Energy Poverty in low-income countries: comparing Côte d'Ivoire with Bolivia

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Abstract

In this paper we compare two low income countries, Bolivia and Côte d'Ivoire, in terms of access to energy infrastructure, access to energy services, and energy poverty. Bolivia is ahead of Côte d'Ivoire in terms of access to electricity (91.5% as compared to 56.3% of households) even if the latter is more densely populated and urbanized, which facilitates the deployment of the power network. In terms of clean cooking, both countries have a very low coverage of around 18%. Looking at households with access to infrastructure, around 6.5% in Bolivia and 14% in Côte d'Ivoire are energy poor. Using logit/probit and go-logit techniques, we find, first, that access to infrastructure is mostly present in houses with permanent materials that are in urban areas, but the relative importance of the previous variables with respect to demand determinants is very different between countries, reflecting their differences in human development. Second, we observe that in Bolivia the probability of having access to at least one energy service positively depends on working outside of the agriculture sector, having education and on the family and house size. Instead, in Côte d'Ivoire, current income is the key determinant as compared to other determinants of permanent income like education. Then, the importance of these drivers increase in magnitude when we wish to explain access to energy services. Finally, considering the affordability problem analyzed by two alternative operative definitions of energy poverty, in Côte d'Ivoire determinants of energy poverty are as expected whereas this is not the case for Bolivia, where energy poor households are usually female headed, educated and older, employed and in general outside of agriculture, living in big houses but with low income, in particular from the first quantile. This result suggests the existance of an energy-poverty trap: standards of living impose that the population become used to certain energy services that are unable to afford.

Keywords: Energy, Poverty, Low-income, Africa, Latin-America, Côte d'Ivoire, Bolivia.
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1 Introduction

Developing banks and other agencies have generally concentrated their investment efforts in infrastructure building in lower income countries. This derives from the fact that human development

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indicators depend on the capability of households to have access to such infrastructure, in particular energy (see Acheampong et al. (2021) for a recent review). Access to clean water and sewerage avoid sickness and the use of clean energy for cooking curbs indoor pollution, all which increases health indicators. Access to light allows numerous activities to be carried out at home after dark and together with time saving appliances for food storage and cooking improve productivity and school outcomes. Similarly, transport infrastructure reduces time and effort to go to work and access to telecommunications increase productivity and literacy.

Even if huge investment efforts have been undertaken, only few households actually profit from infrastructure services in low-income countries. This is due to numerous factors adding up on the demand and on the supply side. Firstly, infrastructure itself is not enough. The fact that a village is now connected to the electric grid does not mean that households have installed electricity inside their homes, or that they have changed their traditional way of cooking to use clean cooking, for example, or even that such service is affordable for most of the population. On the supply side, the electricity supplied may be unreliable (numerous brownouts, changes in voltage, etc.) making it non-beneficial for households in terms of welfare.

In a first attempt to account for the different barriers that stand in the way of access to reliable and affordable energy, Bhatia and Angelou (2015), for the World Bank, elaborate the Multi-tier framework (MTF). This framework defines different stages of access to energy services incorporating the affordability dimension as well as the reliability and capacity of the connection that allows the usage of different appliances. Since then, the framework has only been applied to Myanmar, Rwanda, Ethiopia, and Cambodia. This limited panel of cases is due to the need of detailed data for such an assessment, data that is in general missing in low-income countries.

Another strand of literature, less data intensive, has concentrated on measuring access to reliable and affordable energy services by studying "energy poverty" or "fuel poverty". This concept was coined in the developed world, precisely in the United Kingdom. It first considered as fuel-poor all households that spent more than 10% of their income in energy (Boardman, 1991). Since then it has greatly evolved (Pachauri and Spreng, 2011). Most recently it incorporates new dimensions that drive this concept closer to the MTF, like ownership of appliances that help households avoid temperature discomfort, clean cooking and other energy services that improve welfare (Grottera et al., 2018).

Almost all studies on energy poverty are in the developed world, with few exceptions that concentrate in upper-middle-income countries, most likely due to data availability. The sole and recent exception is Poblete-Cazenave and Pachauri (2021) that include Ghana in their simulation of future energy needs. Herein we fill this gap by studying and comparing two lower-middle income countries on two continents: Côte d'Ivoire and Bolivia.

Sy and Mokaddem (2022) explain the inadequacy of applying fuel or energy poverty concepts coined in developed countries to developing ones. Herein we further contribute to the literature by studying energy poverty considering the two complementary approaches mentioned and discussing the adequacy of such measures to low-income countries. In particular, we first study access to the infrastructure itself and then, among the population that has access to the infrastructure we study access to energy services, affordability of those services and its determinants.

The comparison of the selected countries is of interest for numerous reasons. Both are classified as low-income countries, where the energy and development transition is still ongoing. They are also comparable in terms of the dynamics of GDP growth, GNI per capita, headcount of poor as a percentage of population and energy use (see Table 1). Instead, they are very different in other dimensions that are

relevant for the way energy is used as well as on the best way to provide it. Ivorian population doubles Bolivian population in a surface that is less than one third, which partially explains the difference in population density which is almost 8 to 1. This big difference is also explained by urbanization, which is increasing almost twice faster in Côte d'Ivoire.

Table 1 – Comparison of Development Indicators

	Côte d'Ivoire	Bolivia
Population, total	27.053.629	11.832.936
Surface area (sq. km)	322.460	1.098.580
Population density (people per sq. km of land area)	85	11
Urban population growth (annual %) - 2021	3,44	1,86
GNI per capita, Atlas method (current US$) - 2021	2.450	3.360
GDP (current US$) - 2021	69.764.827.467	40.408.208.524
GDP growth (annual %) - 2021	7,02	6,11
Poverty headcount ratio at national poverty lines (% of pop.)	39,5 (2018)	39 (2020)
Income share held by lowest 20% - 2018 & 2020 resp.	7	4,7
Life expectancy at birth, total (years) -2020	58	72
Energy use (kg of oil equivalent per capita) -2014	613	778
Electric power consumption (kWh per capita) - 2014	275	743

Source: World Development Indicators (July, 2022)

The 7^{th} Sustainable Development Goal promotes clean and affordable energy for all. This is because, according to the Energy Poverty Action initiative of the World Economic Forum, "Access to energy is fundamental to improving quality of life and is a key imperative for economic development. In the developing world, energy poverty is still rife." (IEA, 2017).

