The Energy Ladder: A Valid Model for Household Fuel Transitions in Sub-Saharan Africa?

A thesis submitted

by

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Table of Contents

List of Tables

List of Figures

Abbreviations Key

BMZ Federal Ministry for Economic Cooperation and Development

DHS Demographic and Health Surveys

LPG Liquefied Natural Gas

UN United Nations

UNDP United Nations Development Program

USAID United States Agency for International Development

Chapter 1: Introduction

Unlike developed countries with near universal electrification, households in developing countries often choose their fuel type. They weigh solid fuels—like dung, wood, crop residue, and charcoal—against liquid fuels such as kerosene or liquid petroleum gas. The questions of modern vs. traditional and collection vs. purchase may also carry relevance. Increasingly, households face the decision of whether to electrify. A household's energy portfolio, that is the types and quantities consumed, incurs economic, environmental, gender and health implications.

The price of securing energy could be monetary and/or in the form of opportunity costs. A type of fuel that requires an initial fixed cost or sizable, irregular expenditures may burden households that lack a constant source of income (Goldemberg 2000). Using fuels that require collection rather than purchase creates opportunity costs. These costs disproportionately fall on women, who often hold the responsibility of obtaining fuel (Heltberg 2004). The task of fuel collection limits their capacity to use their time for other productive activities, including education or employment outside the home. Women additionally tend to suffer any adverse health effects stemming from fuel choice more than men (Heltberg 2005). For example, cooking—also a frequent responsibility of women—with wood, charcoal, or agricultural residues produces dangerous levels of indoor pollution if the solid fuel is not safely combusted. The level of outdoor air pollution a household emits, in the form of black carbon,

carbon dioxide, and sulfur dioxide, too, relates to fuel type (DeFries and Pandey 2009; Taylor 2011).

The extent of negative health, gender and environmental consequences diminish with modern cooking fuels of higher efficiency and improved cleanliness, but this comes with increased costs (Goldemberg 2000). For this reason, economic status exerts considerable influence on a household's energy profile. This thesis explores the determinants of household fuel use within the context of the energy ladder hypothesis. Rooted in economic theory, the hypothesis constructs a linear model of household energy use in developing countries. I draw on existing survey data assembled by the United States Agency for International Development (USAID) to construct a dataset of 26 sub-Saharan African countries. Using this, I assess the validity of the energy ladder in this geographical context. My analysis seeks to examine the relationship between wealth and fuel use, as measured by the shares of households reporting the use of traditional, transitional or modern cooking fuels at the enumeration level, an administrative definition created for census sampling. I additionally test for the effects of other characteristics, such as asset ownership and demographic characteristics. Furthermore, I explore the differences in influences on fuel use between rural and urban areas.

Chapter 2: Review of Existing Literature

Overview of the Energy Ladder Hypothesis

An interest in the idea of an energy ladder emerged with the perception of a fuelwood crisis in the 1970s and 1980s (Kowsari and Zarriffi 2010; Taylor 2011). Energy researchers posited a hierarchical relationship of fuel types that a household follows with rising economic status. Hosier and Dowd's 1987 paper is credited as one of the first academic papers to discuss this relationship (Arthur et al. 2010). The idea extends consumer economic theory to energy, assuming that households act as utility maximizing neoclassical consumers (Hosier and Dowd 1987; Kowsari and Zerriffi 2011; Van Der Kroon et al. 2013). With increasing income, the consumer chooses to purchase more of some goods and less of the inferior goods. In the context of the energy ladder, as income rises households consume fuels that occupy higher rungs, ascending the energy ladder. A fuel's rung is dictated primarily by its cost, a reflection of its cleanliness and efficiency (Goldemberg 2000).

Hosier and Dowd present a five-rung ladder: gathered fuel wood, purchased fuelwood, transition fuels, kerosene, and electricity. Subsequent papers propose slight variations of the ladder's structure. Reddy's 1995 paper relies on a six rung ladder: dung/waste, fuelwood, charcoal, kerosene, LPG, and electricity. Van Der Kroon separates fuels into three classifications, primitive, transition and advanced, with multiple fuels under each (2013). The United Nations Development Programme's World Energy Assessment describes separate ladders for cooking, lighting, and mechanical uses (Goldemberg 2000). The characteristics of the several fuel types are detailed in the subsequent section.

Criticism of the Energy Ladder Hypothesis

Later literature proposed a critical modification of the energy ladder hypothesis, termed energy stacking or fuel stacking. This model still constructs a hierarchical relationship of fuel types, but counters that households do not immediately ascend to improved fuels and simultaneously abandon inferior ones. Rather, the fuel stacking hypothesis conjectures that households rely on multiple types of fuel, consuming a higher proportion of superior fuels with rising income.

