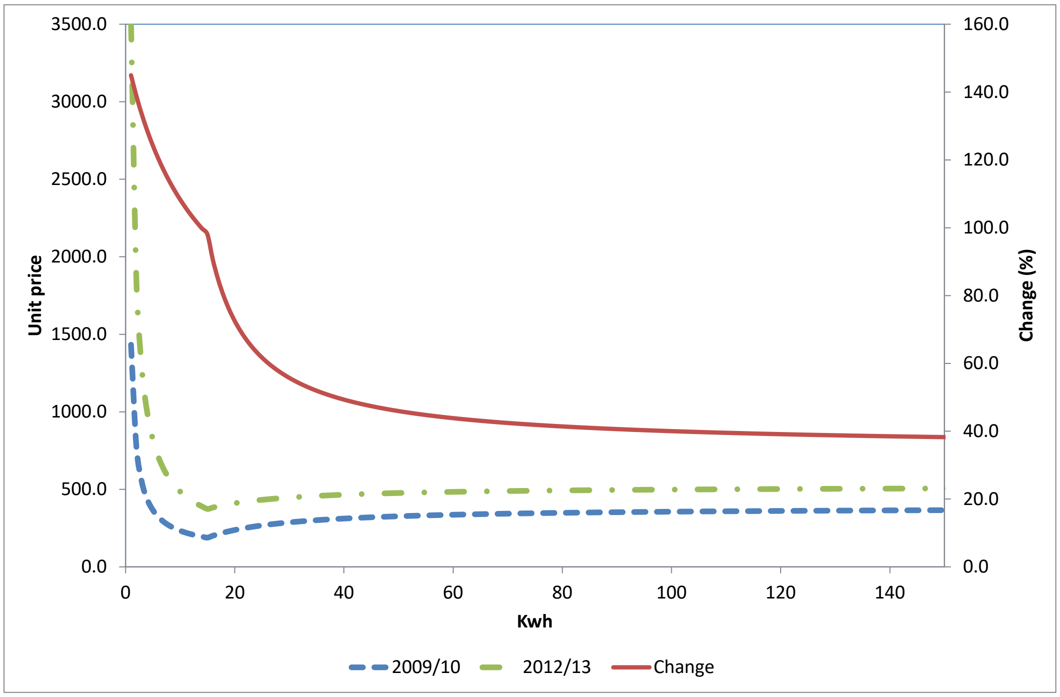
Two types of microeconomic analysis are performed. First, the impact of the increase in tariffs (displayed in table 7.1) on the welfare measure (consumption per equivalent adult) and on poverty is estimated. Second, the impact of the tariff increased on the affordability of electricity is discussed. Before providing the results, it is worth noting that because of the increase in the service charge, the tariff increase (including the service charge) has been higher for households consuming lower amounts of electricity. This is shown in Figure 7.2 which displays the total bill at different levels of consumption for each of the two years as well as the increase in the bill between the two years. But at the same time, even though on average the amounts consumed per household in the 2012/13 survey are slightly below those in the 2009/10 survey, there does not seem to have been any large reduction in consumption by households after the tariff increase.

Table 7.1: Residential Electricity Tariffs, 2009/10 and 2012/13

2009/10		2012/13	
Tariff block	Cost (UGx)	Tariff block	Cost (UGx)
Consumption 0-10 kWh	100.0	Consumption 0-15 kWh	100.0
Consumption above 10 kWh	385.6	Consumption above 15 kWh	524.5
VAT	18%	VAT	18%
Service Charge	1333	Service Charge	3360