The definition of energy poverty is a subject of an open debate. According to González-Eguino, M., (2015), energy poverty is having a level of consumption that is insufficient to meet basic needs and is analyzed in the literature on two dimensions: (i) absence of physical opportunity to connect/acquire energy, and/or (ii) inability to consume modern energy for various reasons.

Sy and Mokaddem (2022), in their extensive review of this literature, classify the definitions of energy poverty in three broad categories: the "single indicator" approach, the "dashboard indicators" approach and the "composite indicators or multidimensional" approach. The first way of defining energy poverty is based on whether the household consumes more or less than the threshold that defines the energy poor category. That threshold can be defined in economic terms (relative to income) or in technical terms (kwh consumed, e.g.). Dashboard indicators, instead, focus at the same time on economic, environmental, social, technical and even institutional sustainability of energy access. The Latin America Energy Organisation, United Nations Economic Commission for Latin America and the Caribbean, and GIZ carried out the first investigation into dashboard indicators in developing countries (OLADE, ECLAC, GTZ, 1997). This constitutes a great example because the indicators include electricity access rate, consumption of useful residential energy, and indoor air pollution in the residential sector. Finally, multidimensional measurement is mostly applied to developing countries where the lack of harmonized data makes it useful to intersect several dimensions at the time. Among the different multidimensional measurements, the most commonly used is the Multidimensional Enegy Poverty Index (MEPI) developed by Nussbaumener et al. (2012) that focuses on the deprivation of access to modern energy services such as cooking, lighting, cooling, entertainment and education, and communications.

The "single indicator" approach has been dominant to define energy poverty due to its simplicity of implementation. Historically, it was first measured as "fuel poverty" by Boardman (1991) in the United Kindom, where a household was considered energy poor if it spent more than 10% of its income in energy. Since then, numerous refinements of the concept have been applied. Particularly relevant in developed countries is the "Low income - High Cost" index (Hills, 2012) which considers a household as energy poor when its energy bill is above a certain level (generally the national median level), and its residual income below a certain level, for example the relative poverty line. This measurement is the on that has been recently used in the United Kindom substituting Boardman's measure.

Another approach to identify households with energy efficiency problems uses the 2M indicator. This latter defines a household as energy poor if it spends more than double than the mean (or median) energy expenditure in the country. Finally, the MIS indicator or "minimum income standard" is a measurement that considers energy poor the household that, after paying for energy, is left with an income that is less than the minimum required to live.

Herein we study energy poverty using alternative definitions, which we consider to be more appropriate to developing countries. We first use a single indicator of access to the infrastructure (electricity or clean cooking), then we use a multidimensional approach to study access to energy services by looking at appliance ownership and finally, we study single energy poverty indicators.

Our main findings are that Bolivia is ahead of Côte d'Ivoire in terms of access to electricity (91.5% as compared to 56.3% of households) even if the latter is more densely populated, more urbanized and with less geographical accidents, which facilitates the deployment of the power network. Instead, in terms of clean cooking, both countries have very low coverage of around 18%. Looking at households with infrasctucture access, 6.5% in Bolivia and 14% in Côte d'Ivoire suffer from energy poverty. By using logit/probit and go-logit techniques, we then explore the main determinants of the previous results. First, we find that access to infrastructure is mostly attained in houses with permanent materials that are in urban areas, but the relative importance of the previous variables with respect to demand determinants is very different between countries, reflecting their differences in human development. Second, we observe that in Bolivia the probability of having access to at least one energy service mostly depends on working outside of agriculture, education, the family and house size. Instead, in Côte d'Ivoire, current income is the key determinant. Then, these drivers become more and more important in magnitude when we wish to explain access to more or all energy services together. Finally, considering the affordability problem analyzed by two alternative indicators of energy poverty, in Côte d'Ivoire specific determinants are as expected whereas this is not the case for Bolivia. In Bolivia, energy poor households are usually female headed, educated and old, employed and in general outside of agriculture, living in big houses but with low income, in particular from the first quantile. This result suggests that population becomes used to having access to energy services, in particular those allowed by electricity access. Thisleads them to a poverty trap in that those services take a great part of poor households budget.

2 Data description

In particuler, we use the latest Household Survey conducted in Côte d'Ivoire, which contains data about access to electricity, ownership of appliances that provide energy services and energy expenditure. To ease comparison we use data for the same year for the Household Survey conduced in Bolivia. The following section presents summary statistics for the determinants of access to infrastructure.

2.1 Summary statistics for access to electricity and clean cooking technologies

Variables are discriminated by area (rural or urban) since the literature shows this is a key driver to having access to distribution of electricity or distribution of butane (or natural gas) for cooking, which are the two technologies that are inside our variable "combust".