Researchers point to the reluctance of households to completely abandon biomass even when consuming fuels on the adjacent, or an even higher, rung as evidence contradicting the energy ladder. Masera, one of the earliest critics of the energy ladder model, notes that between 1992 and 1996 in three Mexican states, the proportion of households that abandoned biomass ranged from zero to 16 percent (2000). Peng, Hisham and Pan observe less than 10 percent of their sample of households in rural Hubei, China fully abandon biomass and a decline in its use only occurred in the wealthiest households (2010). Taylor et al. find that despite the nearly universal ownership of LPG stoves amongst migrant households in Guatemala, 77 percent maintained fuelwood as their primary form of fuel (2011). In Nansaior et al.'s study, a decline in the use of biomass occurred only in an urban community within the study area of northern Thailand. Suburban households within the sample actually consumed more biomass per capita than those in rural areas (2011). Campbell et al. observe a similar resistance to abandoning fuel occupying the middle rungs of the ladder in Zimbabwe. Households did not abandon kerosene even after they adopt electricity (Campbell et al. 2003). The fuel-stacking hypothesis captures the tendency for households to continue to consume inferior fuels along with new, superior fuels. Masera proposes that stacking fuel types provides households greater energy security in the face of uncertain and volatile supply, prices, or incomes (2000).

Other authors discount the energy ladder for its failure to incorporate the influence of cultural or habitual factors, instead focusing exclusively on income. The literature discusses the importance of factors such as education, fuel availability, household composition, tradition, and urbanization. A later section will detail the influence of these factors. Recognizing that far more personal and contextual factors than income dictate fuel choice and transition, Kowsari and Zerriffi reject both models and instead propose an energy profile cube (2011). The dimensions are the quality of the fuel itself, the efficiency of the conversion technology and the extent of the demand for energy (Kowsari and Zerriffi 2011).

Papers differ substantially in their working definition of energy ladder and fuel stacking, which contributes to the debate between proponents of the two hypotheses. Some researchers reject the energy ladder on the assumption that the model dictates a linear, unidirectional relationship, while other researchers still invoke the energy ladder hypothesis to situations where households do not fully abandon inferior fuels, nor rely on one source of energy alone. The applications of the latter cohort essentially incorporate the characteristics of fuel transitions that critics argue the energy ladder lacks. For instance, Nansaior et al. seek to determine whether the energy ladder hypothesis or fuel stacking more appropriately fit the trends of energy use in the Khon Kaen province of northern Thailand. Within their sample, the share of biomass did decline with rising income as spurred by urbanization, consistent with the energy ladder. The decline, however, was gradual and continuous rather than sharp and discontinuous as the energy ladder hypothesis predicts. Most households continued to use biomass in addition to kerosene, LPG, or even electricity (2011). Nansaior et al.'s relatively flexible definition of the energy ladder leads them to interpret these results as supportive of both models.

Scope of Existing Literature

Papers published on the fuel transitions vary in their scope. Many draw from case studies of a specific country or even of a smaller region within a country. For instance, Hosier and Dowd's paper use national survey data from Zimbabwe (1987). Masera collects data from three Mexican states and one illustrative village (2000). Hiemstra-Van de Horst and Hovorka interview 78 households in Maun, Botswana and the adjacent peri-urban areas (2008). Maconcahie, Tanko, and Zakariya also restrict their analysis to a single urban center, Kano, located in northern Nigeria (2009). Peng, Hisham, and Pan use a sample representative of Hubei province, which is predominantly rural (2010). Link, Axinn, and Ghimire select the Western Chitwan Valley, nestled in the foothills of the Nepalese Himalayas, as their study area (2011). Campbell et al.

test the energy ladder hypothesis using one period of survey data collected from four small and four large towns in Zimbabwe (2013). Campbell et al. offer one of very few papers in which the analysis incorporates two settings of differing densities. Most authors concentrate on strictly rural or strictly urban areas, as evidenced by the selection mentioned above. Nansaior et al. provides one other exception in a 2011 paper that focuses on three communities in the Khon Kaen province of Thailand. One site represents a rural village, another a dense urban settlement, and the third, a suburban area (2011).

Less frequently, authors compile data from multiple countries to test the energy ladder hypothesis. Heltberg's 2004 paper combines information from eight national surveys administered between 1993 and 2000 that the author deems comparable (2004). The countries included are Brazil, Ghana, Guatemala, India, Nepal, Nicaragua, South Africa, and Vietnam (Heltberg 2004). Van der Kroon et al. execute a meta-analysis of 12 case studies that examine the energy ladder across Africa, Asia, and Latin America (2013). The authors incorporate both studies that examined the energy ladder and studies that examined the energy stacking model. Knight and Rosa compile Food and Agriculture Organization data from 87 developing countries, but they focus primarily on fuelwood consumption rather than all rungs of the ladder (2012). Burke stands out in that the author applies the concept of a household energy ladder to a national scale. He uses cross-sectional panel data on 134 countries that spans 1960-2010 from the International Energy Association and the Penn World Tables (Burke 2013). Van Ruijven et al. evaluate the validity of the energy ladder at the continental level, but the bases of their analysis are projections rather than empirical data (2008). In sum, the most conventional means of evaluating the energy ladder uses household survey data collected within a relatively small study area. Subsequent papers that build on this literature extended the scope of the study area or applied the energy ladder, typically conceived at the household level, to a higher unit of observation.