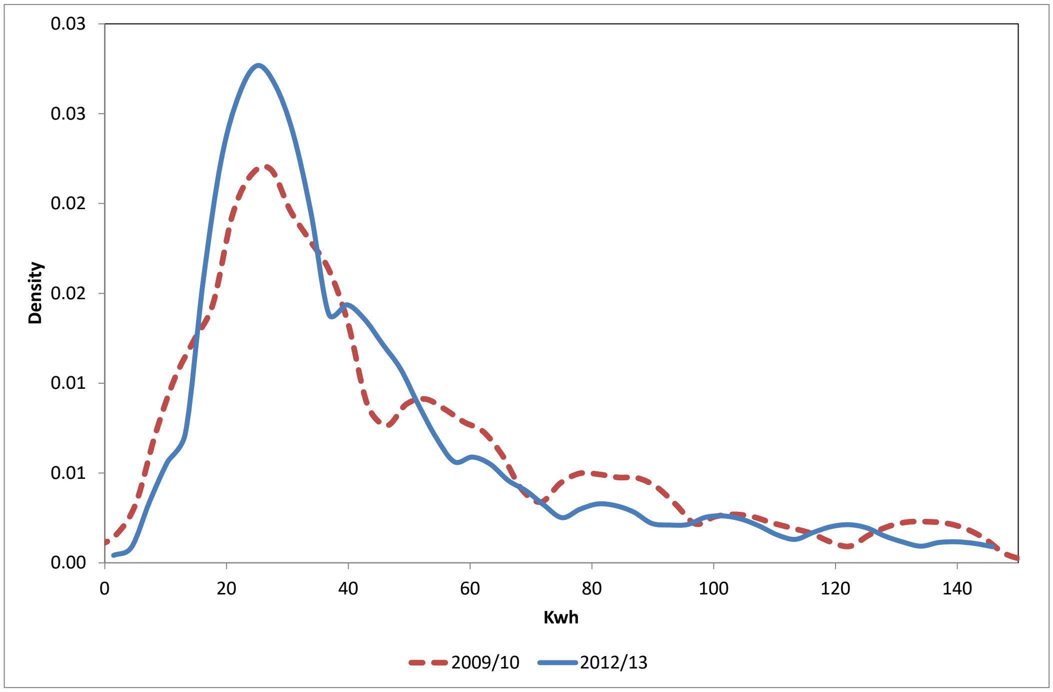
Source: UMEME.

Figure 7.1: Change in the Cost of Electricity per kWh Including the Fixed Charge



Source: Authors based on UMEME tariff structure.

Figure 7.2: Distribution of Electricity Consumption, 2009/10 and 2012/13



Source: Authors based on Uganda 2009/10 and 2012/13 UNHS surveys.

To keep things simple the assessment of the impact on poverty of the increase in tariffs is done in a simplified way. Denote by Y_i the consumption per equivalent adult of household i and by E^{t2}_i its spending on electricity in the second period $t2$ (the survey year 2012/13). Assume that there has been no change in electricity consumption due to the tariff increase. This is equivalent to assuming a zero price elasticity, thereby overstating the negative impact on households of the change in electricity tariffs. Then the level of welfare that the household could have experienced without the tariff increase is computed as E^{t1}_i with $E^{t1}_i < E^{t2}_i$. Denoting N_i the household size (in terms of the number of equivalent adults in the household), and noting that without the tariff increase the household would have been able to spend E^{t2}_i - E^{t1}_i on other goods, the counterfactual consumption per equivalent adult without tariff increase Y_i^C is computed as:

$$Y_i^C = Y_i + \frac{E_i^{t2} - E_i^{t1}}{N_i}$$

Standard FGT poverty measures (Foster, Greer et Thorbecke, 1984) are then used to estimate the impact of the change in tariffs among households connected to the network and among the population as a whole. Denoting the poverty line by Z, and the size of the population by n, the poverty measures with (P) and without (P^C) the change in tariffs are estimated as:

$$P = \frac{1}{n}\sum_{i=1}^{n} 1_{Z>Y_i}\left[\frac{Z - Y_i}{Z}\right]^{\alpha} \text{ and } P^C = \frac{1}{n}\sum_{i=1}^{n} 1_{Z>Y_i}\left[\frac{Z - Y_i^C}{Z}\right]^{\alpha}$$

The headcount index of poverty is obtained for α equal to zero, the poverty gap for α equal to one, and the squared poverty gap for α equal to two. While the headcount index provides the share of the population in poverty, the poverty gap takes into account the distance separating the poor from the poverty lines well as the proportion of the poor in the population, and the squared poverty gap is based on the square of that distance. More sophisticated methods could be used to measure the general equilibrium effect of the increase in tariffs (including for commercial and industrial customers), and these are discussed in the next section, but the estimations given in this section provide a quick "first round" welfare (consumption) and poverty effects from higher tariffs paid directly by households for their electricity consumption. Again, because we have assumed no price elasticity, the effects tend to be overestimated.