Table 2 – Summary statistics for Bolivia

	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
	Count			Row percentages			Column percentages		
Access to electricity (0=NO, 1=YES)									
NO	825	37	862	95.7%	4.3%	100.0%	25.0%	0.5%	8.5%
YES	2,470	6,839	9,309	26.5%	73.5%	100.0%	75.0%	99.5%	91.5%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	3,265	5,051	8,316	39.3%	60.7%	100.0%	99.1%	73.5%	81.8%
YES	31	1,824	1,855	1.7%	98.3%	100.0%	0.9%	26.5%	18.2%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent, 1=Permanent)									
Non-permanent materials	1,718	408	2,126	80.8%	19.2%	100.0%	52.1%	5.9%	20.9%
Permanent materials	1,577	6,468	8,045	19.6%	80.4%	100.0%	47.9%	94.1%	79.1%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Occupation status (0=Other, 1=Owner)									
Other status	534	3,043	3,577	14.9%	85.1%	100.0%	16.2%	44.3%	35.2%
Owner	2,761	3,832	6,594	41.9%	58.1%	100.0%	83.8%	55.7%	64.8%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Gender of household head (0=Female, 1=Male)									
Female	614	1,801	2,415	25.4%	74.6%	100.0%	18.6%	26.2%	23.7%
Male	2,681	5,075	7,756	34.6%	65.4%	100.0%	81.4%	73.8%	76.3%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Head's age (0=[0-55], 1=+55)									
$[0-55]$	2,055	5,075	7,129	28.8%	71.2%	100.0%	62.4%	73.8%	70.1%
$+55$	1,241	1,801	3,042	40.8%	59.2%	100.0%	37.6%	26.2%	29.9%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Employment sector (0=Agriculture, 1=Other)									
Agriculture	2,118	307	2,425	87.4%	12.6%	100.0%	64.3%	4.5%	23.8%
Other sectors	1,177	6,569	7,746	15.2%	84.8%	100.0%	35.7%	95.5%	76.2%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	443	290	733	60.5%	39.5%	100.0%	13.4%	4.2%	7.2%
Primary	1,712	1,583	3,295	51.9%	48.1%	100.0%	51.9%	23.0%	32.4%
Secondary	939	3,146	4,085	23.0%	77.0%	100.0%	28.5%	45.8%	40.2%
University	202	1,857	2,058	9.8%	90.2%	100.0%	6.1%	27.0%	20.2%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	1,687	5,119	6,806	24.8%	75.2%	100.0%	51.2%	74.5%	66.9%
Poor	1,608	1,757	3,365	47.8%	52.2%	100.0%	48.8%	25.5%	33.1%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
N	2,236	7,935	10,171						

In Table 2 we observe that, for the case of Bolivia, rural areas account for 96% of the people that have no access to electricity, 81% of people that have a house with non-permanent materials, 84% of household's head work in the agricultural sector and 60% have no education. Ownership status of the house and poverty status of the family seem less influenced by the area.

It is worth noting that even if almost all of the households without access to electricity are in rural areas, there are only few households left since 91.5% of the population has access to electricity. Instead, only 18% of population has access to clean cooking using electricity or gas.

In Table 3 we observe summary statistics for Cote d´Ivoire. In this country 44% of households still lack access to electricity and 82% lack access to clean fuels for cooking like gas or electricity. For the case of Côte d'Ivoire, rural areas account for 82% of the people that have no access to electricity, 60% of households without access to clean cooking technologies, 73% of people that have a house with non-permanent materials. Similarly to Bolivia, rural households account for 80% of household's head work in the agricultural sector and 60% have no education. Ownership status of the house and poverty

Table 3 – Summary satistics for Côte d'Ivoire

	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
	Count			Row percentages			Column percentages		
Access to electricity (0=NO, 1=YES)									
NO	4,585	1,052	5,638	81.3%	18.7%	100.0%	68.3%	17.0%	43.7%
YES	2,124	5,137	7,261	29.3%	70.7%	100.0%	31.7%	83.0%	56.3%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	6,430	4,177	10,606	60.6%	39.4%	100.0%	95.8%	67.5%	82.2%
YES	280	2,013	2,293	12.2%	87.8%	100.0%	4.2%	32.5%	17.8%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent, 1=Permanent)									
Non-permanent materials	4,082	1,474	5,556	73.5%	26.5%	100.0%	60.8%	23.8%	43.1%
Permanent materials	2,628	4,715	7,343	35.8%	64.2%	100.0%	39.2%	76.2%	56.9%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Occupation status (0=Other, 1=Owner)									
Other status	2,560	4,730	7,290	35.1%	64.9%	100.0%	38.2%	76.4%	56.5%
Owner	4,150	1,460	5,609	74.0%	26.0%	100.0%	61.8%	23.6%	43.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Gender of household head (0=Female, 1=Male)									
Female	1,129	1,392	2,521	44.8%	55.2%	100.0%	16.8%	22.5%	19.5%
Male	5,581	4,798	10,378	53.8%	46.2%	100.0%	83.2%	77.5%	80.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Head's age (0=[0-55], 1=+55)									
$[0-55]$	5,583	5,321	10,904	51.2%	48.8%	100.0%	83.2%	86.0%	84.5%
$+55$	1,127	869	1,995	56.5%	43.5%	100.0%	16.8%	14.0%	15.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Employment sector (0=Agriculture, 1=Other)									
Agriculture	3,995	971	4,966	80.4%	19.6%	100.0%	59.5%	15.7%	38.5%
Other sectors	2,715	5,218	7,933	34.2%	65.8%	100.0%	40.5%	84.3%	61.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	4,254	2,779	7,033	60.5%	39.5%	100.0%	63.6%	45.5%	55.0%
Primary	1,261	989	2,250	56.1%	43.9%	100.0%	18.9%	16.2%	17.6%
Secondary	1,095	1,768	2,864	38.2%	61.8%	100.0%	16.4%	28.9%	22.4%
University	78	572	650	12.1%	87.9%	100.0%	1.2%	9.4%	5.1%
Total	6,689	6,108	12,797	52.3%	47.7%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	4,056	4,716	8,772	46.2%	53.8%	100.0%	60.4%	76.2%	68.0%
Poor	2,654	1,473	4,127	64.3%	35.7%	100.0%	39.6%	23.8%	32.0%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
N	7,115	5,784	12,899						

status of the family seem less influenced by the area.

Bolivia is ahead of Côte d'Ivoire in terms of permanent income proxies like education, house materials and ownership, for example. The gap is very consistent ranging from 15 to 20% difference in all of these variables. This indeed explains important gaps in terms of energy usage but not all of them. Particularly, even if geographic and demographic condition in Côte d'Ivoire facilitate the deployment of the power network (less surface, more population density and urbanization) only 56.3% of households use electricity as compared to 91.5% for Bolivia. This huge gap is nonexistent, on the other hand, in terms of clean cooking where both countries are around a 18% usage.

To study access to quality services, in Table 4 we focus on households that have declared to have access to electricity or clean cooking, which implies dropping 48% of households in the case of Côte d'Ivoire and 6% in the case of Bolivia.