Contribution to the Literature

As discussed in previous sections, household energy consumption in developing countries has environmental, economic, and gender implications. A number of programs have attempted to encourage households to adopt cleaner and more efficient forms of energy with limited success. These include subsidies and financing strategies, distribution of cook stoves, and electrification projects (Barnes and Floor 1996; Heltberg 2005; Kowsari 2011). Yet, in some developing countries nearly 90 percent of the population lacks adequate access to continuous or sufficient energy supplies and 2.4 billion people still rely on biomass for their primary source of energy (Barnes and Floor 1996; Link, Axinn, and Ghimire 2011). With continued debate surrounding the pattern of fuel transitions and its determinants and limited success in encouragement programs to induce households to transition, opportunities to enter the conversation and propose policy solutions abound.

This thesis contributes to the literature firstly by expanding the scope of the study area to a sizable number of countries and multiple time periods. To my knowledge, no previous work concentrated on a single region as I do nor comprehensively represented a large geographic region. In terms of papers with similar or larger scope, Knight and Rosa's (2012) dataset includes 87 countries. Their methodology and their research question, however, differ slightly from mine. They employ a STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) model and emphasize population changes and their subsequent ecological implications. Burke's (2013) dataset is even larger, 134 countries, but the author measures energy consumption at the national level, meaning the fuels studied are not only for household purposes but industrial and commercial as well. Heltberg (2004) employs a similar methodology to mine and includes multiple countries, but the eight countries included are chosen based solely on comparability of surveys rather than any other uniting factors, such as geography. Furthermore, the Demographic Health Surveys, to my knowledge, have not been utilized in studies of energy ladder. Therefore, my project also contributes to the literature by exploring the topic with a new dataset.

Additionally, a second contribution stemming from the scope of my data relates to my research question on the disparities and differences between rural and urban energy use. Much of the case study based literature focuses solely on an urban area or a rural area. As mentioned earlier within the literature review, two notable exceptions are Nansaior et al. (2011) and Campbell et al. (2013).

Chapter 3: Rungs of the Ladder

This section details the characteristics of the fuel type that occupies rungs of the energy ladder in ascending order: biomass, kerosene, LPG, and electricity.

As the model establishes a hierarchy, most of the benefits and drawbacks are framed in relation to other fuel types. The advantages and disadvantages are therefore relative rather than absolute.

Biomass

Biomass occupies the lowest rung of the energy ladder. Biomass refers to any naturally occurring combustible material. Fuelwood is a major component within this classification, but grasses, crop residues, or dung also fall under biomass (Goldemberg 2000). Dung is perhaps the least desirable form of biomass and its use indicates extreme fuel poverty (Goldemberg 2000). Fuelwood, as the most efficient of the group and for other reasons discussed within this section, constitutes the most desirable form. Biomass can simply be burned within an open fire or can be used within special biomass cookstoves.

Not economic in nature, but nonetheless an important factor is taste. Users of biomass, and fuelwood in particular, widely claim that the fuel lends a better flavor to food than other energy sources (Maconachie, Tanko and Zakariya 2009; Masera et al. 2009). A primary driver of the use of biomass is its degree of accessibility. Biomass, in some form, is largely free and widely available in many areas of the globe, particularly rural settings. Biomass does not require any supporting technology to combust, which adds to its accessibility. Biomass is not costless, however. For households living in proximity to natural resources, the burden assumes the form of time and labor rather than money (Heltberg 2004). The opportunity cost of biomass is higher in households with a higher value of time, usually wealthier or more educated (Heltberg 2004). Furthermore, for households living in biomass-scarce areas, such as urban centers, that need to purchase the fuel biomass can pose greater long-run costs as compared to other types (Goldemberg 2000), as a large component of the cost of higher rung forms is the initial fixed cost of combustion equipment.

A further detriment to biomass is its inefficiency, estimated to be of substantial magnitude less than kerosene or gas. Efficiency measures the fraction of energy released from the fuel that is actually employed by the device of combustion (Goldemberg 2000). A World Energy Assessment conducted by the United Nations Development Programme (UNDP) and the World Energy Council estimated the efficiency of fuelwood, for example, at 15% as compared to kerosene at 50% and gas at 65% efficiency (Goldemberg 2000). Related to its inefficiency, biomass does not burn cleanly. Of all types on the ladder, burning biomass releases the greatest emissions of carbon dioxide, sulfur dioxide, and particulates, leading to both indoor and outdoor air pollution (Goldemberg 2000; Van Rujiven 2008; Heltberg 2005).