The results of the simulations are provided in table 7.2. There is simply no impact on poverty at all because in the 2012/13 survey there are almost no poor households connected to the grid in the sample (and a few households in the sample who declare being connected also declare not paying for their consumption). Since there is no impact on poverty among connected households, there is also no impact for the population as a whole, as shown in table 7.2. In other words the progressive reduction in poverty measures over time, including over the last few years, and the persistent low rate of electricity coverage have combined to reduce even more than before the number of poor households who are connected to the grid.

The effects of the tariff increase on the consumption aggregate are a bit more visible in table 7.2 and these are provided for the sample of connected households as well as nationally. But these effects on consumption are very mild with the simulated counterfactual consumption without the tariff increase only very slightly above consumption without the increase.

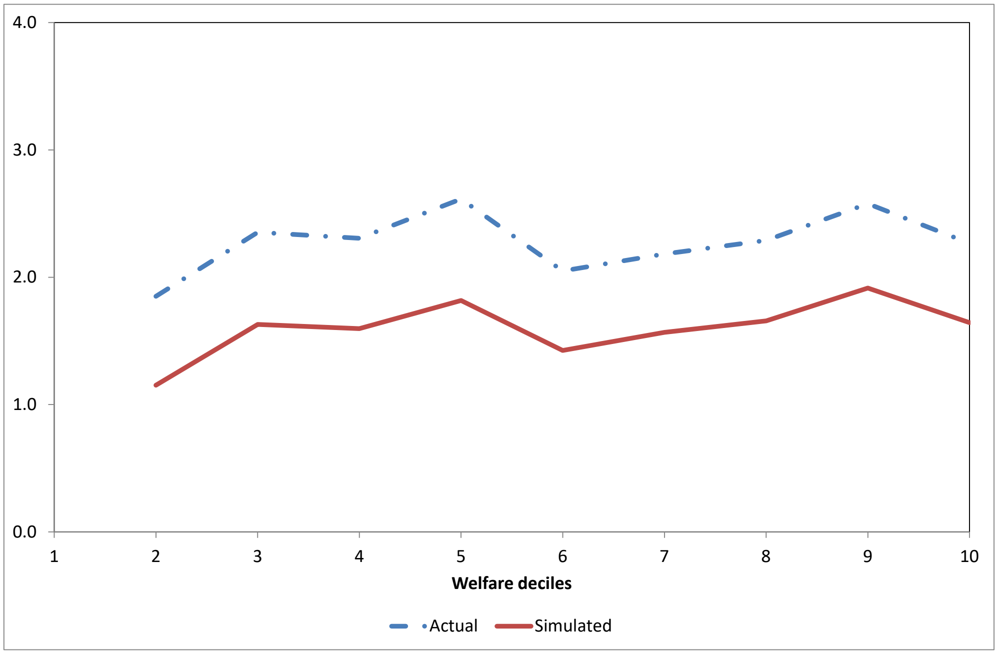
Why are those effects on welfare (consumption) and poverty so small? Because few households are connected, and among those virtually none in poverty, but also because as shown in Figure 7.3 the average electricity burden (the share of household consumption allocated to electricity), is small for those connected, at just above two percent in 2012/13 (and even less under the counterfactual of no tariff increase). As a rule of thumb, the cost of electricity consumption is often considered as affordable if the burden it represents as a share of household budgets is below five percent. Figure 7.3 shows that this is clearly the case at least on average by decile of overall consumption in Uganda for those households who are connected to the network.