2.2 Summary statistics for households that have access to either electricity and or clean cooking

In Table 4 we observe that in the subsample where households without access to one of the infrastructures is dropped for Bolivia, only 10% have no access to entertainment but 41% still have no access to a fridge and only 27% have access to a computer. The most striking is that almost no-one has access to an improved kitchen. Regarding socio-economic conditions, these households that have basic access to infrastructure are mostly owners of their home which is made of permanent materials, are in 80% employed outside of the agricultural sector and the majority have completed secondary education.

In the case of Côte d'Ivoire in Table 5, we observe that most indicators describe a situation worst than in Bolivia with exception of clean cooking. In this subsample, almost half have no access to entertainment 81% have no access to a fridge and only 7% have access to a computer. Instead, in terms of improved kitchen, the situation is better than in Bolivia with 14% having access. Regarding socio-economic conditions, as in Bolivia, households that have basic access are mostly owners of their home which is made of permanent materials, are again almost at 80% employed outside of the agricultural sector. The biggest difference is in terms of education since 44% have no education.

2.3 Summary statistics for energy affordability

The last aspect we wish to study herein is energy affordability since a dimension of poverty is the incapacity for households to use energy services due to the impossibility of paying the bill.

In the first line of graphs in Figure 1, we observe that considering only households with access to energy, important affordability issues arise. For some of the poorest households with access, both in Bolivia and in Côte d'Ivoire, energy represents more than 10% of their spending. This means that, if we apply the fuel poverty definition first defined by Boardman (1991) for the UK, they can be considered energy poor. In the second line we observe that energy poverty is particularly important in cities and that the problem is deeper in Côte d'Ivoire. Finally, the third line shows the important positive correlation between energy expenditure and income.

3 Methodology

We first study access to electricity and clean cooking infrastructures. With this purpose we estimate the probability of having access as a function of the area where the household is (rural or urban) and as

Table 4 – Summary statistics for household with access in Bolivia

	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
	Count			Row percentages			Column percentages		
Access to electricity (0=NO, 1=YES)									
NO	2	3	5	35.0%	65.0%	100.0%	0.1%	0.0%	0.1%
YES	2,537	7,024	9,561	26.5%	73.5%	100.0%	99.9%	100.0%	99.9%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	2,507	5,154	7,661	32.7%	67.3%	100.0%	98.8%	73.3%	80.1%
YES	32	1,874	1,905	1.7%	98.3%	100.0%	1.2%	26.7%	19.9%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
TV ownership (0=NO, 1=YES)									
NO	691	255	946	73.1%	26.9%	100.0%	27.2%	3.6%	9.9%
Yes	1,847	6,772	8,619	21.4%	78.6%	100.0%	72.8%	96.4%	90.1%
Total	2,539	7,026	9,565	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Fridge ownership (0=NO, 1=YES)									
NO	1,694	2,221	3,914	43.3%	56.7%	100.0%	66.7%	31.6%	40.9%
YES	845	4,807	5,652	15.0%	85.0%	100.0%	33.3%	68.4%	59.1%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Computer ownership (0=NO, 1=YES)									
NO	2,324	4,693	7,017	33.1%	66.9%	100.0%	91.6%	66.8%	73.4%
YES	214	2,334	2,549	8.4%	91.6%	100.0%	8.4%	33.2%	26.6%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Cooker ownership (0=NO, 1=YES)									
NO	2,537	6,990	9,527	26.6%	73.4%	100.0%	99.9%	99.5%	99.6%
YES	2	37	39	5.0%	95.0%	100.0%	0.1%	0.5%	0.4%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent, 1=Permanent)									
Non-permanent materials	1,073	396	1,469	73.1%	26.9%	100.0%	42.3%	5.6%	15.4%
Permanent materials	1,466	6,632	8,097	18.1%	81.9%	100.0%	57.7%	94.4%	84.6%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Occupation status (0=Other, 1=Owner)									
Other status	460	3,107	3,568	12.9%	87.1%	100.0%	18.1%	44.2%	37.3%
Owner	2,079	3,920	5,998	34.7%	65.3%	100.0%	81.9%	55.8%	62.7%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Gender of household head (0=Female, 1=Male)									
Female	503	1,842	2,345	21.5%	78.5%	100.0%	19.8%	26.2%	24.5%
Male	2,036	5,186	7,221	28.2%	71.8%	100.0%	80.2%	73.8%	75.5%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Head's age (0=[0-55], 1=+55)									
$[0-55]$	1,602	5,185	6,787	23.6%	76.4%	100.0%	63.1%	73.8%	70.9%
$+55$	936	1,843	2,779	33.7%	66.3%	100.0%	36.9%	26.2%	29.1%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Employment sector (0=Agriculture, 1=Other)									
Agriculture	1,517	311	1,828	83.0%	17.0%	100.0%	59.8%	4.4%	19.1%
Other sectors	1,022	6,716	7,738	13.2%	86.8%	100.0%	40.2%	95.6%	80.9%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	292	292	584	50.0%	50.0%	100.0%	11.5%	4.2%	6.1%
Primary	1,267	1,607	2,874	44.1%	55.9%	100.0%	49.9%	22.9%	30.0%
Secondary	793	3,223	4,016	19.7%	80.3%	100.0%	31.2%	45.9%	42.0%
University	187	1,905	2,093	9.0%	91.0%	100.0%	7.4%	27.1%	21.9%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	1,421	5,239	6,660	21.3%	78.7%	100.0%	56.0%	74.6%	69.6%
Poor	1,118	1,788	2,906	38.5%	61.5%	100.0%	44.0%	25.4%	30.4%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Energy poverty (LIHC)									
Not poor	2,403	6,523	8,927	26.9%	73.1%	100.0%	94.7%	92.8%	93.3%
Poor	135	504	639	21.2%	78.8%	100.0%	5.3%	7.2%	6.7%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Energy poverty (over 10%)									
Not poor	2,321	6,624	8,946	26.0%	74.0%	100.0%	91.4%	94.3%	93.5%
Poor	217	403	620	35.0%	65.0%	100.0%	8.6%	5.7%	6.5%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
N	1,674	7,892	9,566						