Indoor air pollution poses substantial health hazards to users, including acute respiratory infections, chronic obstructive pulmonary diseases, eye and vision issues, and lung cancer (Heltberg 2005). Babies born to women exposed to indoor air pollution face the risk of stillbirth and low birth-weight (Goldemberg 2000). An estimated 1.6 million deaths per year are attributable to the use of biomass (Van Rujiven 2008). Though unrelated to pollution, using biomass also increases the risk for burns (Heltberg 2005). The use of cookstoves can mitigate these risks. But, if stoves simply release the emissions outside of the home without reducing the volume of particulate matter, they do not alleviate the concerns of outdoor air pollution (Heltberg 2005). Some stoves, however, reduce pollution by as much as 30% (Masera et al. 2000). This reduction is environmentally significant as the combustion of biomass releases carbon dioxide and black carbon, the two most noteworthy contributors to climate change (Taylor et al. 2011; DeFries and Pandey 2009).

Deforestation is an additional, though less significant, environmental concern stemming from the use of biomass, specifically fuelwood (Link, Axinn and Ghimire 2011). Fuelwood collection exacerbates rather than causes deforestation. Agriculture, logging, and urbanization all play a larger role in the problem (Heltberg 2005; Hiemstra-Van Der Horst and Hovorka 2008; Maconachie, Tanko and Zakariya 2009; Link, Axinn and Ghimire 2011). Moreover, the issue is more localized than the global concern of climate change (Heltberg 2005). Nonetheless, the contribution of biomass collection to environmental degradation cannot be ignored. Stoves also reduce the extent of deforestation attributable to biomass by improving the efficiency of the fuel and therefore reducing demand (Masera et al. 2000).

Charcoal

Charcoal is a solid fuel derived from wood through a process called pyrolysis, which involves heating the wood to burn off most of the material and therefore leave nearly pure carbon (Federal Ministry for Economic Cooperation and Development (BMZ) 2014). Consequently, charcoal shares a number of advantages and disadvantages with biomass.

A historical and cultural fuel, charcoal preserves the taste of many traditional cooking fuels in contrast to modern energy sources (Nansaior et al. 2011). The economic and opportunity costs of charcoal as compared to higher rung fuels align with those of biomass, too. Charcoal can be produced within the home from gathered fuelwood. Like biomass, charcoal emits organic and non-organic compounds harmful both to human health and the environment (Federal Ministry for Economic Cooperation and Development (BMZ) 2014). The degree of the deleterious fumes emitted is often less than wood due to the stoves sometimes used in conjunction with charcoal (Federal Ministry for Economic Cooperation and Development (BMZ) 2014). The amount of carbon monoxide, in contrast, exceeds that of biomass due to the process of pyrolysis, which greatly increases the concentration of carbon relative to wood (Goldemberg 2000).

Using charcoal generates a larger environmental impact than burning biomass alone; the production of charcoal releases significant stores of the wood's energy, meaning a smaller volume of wood relative to charcoal would be required to produce a given amount of energy (Federal Ministry for Economic Cooperation and Development (BMZ) 2014). Consequently, charcoal puts a greater strain on resources than most other fuel types.

Kerosene

Kerosene lies on the rung just above charcoal. Kerosene is derived from petroleum and is produced during the distillation of crude oil (Lam et al. 2012). Formally, kerosene is defined as the proportion of crude oil that boils when heated between 145 and 300°C (Lam et al. 2012). Compared to its immediate predecessor and biomass, kerosene burns more cleanly and more efficiently, an advantage in terms of both user health and the environment. In urban or other resource scarce settings, obtaining kerosene may require less time than gathering biomass. Or, biomass may just be located too far from the household for collection. Kerosene costs less than the fuels above it on the ladder, lending it an advantage over LPG and electricity.

Households that use kerosene without question must rely on a supply and distribution system. Remote areas that lack local markets or infrastructure to access them may find kerosene particularly unobtainable for reasons of inconvenience or prohibitive pricing. Interruptions or volatility in supply threaten their daily life (Goldemberg 2000). If opportunities to purchase kerosene are infrequent or uncertain a household may be forced to purchase large quantities at one time to ensure an adequate supply, which poor households with little savings cannot afford (Van Der Kroon et al. 2013). Transaction costs are particularly high for isolated communities with weak market access (Masera and Navia 1996). Furthermore, kerosene requires substantial expenditures at the first instance of purchase because combusting the fuel requires additional equipment. These fixed costs may deter use, particularly if the household faces liquidity or credit constraints (Van Der Kroon et al. 2013). Lastly, some households consider the taste of food cooked using kerosene to be inferior to that of wood-cooked (Maconachie, Tanko and Zakariya 2009).