Table 7.2: Impact of the Tariff Increase on Consumption and Poverty

	Connected households		National population					
	Consumption per eq. adult		Consumption per eq. adult		Poverty headcount		Poverty gap	
	Actual	Simulated	Actual	Simulated	Actual	Simulated	Actual	Simulated
Area								
Urban	164,939	165,735	109,400	109,734	9.63	9.63	2.54	2.54
Rural	178,907	180,117	56,008	56,016	22.35	22.35	5.92	5.92
Region								
Central	190,082	191,354	103,781	104,037	5.12	5.12	1.03	1.03
Eastern	124,797	125,389	51,036	51,055	24.08	24.08	5.26	5.26
Northern	171,345	172,317	42,902	42,909	43.76	43.76	14.18	14.18
Western	155,263	156,438	72,995	73,031	7.63	7.63	1.47	1.47
National	177,392	178,557	68,082	68,164	19.48	19.48	5.16	5.16

Source: Authors based on Uganda 2012/13 UNHS.

Figure 7.3: Average Electricity Burden among Connected Households, by Decile (Share of Household Consumption Allocated to Electricity, 2012-13)



Source: Authors based on Uganda 2012/13 UNHS.

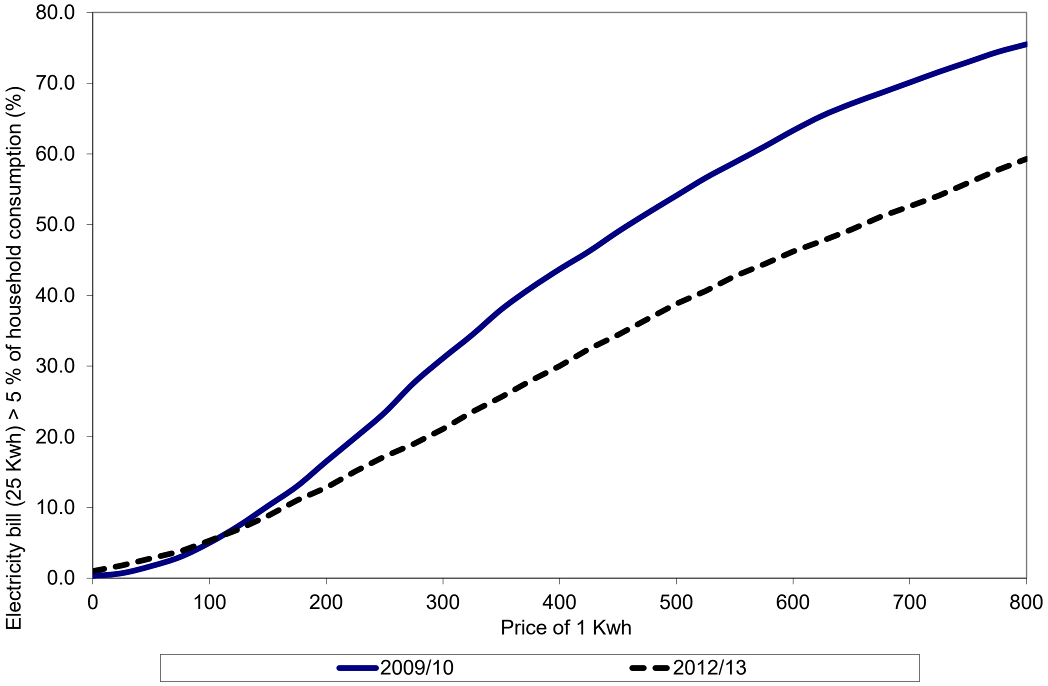
Does this means that electricity is affordable for all households connected to the grid and even perhaps for those not connected, assuming they might be able to connect at some point? Not necessarily. What is considered affordable is a normative judgment, but as just mentioned it is often suggested that the electricity bill of a household should ideally not exceed five percent of its total consumption. In Figures 7.4 to 7.7, we provide estimates of the share of the various groups in the population for which the electricity bill would represent a burden considered "too high" (i.e., more than five percent of their total consumption) under different scenarios as to the unit price of electricity (on the horizontal axis). To assess affordability, we consider that the minimum level of consumption that a household should be able to afford is 25kWh per month. This is a rather low level of consumption, but still higher than the lifeline in the tariff structure.