Table 5 – Summary statistics for household with access in Côte d'Ivoire

	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
	Count			Row percentages			Column percentages		
Access to electricity (0=NO, 1=YES)									
NO	114	28	142	80.2%	19.8%	100.0%	5.6%	0.6%	2.1%
YES	1,921	4,645	6,565	29.3%	70.7%	100.0%	94.4%	99.4%	97.9%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	1,781	2,853	4,634	38.4%	61.6%	100.0%	87.6%	61.1%	69.1%
YES	253	1,820	2,073	12.2%	87.8%	100.0%	12.4%	38.9%	30.9%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
TV ownership (0=NO, 1=YES)									
NO	1,339	1,639	2,978	45.0%	55.0%	100.0%	65.8%	35.1%	44.4%
Yes	695	3,031	3,726	18.7%	81.3%	100.0%	34.2%	64.9%	55.6%
Total	2,034	4,670	6,704	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Fridge ownership (0=NO, 1=YES)									
NO	1,945	3,913	5,858	33.2%	66.8%	100.0%	95.6%	83.8%	87.4%
YES	89	756	845	10.5%	89.5%	100.0%	4.4%	16.2%	12.6%
Total	2,034	4,669	6,703	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Computer ownership (0=NO, 1=YES)									
NO	2,005	4,294	6,299	31.8%	68.2%	100.0%	98.6%	91.9%	93.9%
YES	28	379	407	6.8%	93.2%	100.0%	1.4%	8.1%	6.1%
Total	2,032	4,674	6,706	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Cooker ownership (0=NO, 1=YES)									
NO	1,975	3,775	5,750	34.3%	65.7%	100.0%	97.1%	80.8%	85.7%
YES	59	897	956	6.2%	93.8%	100.0%	2.9%	19.2%	14.3%
Total	2,034	4,672	6,706	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent, 1=Permanent)									
Non-permanent materials	754	715	1,469	51.3%	48.7%	100.0%	37.1%	15.3%	21.9%
Permanent materials	1,280	3,958	5,238	24.4%	75.6%	100.0%	62.9%	84.7%	78.1%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Occupation status (0=Other, 1=Owner)									
Other status	1,045	3,815	4,860	21.5%	78.5%	100.0%	51.4%	81.6%	72.5%
Owner	989	858	1,847	53.5%	46.5%	100.0%	48.6%	18.4%	27.5%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Gender of household head (0=Female, 1=Male)									
Female	444	1,090	1,535	28.9%	71.1%	100.0%	21.8%	23.3%	22.9%
Male	1,590	3,582	5,172	30.7%	69.3%	100.0%	78.2%	76.7%	77.1%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Head's age (0=[0-55], 1=+55)									
$[0-55]$	1,651	4,021	5,672	29.1%	70.9%	100.0%	81.2%	86.0%	84.6%
$+55$	383	652	1,035	37.0%	63.0%	100.0%	18.8%	14.0%	15.4%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Employment sector (0=Agriculture, 1=Other)									
Agriculture	1,040	465	1,505	69.1%	30.9%	100.0%	51.1%	9.9%	22.4%
Other sectors	994	4,208	5,202	19.1%	80.9%	100.0%	48.9%	90.1%	77.6%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	1,026	1,917	2,944	34.9%	65.1%	100.0%	50.8%	41.7%	44.5%
Primary	473	726	1,199	39.5%	60.5%	100.0%	23.4%	15.8%	18.1%
Secondary	485	1,447	1,932	25.1%	74.9%	100.0%	24.0%	31.5%	29.2%
University	35	510	546	6.5%	93.5%	100.0%	1.8%	11.1%	8.2%
Total	2,020	4,601	6,621	30.5%	69.5%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	1,331	3,712	5,043	26.4%	73.6%	100.0%	65.4%	79.4%	75.2%
Poor	703	961	1,664	42.3%	57.7%	100.0%	34.6%	20.6%	24.8%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Energy poverty (LIHC)									
Not poor	2,008	4,540	6,548	30.7%	69.3%	100.0%	98.7%	97.2%	97.6%
Poor	26	133	159	16.4%	83.6%	100.0%	1.3%	2.8%	2.4%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Energy poverty (over 10%)									
Not poor	1,885	3,864	5,749	32.8%	67.2%	100.0%	92.7%	82.7%	85.7%
Poor	149	809	958	15.6%	84.4%	100.0%	7.3%	17.3%	14.3%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
N	2,102	4,605	6,707						