Liquid Petroleum Gas (LPG)

Above kerosene on the energy ladder sits liquefied petroleum gas, abbreviated LPG. LPG, like kerosene, is derived from petroleum. LPG can contain propane, butane, or a combination of the two. Similar advantages that kerosene presents relative to biomass and charcoal apply to LPG as compared to kerosene: namely, increased efficiency and cleanliness of combustion. LPG allows for quicker heating of food or water with fewer emissions. In particular, LPG releases much less sulfur dioxide than kerosene or biomass (Goldemberg 2000). Disadvantages of LPG, too, mimic the drawbacks of kerosene. Firstly, distribution concerns apply to LPG, just as they do to kerosene. Secondly, the requirement of an LPG stove presents an "investment barrier," due to the cost of the equipment (Masera and Navia 1996). Households must additionally pay a deposit for the cylinders that contain the gas (Heltberg 2005). To combat the risks associated with distribution, a household may purchase multiple canisters, increasing the uptake costs of LPG further (Heltberg 2005). After these initial fixed costs, however, the cost of LPG on a monthly basis may be less than the cost of purchasing biomass (Heltberg 2005; Taylor et al. 2011). Since LPG is derived from petroleum, which is susceptible to price shocks, its cost can be volatile (Goldemberg 2000).

Electricity

Electricity claims the highest position on the energy ladder. Electricity can be grid-based or not. Non-grid electricity utilizes small-scale oil generators or renewable energy, while grid electricity draws from large-scale sources such as coal, gas, and nuclear (Van Ruijven 2008). Grid electricity is steadily increasing in prevalence (Goldemberg 2000).

Electricity is the cleanest and most efficient of all fuels on the energy ladder. Electricity can serve a wider variety of purposes than lower rungs. More extensive lighting and the use of other appliances, such as fans and refrigerators, are possible (Campbell et al. 2003). Thus, electricity can improve a household's health, safety, and overall wellbeing. Electricity, especially if grid-based, requires less additional work on the part of the user than other forms of energy. The tasks of collection, purchase, or replenishing supplies largely do not apply, with the exception of prepaid electricity in which users must visit a utility to make payments.

But for many, no grids yet operate in their community, nor does the potential to be served by a grid guarantee access. Volatile supply remains an issue. Grid failure or rolling blackouts undermine the benefits of electricity access. Moreover, households may need to pay for the connection, a prohibitive fixed cost that limits some households' access (Arthur 2010; Heltberg 2005).

Chapter 4: Determinants of Fuel Usage

While the energy ladder focuses on the relationship between wealth and fuel, most of the literature additionally examines the impact of other household demographics or location characteristics. This section examines the influence of education, household size, urbanization and culture on fuel transitions.

Education

A number of studies find evidence that education influences fuel choice. More highly educated households are more likely to adopt non-solid fuels and to transition away from lower rung fuels (Van der Kroon et al. 2013; Kowsari and Zerriffi 2011; Peng, Hisham, and Pan 2011). Heltberg argues that educational attainment influences fuel use through relative opportunity costs. Time usually commands a higher value with schooling, making the tasks of gathering biomass relatively more costly for more educated individuals (2004). Van Der Kroon et al. suggest that perhaps individuals with more education possess more knowledge of alternatives to biomass and a stronger understanding of the associated benefits (2013). Van Der Kroon et al. conclude based on their meta-analysis that the effect of education on fuel choice exists within both rural and urban study areas (2013).

Household Size

The effects of household size on fuel choice also appear consistently throughout the literature, but several channels are proposed for the relationship. A larger household could reasonably increase the use of traditional cooking fuels, in particular those that can be collected, because more members mean more labor available for gathering. Alternatively, with more members the per capita, the fixed costs of adopting non-traditional are lower and might encourage larger households to switch to transitional or modern cooking fuels.

The evidence is also mixed and somewhat contradictory. Hosier and Dowd conclude that larger households are more likely to adopt kerosene over wood, but less likely to progress to electricity (1987). Knight and Rosa, who address the energy ladder hypothesis within the context of ecological footprints, find that a smaller household uses less biomass, specifically fuelwood, per capita (2012). This finding supports Hosier and Dowd's previous claim. Contrastingly, Heltberg finds that in Guatemala household size did not affect the likelihood that a family uses fuelwood, but that smaller households were more likely to use LPG exclusively (2005). He also determines that a larger household size led to fuel stacking (Heltberg 2005). Households with more members tended to use more of both biomass and LPG, the two fuels he concentrates his efforts on. Reddy concludes that household size affected the decision between wood and kerosene, as well as between wood and LPG, but not between kerosene and LPG (1995).