Consider Figure 7.4 for the population as a whole, comparing the last two survey years for 2009/10 and 2012/13. The higher curve in the Figure is for the year 2009/10, and the curve for 2012/13 is well below, suggesting substantial improvements in affordability between the two years, essentially because this was a period of economic growth in which consumption levels for households increased (and poverty was reduced). Given the unit price of 524.5 UGx per kWh in 2012/13, the cost of a 25 kWh level of consumption per month would not be affordable (i.e., would represent a burden of more than five percent of total household consumption) for close to 40 percent of households in 2012/13 in the population as a whole.

However, when considering only households with a connection to the grid, the curves are much lower since that population group tends to have much higher levels of consumption than the population as a whole. As shown in Figure 7.5, at current unit prices, a consumption of 25 kWh per month would not be affordable for five to ten percent of connected households in 2012/13. Figures 7.6 and 7.7 provide the same information for two other groups of households: those with access in their area but no connection, and those without access in their area. The curves for those without access in their area are somewhat similar to those for the population. The curves for those with access in their area but no connection suggest that at current prices a consumption of 25 kWh per month would not be affordable for about a third households in that group. Thus, there would be quite a few households potentially facing an affordability issue, as defined here in terms of burden, if connections were made available to that group, but for still a large majority of households, the service would be affordable, and willingness to pay studies suggest that indeed many households would be willing to pay in order to have the service (prepayment meters can also sometimes help households in managing their energy consumption so that it becomes more affordable, while also reducing the risk of nontechnical losses for utilities; on the experience with prepayment meters in Uganda, see Mwaura, 2012).

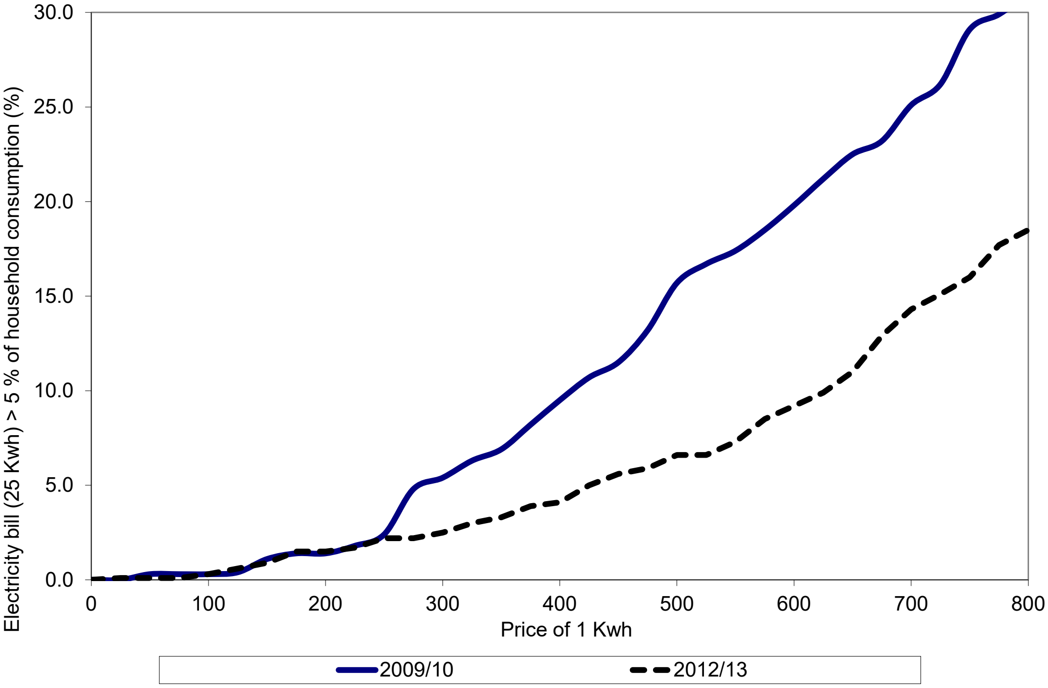
The upshot of the microeconomic analysis presented in this section is that i) there was virtually no impact of the increase in tariffs on poverty in Uganda; ii) the impact on welfare as measured by consumption per equivalent adult was mild; iii) for more than nine in ten households connected to the grid, electricity is affordable; and iv) for two out of three households with access in their area but not connected, electricity should be affordable. This is not too surprising given that as mentioned earlier, previous tariff increases were considered as acceptable by households (Sendegeya et al., 2009) – and at that time the population was poorer.