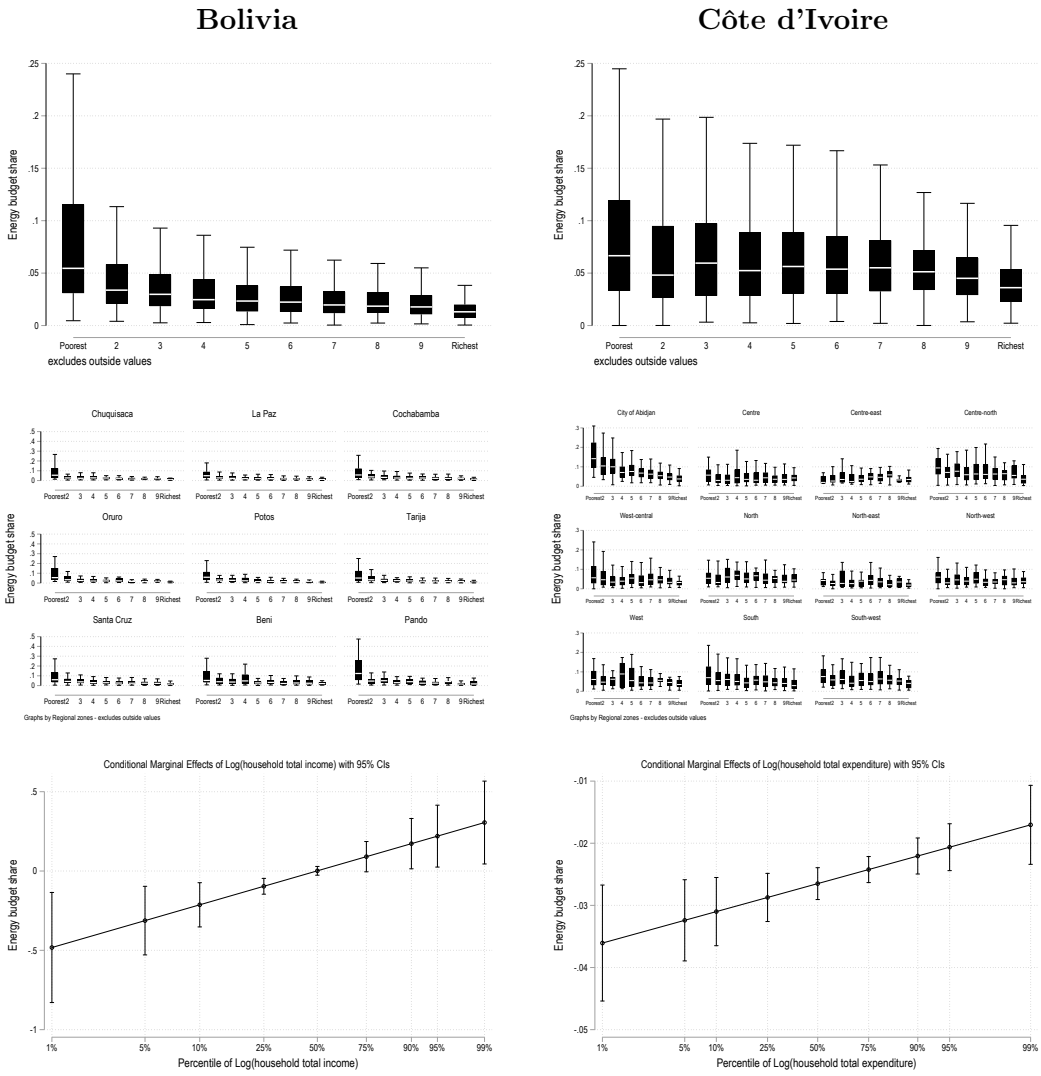

Figure 1 – Energy Budget Shares

a function of socioeconomic characteristics that the literature has proven important to determine energy demand. With this purpose we apply a standard logit (and probit) estimation when the dependent variable is access to electricity or access to clean cooking, respectively.

Then, we wish to understand which are the key variables that determine having access to all infrastructure together. To do this we perform a gologit estimation meaning that we consider access as an ordinal variable with 3 categories: no access (0), access to either electricity or clean cooking (1) and access to both (2). A detailed explanation of the methodology can be found in Williams (2006). Then, the probability of having access follows the form:

$$P(A_i > j) = \frac{e^{(c_j + X_i\beta_j)}}{1 + e^{(c_j + X_i\beta_j)}}, \; j = 1, 2, 3 \tag{1}$$

We also apply this methodology to study the determinants for access to energy services among the households that have basic access to the infrastructure. To this end the dependent variable takes the value 4 if a household has access to TV, fridge, computer and cooker, 3 if only to three of them, 2 if only to two and so on. The results are presented in the next section.

Finally, we study energy affordability, of what is commonly known as fuel poverty. To this end,

among the households that have access to infrastructure, we look at those for which energy expenditure is so important that their income is constrained after paying the bill. This is what is commonly known as the Low Income-High Cost (LIHC) definition of energy poverty first proposed by Hills (2012). Specifically, a household is energy poor if simultaneously verifies the following two conditions:

$$\begin{aligned} &(i) \quad \text{EE} > median(\text{EE}) \ , \\ &(ii) \quad \text{Income} - \text{EE} < 60\% \Big(median(\text{Income}) - median(\text{EE}) \Big) \end{aligned} \tag{2}$$

where EE stands for energy expenditure. We follow Romero et al. (2018) in subtracting the median energy from the median household income to be consistent with the first term of the equation and to overcome the criticism that Robinson et al. (2018) makes to Hills (2012) regarding the consideration of the median energy cost instead of the 60% of the median.

Once we identified households belonging to this category among those who have access to infrastructure we study the determinants of belonging to this category again using a logit and probit estimation. Results are presented in the following section.

4 Results

4.1 Determinants of access to infrastructure

Table 6 – Dependent variable respectivelly: Access to electricity | Access to clean cooking

	Access to electricity				Access to clean cooking			
	Logit		Probit		Logit		Probit	
	BOL	CIV	BOL	CIV	BOL	CIV	BOL	CIV
Area (0=Rural, 1=Urban)	0.095***	0.203***	0.082***	0.207***	0.349***	0.053***	0.302***	0.049***
	(0.007)	(0.006)	(0.006)	(0.007)	(0.024)	(0.006)	(0.018)	(0.006)
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.013***	0.038***	0.013***	0.039***	0.053***	0.028***	0.054***	0.030***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.005)	(0.002)	(0.005)	(0.002)
Employment sector (0=Agriculture, 1=Other)	0.021***	0.090***	0.020***	0.093***	0.070***	0.059***	0.065***	0.053***
	(0.005)	(0.007)	(0.005)	(0.008)	(0.020)	(0.007)	(0.018)	(0.007)
Head's age (0=[0-55], 1=+55)	0.003	0.042***	0.006	0.043***	0.055***	-0.013*	0.056***	-0.011
	(0.005)	(0.009)	(0.005)	(0.009)	(0.009)	(0.007)	(0.009)	(0.007)
log(Number of dependents)	-0.001	0.034***	-0.000	0.035***	-0.026***	0.014***	-0.025***	0.011**
	(0.004)	(0.006)	(0.004)	(0.006)	(0.007)	(0.005)	(0.007)	(0.005)
Employed per Working-age pop.	-0.000	0.027**	-0.001	0.028**	-0.014	0.022***	-0.014	0.023***
	(0.005)	(0.011)	(0.005)	(0.011)	(0.011)	(0.008)	(0.011)	(0.008)
Gender of household head (0=Female, 1=Male)	-0.013**	-0.020**	-0.012**	-0.019**	-0.000	-0.014**	-0.001	-0.010*
	(0.005)	(0.009)	(0.005)	(0.009)	(0.008)	(0.006)	(0.008)	(0.006)
Occupation status (0=Other, 1=Owner)	-0.002	-0.072***	-0.002	-0.074***	0.072***	-0.016***	0.071***	-0.014**
	(0.005)	(0.007)	(0.005)	(0.007)	(0.008)	(0.006)	(0.008)	(0.006)
Number of rooms	0.011***	0.001	0.010***	0.002	0.041***	0.004**	0.041***	0.003**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
House (0=Non-Permanent, 1=Permanent)	0.056***	0.199***	0.055***	0.203***	0.073***	0.050***	0.060***	0.047***
	(0.004)	(0.006)	(0.004)	(0.006)	(0.021)	(0.006)	(0.019)	(0.006)
log(Income per CU)	0.007***	0.049***	0.008***	0.049***	0.006	0.064***	0.005	0.056***
	(0.002)	(0.006)	(0.002)	(0.006)	(0.005)	(0.004)	(0.004)	(0.004)
Observations	10168	12797	10168	12797	10168	12797	10168	12797