Urbanization

Locational setting affects available resources and accessible fuels. The UNDP's World Energy Assessment claims that households in cities tend to ascend the energy ladder at a lower income threshold and are more likely to fully transition than households in rural areas (Goldemberg 2000). Kowsari and Zerriffi assume the same stance: partial fuel switching, or fuel stacking, is more common in rural areas (2011). Van Der Kroon et al. argue instead that urbanization encourages multiple fuel adoption and at a more rapid pace as compared to rural areas by creating more dynamic markets (2013). Heltberg (2005) agrees with the claim of Van Der Kroon. Living in urban areas often undermines a household's ability to collect firewood, and therefore, leads the household to purchase the fuel wood they consume (Hiemstra-Van Der Horst and Hovorka 2008, 3333). Nansaior et al. as well as DeFries and Pandey assert that urban households consequently consume a smaller share of fuelwood relative to other types and less fuelwood per capita as compared to rural households (Nansaior et al. 2011, 4184; DeFries and Pandey 2009, 133). Urbanization also tends to reduce average household size, which as previously discussed, may or may not affect fuel transitioning (Nansior et al. 2011, 4186).

Culture and Tradition

The most qualitative of the factors discussed here, culture, too, has been identified as a major influence, or perhaps obstacle to fuel transitions. Many societies' traditional recipes require cooking food over a wood fire. For example, Taylor et al. focus on the relationship between the energy ladder and migration, specifically within Guatemala. Migrants often earn higher incomes than individuals electing to seek employment in their home community. The influx of money, the authors reason, could induce households to transition to better fuels (Taylor et al. 2011). Yet, the authors find that even though families of migrants gain the financial standing to obtain LPG and LPG stoves, and many do make these purchases, households continue to utilize fuelwood to avoid altering traditional preparation techniques (Taylor et al. 2011). The migrants stack their fuels rather than abandon low-level fuels. Masera et al., to some extent, also attribute continued dependence on biomass in rural areas to the strength of the local cooking culture (2000). In his study of Guatemala, Heltberg acknowledges that indigenous groups, like the Maya, rely more heavily on fuelwood than other groups, even in urban settings (2005). He posits that a preference for a more traditional lifestyle may be the reason, or, that indigenous peoples are less likely to be integrated into the modern economy (Heltberg 2005).

Chapter 5: Research Design

Research Questions

My primary research question revolves around the validity of the energy ladder hypothesis within the context of sub-Saharan Africa. Although the data do not allow me to address the shares of the household's total energy consumption, I seek to answer whether trends in primary form of cooking fuel follow wealth, as the energy ladder predicts. Secondly, I attempt to identify the extent to which other characteristics significantly impact fuel usage, including those widely discussed in previous literature.

A third question centers on the differences in household fuel choice between urban and rural households. All surveys within my dataset, as discussed in the following section, report whether the household lives in a rural or urban community. A sizeable subset additionally detail whether the location of residence is a large or capital city, a small city, a town or the countryside. Existing literature that discusses urbanization within the context of the energy ladder acknowledges that a household's place of residence affects fuel availability and thus fuel usage (DeFries and Pandey 2009; Heltberg 2005; Kowsari and Zerriffi 2011; Van Der Kroon 2013). The identification of households as rural or urban within the available data will allow me to explore and hopefully quantify the differences in the patterns of fuel usage between these types of communities.

Data Source

The primary proposed data source for this thesis is Demographic and Health Surveys (DHS) administered by the United States Agency for International Development (USAID). The data is publicly available but requires a short application to attain access. Since the program's start in 1984, USAID executed seven phases of the survey. The most recent began in 2013 and will conclude in 2018. USAID does not collect data from each country in every phase, however. While as many as six separate datasets are available for some countries, most have far fewer. Each survey round employs probability sampling that covers 100 percent of the target population (women aged 15-49 and children younger than five years) and is representative of the national level. Thus, a household would appear in multiple survey rounds only by chance and not by survey design. Variations of the survey are administered at the household level as well as the individual level. This research will draw exclusively from household level questionnaires administered as part of the Standard DHS, MIS (Malaria Indicator Survey) or AIS (AIDS Indicator Survey). Surveys typically include more than 9,000 observations and as many as 38,000 per phase per country.

Survey questions cover topics such as child health, family planning, fertility, HIV/AIDS, marriage, mortality, nutrition, and reproductive health (Rutstein and Rojas 2012). They also include information on socio-economic indicators. Though significant overlap exists among surveys, the questionnaires differ slightly between phases and/or countries. For example, some questions that appear in the Phase IV Rwanda DHS do not appear in the Phase II Rwanda DHS or in the Phase IV DHS surveys of other countries.