Figure 7.4: Affordability of Electricity, Population as a Whole



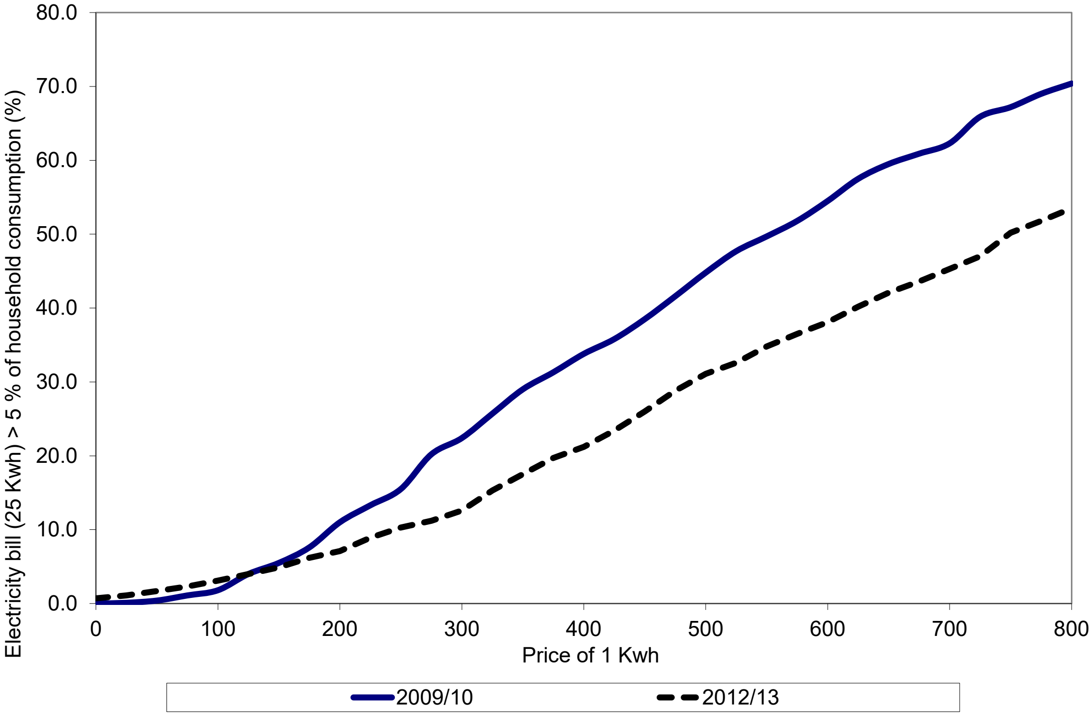
Source: Authors using Uganda 2009/10 and 2012/13 UNHS survey.