Standard errors in parentheses

Inludes regional zones FE. Coefficients represent the average marginal effects

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 shows that being in a urban area increases the probability of having access but that this effect is stronger for access to electricity in CIV and for access to clean cooking in BOL. This is probably because clean cooking is very extraordinary in Bolivia while access to electricity is quite extended. Instead in CIV a large share of the population lacks access independently of being rural

or urban. Regarding demand determinants, some are always significant with a positive influence like education, employment outside of agriculture, living in a house with permanent materials and the size of the house proxied by the number of rooms. Other variables are less clear, in line with the literature. Households headed by female are in general less likely to have access. Other variables have a different impact in one country and the other. Ownership has a negative impact in access in CIV while it has a positive impact on access to clean cooking in BOL. This may be due to the fact that wealthier people in CIV live in rented houses when there and an important part of the year abroad. Employment of the household members with sufficient age for working is only significant in CIV. Finally, the age of the household's head after the retirement age of 55 has a positive effect in access to clean cooking in BOL, probably due to accumulation of income. Instead, in CIV this impact is less clear and the retired condition must be playing a more important role.

Next, let us analyze the determinants of access to energy services among the population who has access to at least one of the infrastructures.

In Table 7 we observe that to have access to at least one of them (which in general is TV as we learnt from the descriptive statistics) determinants signs are similar for both counties but relative importance is different. In Bolivia the most important driver is employment outside of agriculture and on education, both proxies of a higher permanent income, whereas in CIV current income is more important than education. The amount of adults working has a different impact in Bolivia than in CIV. Signs are perceived for the cases of having access to more services or even all of them but relative importance changes. In particular, education and income gain in importance as access to cumulative services increases in both countries. Moreover, proxies of a higher permanent income like working outside of agriculture and education increase their importance while other socioeconomic variables decrease in importance. Comparing one country to the other, having access to the first service is more strongly determined by education and employment sector in Bolivia than in Côte d'Ivoire but the way these variables determine having access to an increasing number of services is less differentiated among countries. This results suggests that once you have access to the first service households are part of a group that becomes more homogeneous among countries with similar needs and determinants.

Table 7 – Dependent variable: Access to energy services (TV, fridge, computer, cooker)

	BOL	CIV
[0]		
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.878***	0.247***
	(0.072)	(0.031)
Employment sector (0=Agriculture, 1=Other)	1.300***	0.742***
	(0.115)	(0.070)
Head's age (0=[0-55], 1=+55)	-0.035	-0.266***
	(0.119)	(0.079)
log(Number of dependents)	0.764***	0.910***
	(0.100)	(0.056)
Employed per Working-age pop.	-0.451***	0.522***
	(0.129)	(0.093)
Gender of household head (0=Female, 1=Male)	-0.171	0.581***
	(0.114)	(0.067)
Number of rooms	0.497***	0.191***
	(0.045)	(0.021)
log(Income per CU)	0.449***	0.937***
	(0.045)	(0.054)
[1]		
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.878***	0.534***
	(0.037)	(0.037)
Employment sector (0=Agriculture, 1=Other)	0.716***	1.148***
	(0.080)	(0.127)
Head's age (0=[0-55], 1=+55)	0.227***	0.001
	(0.069)	(0.103)
log(Number of dependents)	0.108**	0.902***
	(0.049)	(0.073)
Employed per Working-age pop.	-0.480***	0.282**
	(0.076)	(0.123)
Gender of household head (0=Female, 1=Male)	-0.143**	-0.064
	(0.060)	(0.085)
Number of rooms	0.540***	0.216***
	(0.022)	(0.024)
log(Income per CU)	0.453***	1.414***
	(0.034)	(0.071)
[2]		
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	1.095***	0.888***
	(0.041)	(0.061)
Employment sector (0=Agriculture, 1=Other)	0.449***	1.222***
	(0.122)	(0.237)
Head's age (0=[0-55], 1=+55)	-0.162**	0.143
	(0.074)	(0.161)
log(Number of dependents)	-0.214***	0.927***
	(0.057)	(0.111)
Employed per Working-age pop.	-0.268***	0.063
	(0.092)	(0.201)
Gender of household head (0=Female, 1=Male)	-0.019	-0.104
	(0.068)	(0.135)
Number of rooms	0.550***	0.262***
	(0.021)	(0.035)
log(Income per CU)	0.497***	1.718***
	(0.043)	(0.111)
[3]		
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	2.620***	1.206***
	(0.979)	(0.136)
Employment sector (0=Agriculture, 1=Other)	11.177	1.161**
	(1610.699)	(0.527)
Head's age (0=[0-55], 1=+55)	0.682	0.226
	(0.486)	(0.272)
log(Number of dependents)	-2.660***	0.927***
	(1.017)	(0.193)
Employed per Working-age pop.	-0.218	0.079
	(0.804)	(0.378)
Gender of household head (0=Female, 1=Male)	0.423	-0.218
	(0.643)	(0.246)
Number of rooms	0.042	0.259***
	(0.160)	(0.062)
log(Income per CU)	1.665***	2.043***
	(0.387)	(0.192)
Observations	9557	6501

Standard errors in parentheses

Includes regional zones FE.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Affordability and Energy poverty

Table 8 – Dependent variable: Energy Poverty (LIHC) | Energy poverty (EE≥10%Income)