Construction of the Dataset

To construct the dataset for analysis, I first downloaded all household datasets from phase IV and later for countries geographically classified as Sub-Saharan Africa by USAID, which included standard DHS, Malaria Indicator Surveys (MIS), AIDS Indicator Surveys (AIS), Continuous, Special, and Interim DHS Surveys. Phase IV was chosen as the starting point because the relevant survey question for cooking fuel does not appear in DHS surveys until phase IV or later, depending on the country. The resulting 95 separate datasets spanned the years 1999 to 2014 and ranged in size from 1,600 to 38,500 households. Next, I inventoried each dataset to ascertain whether important variables were included and populated.

I immediately excluded from the final dataset those lacking the key dependent and independent variables, amounting to 21 datasets. Seventy-four datasets, representing 37 countries, remained. Each country corresponded to one to six datasets, meaning that if all remaining datasets were included the resulting panel would be highly imbalanced. Consequently, I imposed additional constraints to correct this imbalance. As half of the countries, 16 of 32, had two and only two separate surveys, I decided to limit my dataset to two periods per country. This decision excluded the six countries for which only one period of data was available. I then determined additional criteria to address the countries with more than two periods of data.

First, I selected for inclusion the most recent survey round that was not missing either variable reporting the location of residence of the household (urban vs. rural; large/capital city, small city, town or countryside). This coincided with the most recent survey administered for a majority of countries, though not all. I established this criterion because these variables are crucial to analyzing the differences in the patterns of energy usage between communities of different populations. The accompanying dataset of the pair was dictated by the difference in time periods. I selected datasets at minimum administered three years prior to the first. In the case of countries with two or more survey rounds that met this condition, I selected the ultimate dataset, again, according to inclusion of the residence variables and subsequently by the number of households represented. In total, the resulting data set includes 52 surveys from 26 countries and a total of 592,432 observations at the household level. The surveys were administered between 2003 and 2014 and represent rounds IV – VI of the DHS. The specific surveys that constitute the final dataset used in the analysis of this research appear in Table 1. Figure 1 below also illustrates relative size and location of these countries.