Figure 7.5: Affordability of Electricity, Connected Households



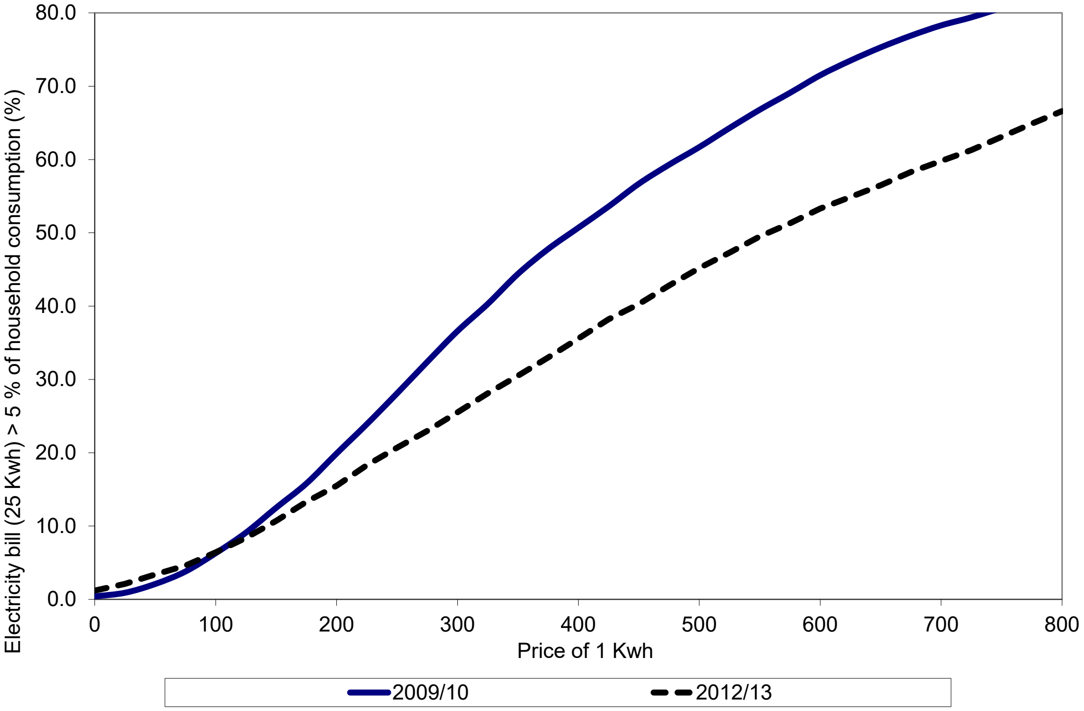
Source: Authors using Uganda 2009/10 and 2012/13 UNHS survey.

Figure 7.6: Affordability of Electricity, Households with Access and No Connection



Source: Authors using Uganda 2009/10 and 2012/13 UNHS survey.

Figure 7.7: Affordability of Electricity, Households without Access



Source: Authors using Uganda 2009/10 and 2012/13 UNHS survey.

3. Macroeconomic Analysis

The macroeconomic analysis is conducted with MAMS (Maquette for MDG – Millennium Development Goal – Simulations), a dynamic CGE model. Such models are useful to account for inter-sectoral linkages and spillover effects of policy changes. Previous studies of this type include ESMAP (2004) on the impact of the removal of electricity subsidies in Mexico. That paper assumed savings from the reduction in subsidies were used on other goods and services with no fiscal impact owing to the reallocation. The study found only small impact on GDP, exports, imports and employment, but the poor were the most affected given the larger proportion of their spending on electricity – this is however a country with much higher rates of electrification than Uganda. Another study by Clements et al. (2003) assessed the impact of removing subsidies on petroleum products in Indonesia. There poverty increased as a result of increasing prices on all goods after removal of the subsidy, but again in Uganda many more households would be affected by changes in petroleum product prices than for electricity. On Uganda, Matovu et al. (2009) looked at the potential impact of an increase in energy (oil) price, but those simulations were made for a much broader sector affecting the entire economy.

MAMS is a dynamic-recursive CGE model that is also linked to a micro-simulation module used to generate poverty estimates under the various scenarios. The model is integrated with an additional MDG module for additional simulations on those indicators. The CGE component of the model used here is based on a standard model developed by Lofgren et al. (2002; see also for example Thurlow, 2004) and adopted for Uganda by EPRC. This is a real model without a financial or banking system. The GAMS software is used to calibrate the model and perform simulations, but this has been simplified and is also now available as an excel interface. The model is based on a 2002 Social Accounting Matrix revised in 2007 by IFPRI.

The impact on various sectors of phasing out subsidies depends on three main factors: i) the importance of energy inputs in production as represented by their cost shares; ii) the ease with which utilities can be substituted by other inputs; and iii) the ability of the producers to pass on increases in tariff to consumers, which depends on the elasticity of demand for the utility. The impact on households of changes in tariffs depends in addition on the availability of substitutes. The model suggests that the increase in electricity tariffs could result into an overall weighted price increase of one percent. The sectors most affected are manufacturing and services, with agriculture only marginally affected. The size of these price increases remains small because the size of the utilities sector in the overall economy and its influence on other sectors is also small.