	Energy Poverty (LIHC)				Energy poverty (EE≥10% Tot inc/exp)			
	Logit		Probit		Logit		Probit	
	BOL	CIV	BOL	CIV	BOL	CIV	BOL	CIV
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.023***	-0.005*	0.023***	-0.004	0.010***	-0.010**	0.010***	-0.010**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.003)	(0.004)
Employment sector (0=Agriculture, 1=Other)	0.057***	0.025***	0.059***	0.024***	0.020***	0.131***	0.021***	0.128***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.012)	(0.006)	(0.012)
Head's age (0=[0-55], 1=+55)	0.013**	-0.015**	0.014**	-0.015**	0.010*	-0.019	0.009*	-0.018
	(0.006)	(0.007)	(0.006)	(0.007)	(0.005)	(0.012)	(0.005)	(0.012)
log(Number of dependents)	-0.034***	-0.025***	-0.037***	-0.026***	-0.036***	-0.028***	-0.037***	-0.030***
	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.008)	(0.004)	(0.008)
Employed per Working-age pop.	0.014**	0.002	0.015**	0.002	0.005	0.006	0.007	0.007
	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.013)	(0.006)	(0.013)
Gender of household head (0=Female, 1=Male)	-0.019***	-0.012**	-0.020***	-0.013***	-0.014***	-0.029***	-0.013***	-0.031***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.009)	(0.005)	(0.009)
Number of rooms	0.004**	-0.003	0.004**	-0.003	0.006***	-0.003	0.006***	-0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
Quintiles of income per CU=2	-0.250***	-0.034***	-0.244***	-0.036***	-0.252***	-0.077***	-0.249***	-0.076***
	(0.014)	(0.010)	(0.014)	(0.010)	(0.014)	(0.017)	(0.013)	(0.017)
Quintiles of income per CU=3	-0.323***	-0.055***	-0.318***	-0.057***	-0.280***	-0.123***	-0.279***	-0.121***
	(0.014)	(0.009)	(0.013)	(0.009)	(0.014)	(0.017)	(0.013)	(0.016)
Quintiles of income per CU=4	-0.346***	-0.071***	-0.341***	-0.073***	-0.293***	-0.175***	-0.291***	-0.172***
	(0.013)	(0.008)	(0.013)	(0.008)	(0.013)	(0.016)	(0.013)	(0.016)
Quintiles of income per CU=5	-0.346***	0.000	-0.341***	0.000	-0.298***	-0.234***	-0.296***	-0.232***
	(0.013)	(.)	(0.013)	(.)	(0.013)	(0.015)	(0.013)	(0.015)
Observations	9563	5296	9563	5296	9563	6621	9563	6621

Standard errors in parentheses

Includes regional zones FE. Coefficients represent the average marginal effects

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Finally in Table 8 we observe that, as expected, the probability of being energy poor decreases with income and when being a female-headed household. However, other determinants are more difficult to assess. Education has a positive impact in BOL and a negative one in CIV. This may be due to the fact that Bolivian households consider necessary having access to energy and spend more whereas educated households in CIV have significantly more income that uneducated households in CIV and avoid the energy poverty trap. In Côte d'Ivoire determinants are as expected whereas this is not the case for Bolivia. In Bolivia energy poor households are usually female headed, educated and old, employed and in general outside of agriculture, living in big houses but with low income, in particular from the first quintile. Instead, in Côte d'Ivoire these are uneducated and young, These results suggest that, once a certain level of access has been attained, households are ready to spend more on energy (a sort of dependency to a new standing of living) that drives them, like in the case of Bolivia, to energy poverty.

5 Conclusions

In this paper we compare two low income countries in terms of the usage of energy services. Considering their geographical and socio-demographic differences, we wish to understand the determinants for households to access energy services as well as the affordability barriers encountered.

Data summarized in our descriptive statistics shows that Bolivia is ahead of Côte d'Ivoire in terms of permanent income proxies like education, house materials and ownership, for example. The gap is very consistent ranging from 15 to 20% difference in all of these variables. This indeed explains important gaps in terms of energy usage but not all of them. Particularly, even if geographic and demographic conditions in Côte d'Ivoire facilitate the deployment of the power network (less surface,

more population density and urbanization) only 56.3% of households use electricity as compared to 91.5% for Bolivia. This huge gap is not observed, on the other hand, in terms of clean cooking where both countries are around a 18% usage.

Given the puzzling reality regarding the usage of energy in the comparison of these two countries, we apply a group of econometric techniques to disentangle the key determinants of: access to the infrastructure (electricity and clean cooking, respectively), access to energy services (TV, fridge, computer and cooker) and affordability (by considering alternative definitions of energy poverty).

Our main findings are that access to infrastructure is mostly attained for houses with permanent materials that are in urban areas in both countries. Instead the relative importance of these determinants is different for each countries. For Côte d'Ivoire these have a very strong impact compared to other determinants in the case of electricity while the magnitude is comparable to other demand drivers for the case of clean cooking. Exactly the opposite happens in Bolivia when 91.5% already have electricity access.

Regarding access to energy services, relative magnitudes are quite different between countries. In Bolivia the probability of having access to at least one energy service mostly depends on working outside of agriculture, education, the family and house size and only afterwards current income. In Côte d'Ivoire, instead, current income is the key determinant and all other variables lie behind. Then, the key determinants become more and more important in magnitude when we wish to explain access to more or all energy services.

Finally, considering the affordability problem analyzed by two alternative indicators of energy poverty, we find reality in both countries is very different. In Côte d'Ivoire determinants are as expected whereas this is not the case for Bolivia. In Bolivia energy poor households are usually female headed, educated and old, employed and in general outside of agriculture, living in big houses but with low income, in particular from the first quintile. Instead, in Côte d'Ivoire these are uneducated and young, These results suggest that, once a certain level of access has been attained, households are ready to spend more on energy (creating a sort of dependency to a new standing of living) that drives them, like in the case of Bolivia, to energy poverty.

To disentangle the macroeconomic differences that could be playing a role in investment on infrastructure we will complete the paper by comparing the analysis of demand determinants performed herein with an analysis including macroeconomic variables in the vein of Fay and Straub (2017).

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