In terms of model closure, the fiscal balance is flexible and financed domestically and through foreign borrowing. Revenue collection remains at its current level of 12-13 percent of GDP. Electricity subsidies are embedded in the budget and remain stable as shares of the budget. Household savings adjust endogenously to investments. A flexible exchange rate is used, and the model is calibrated with the objective of reproducing the current unemployment rate. The period of analysis is 2010-2015 which coincides with the National Development Plan. For the baseline simulations we assume that there are no specific interventions to improve efficiency in the utilities sector (total factor productivity for the utilities sector unchanged at 0.5 percent), and subsidies remain in place. The use of factors of production including both labor and capital are assumed to remain the same with no deliberate effort towards capital investments. The average GDP growth rate generated under these assumptions for the period 2010-15 is 5.78 percent.

To assess the impact of the removal of subsidies, we assume that the resources saved from the subsidies are now spent on other expenditures in the same proportion as in the baseline. In other words, the fiscal position in this scenario remains unchanged. The simulations suggest that the removal of the subsidies and increase in tariffs has very little economy wide effects. The average growth rate of GDP during the period 2010-2015 marginally changes. Exports, imports and employment levels all experience small changes compared to the baseline. This could be a reflection of the neutral fiscal policy stance where these resources are reallocated to other expenditures. At a sectoral level, we observe that the growth of the manufacturing sector is impacted especially during the year when tariffs are increased. However, this decline in the manufacturing sector is compensated by growth in services, including the utilities sector. The impact of the removal of subsidies and increase of tariffs on households depends on whether the income or price effects dominate. But from the consumption point of view, the removal of subsidies and increase of tariffs does not necessarily result into lower demand for the utility.

Energy subsidies lead to a worsened fiscal balance due to increased government expenditure. However, in this scenario, we assume that the savings after removal of the subsidies are utilized on other expenditures and hence implement a budget neutral subsidy removal. Therefore the fiscal situation for remains the same compared to the baseline and therefore there are no multiplier effects due to the fiscal policy stance. The subsidy removal affects the welfare of households positively, but only marginally so as measured through the equivalent variation. Likewise, the impact of subsidy removal on MDGs attainment is positive, but quite small. In summary, the removal of electricity subsidies is overall beneficial for the economy.

A separate simulation is carried to assess the potential of improving efficiency in the sector. Inefficiency within utilities may arise due to many different factors, including outdated technologies, use of inputs that have high costs (thermal power), and transmission losses owing to poor maintenance of the existing infrastructure. For the simulations an improvement in productivity of five percent per year is assumed for the period 2012-2015. Under this scenario, overall output increases by six percent compared to the baseline. The increase is largely driven by the higher output levels of the utility sector, but also to positive spillovers on other sectors. For example services sector growth increases by 0.5 percent on average relative to the baseline. Households are also better off, compared to the baseline. Lastly, this simulation also results into better social outcomes for the MDGs which all show some improvement.

The last simulation combines the tariff increase due to the subsidy removal and the productivity gains. The combined intervention has a large positive impact on the utilities sector, which grows by 45 percent under this scenario as compared to 8 percent under the baseline. The increase in tariffs still raises the cost of doing business for the manufacturing sector, generating lower manufacturing output, but again the overall GDP impact remains very small.

4. Conclusion

This chapter suggests that the impact of the 2012 removal of electricity subsidies on the economy and on households is small. The microeconomic analysis suggests virtually no impact on poverty, and small impacts on consumption and affordability. The macroeconomic analysis suggests a negative impact on the manufacturing sector, but very small overall impacts on GDP and households. The macroeconomic simulations also consider the potential impact of efficiency gains in the sector, which as expected is positive. If efficiency gains were achieved in the sector, this would generate clear gains for all, including for households, assuming that the expenditure associated with the subsidies are reallocated by the government to other sectors (there would probably be a negative impact in the macro simulations if there were no such reallocation).

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