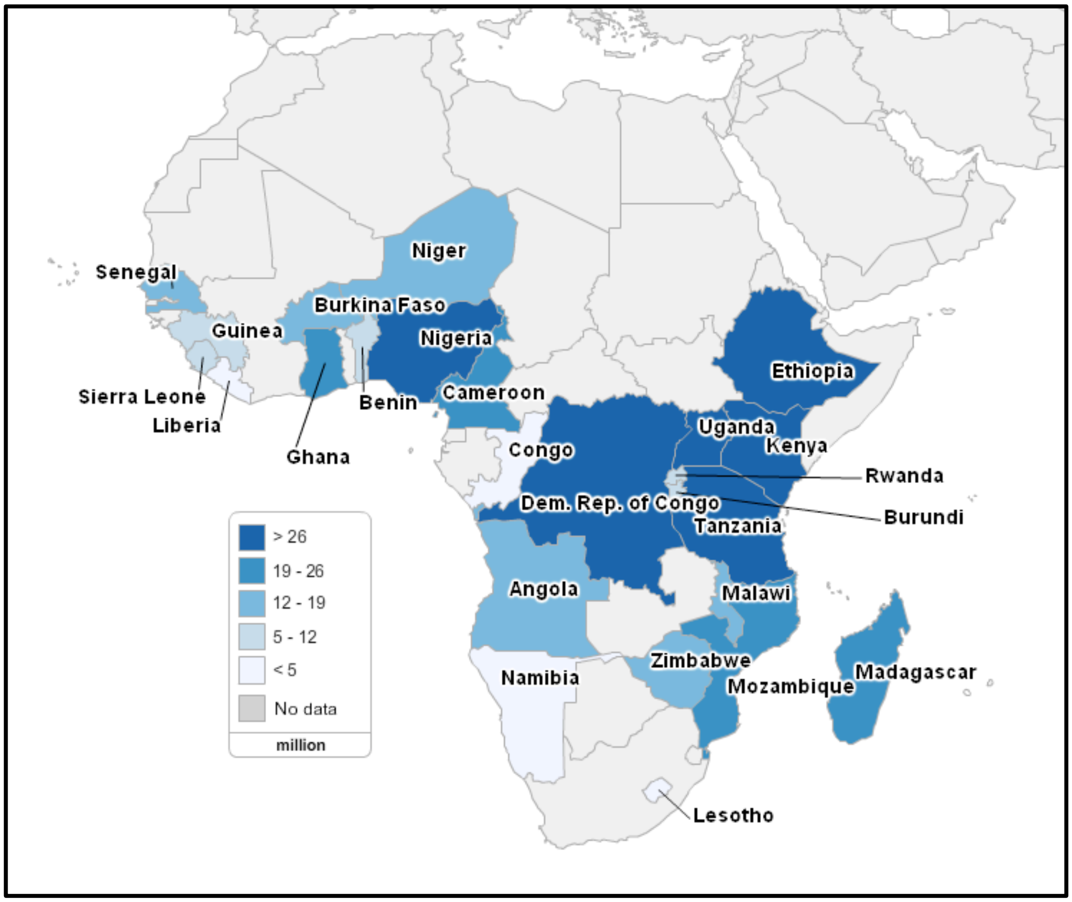

Figure 1: Map of Countries included in Final Dataset

Included countries are labeled and additionally shaded with respect to population.

Table 1: List of Surveys Included in Final Dataset

COUNTRY	YEAR	N (EA)	N (HH)
Angola	2011	238	2,599
Angola	2006-2007	117	8,030
Benin	2011-2012	750	17,422
Benin	2006	750	17,511
Burkina Faso	2010	241	14,424
Burkina Faso	2003	338	9,097
Burundi	2012	573	4,866
Burundi	2010	400	8,596
Cameroon	2011	578	14,214
Cameroon	2004	466	10,462
Congo	2011-2012	536	11,632
Congo	2005	225	5,879
DRC	2013-2014	536	18,171
DRC	2007	300	8,886
Ethiopia	2011	596	16,702
Ethiopia	2005	535	13,721
Ghana	2008	411	11,778
Ghana	2003	412	6,251
Guinea	2012	300	7,109
Guinea	2005	295	6,282
Kenya	2008-2009	398	9,057
Kenya	2003	400	8,561
Lesotho	2009	400	9,391
Lesotho	2004	405	8,592
Liberia	2009	150	4,162
Liberia	2011	150	4,162
Madagascar	2013	274	8,574
Madagascar	2008-2009	594	17,857
Malawi	2010	849	24,825
Malawi	2004	521	13,664
Mali	2012-2013	413	10,105
Mali	2006	407	12,998
Mozambique	2011	610	13,919
Mozambique	2003	604	12,315
Namibia	2013	550	9,849
Namibia	2006-2007	500	9,200
Niger	2012	476	10,750
Niger	2006	342	7,660
Nigeria	2013	896	38,522
Nigeria	2008	886	34,070
Rwanda	2007-2008	249	7,377
Rwanda	2005	462	10,272
Senegal	2008-2009	320	9,291
Senegal	2005	376	7,412
Sierra Leone	2013	435	12,629
Sierra Leone	2008	353	7,284
Tanzania	2010	475	9,623
Tanzania	2004-2005	475	9,735
Uganda	2011	404	9,033
Uganda	2006	368	8,870
Zimbabwe	2005-2006	406	9,285
Zimbabwe	2010-2011	393	9,756

The last step in the construction of the dataset is the aggregation of the household level data at the level of enumeration areas, as defined by DHS. DHS, however, does not themselves define enumeration areas but draws instead from the national census of each country. Enumeration areas are delineated to facilitate accurate counting during national population censuses. Enumeration areas are subdivisions of administrative regions and ideally are smaller than a rural community or an urban ward (United Nations (UN) Statistical Division 2009). Enumeration areas are created to ensure coverage and quality of data collection (UN Statistical Division 2008). According to the United Nations, optimal enumeration areas should:

- "Be mutually exclusive (non-overlapping) and exhaustive (cover the entire country).
- Have boundaries that are easily identifiable on the ground.
- Be consistent with the administrative hierarchy.
- Be compact and have no pockets or disjoined sections.
- Have populations of approximately equally size.
- Be small and accessible enough to be covered by an enumerator within the census period.
- Be small and flexible enough to allow the widest range of tabulations for different statistical reporting units.
- Address the needs of government departments and other data users.
- Be useful for other types of censuses and data-collection activities as well.
- Be large enough to guarantee data privacy." (UN Statistical Division 2009)

DHS employs a nested sample design, whereby it randomizes enumeration areas for inclusion into the survey during the first round of sampling and subsequently uses these enumeration areas as the sampling cluster for individual level analysis. In the second stage of sampling, DHS randomizes households within the enumeration areas into the survey. While DHS provides the region of enumeration areas as well as its classification as rural or urban, DHS lacks full information on the spatial dimension of these tracts.

By collapsing household data, I aim to create an aggregated level energy profile, which not only conveys which fuels are used by households but the relative frequency of each energy type's use. The household level data does not allow for analysis of shares of fuel use, which would nuance the conclusions that I could draw from considering only household level information. Previous examinations of household energy use provide substantial evidence that households rarely rely on one fuel alone (Heltberg 2004; Masera et al. 2000). Examining the enumeration area's energy profile thus provides a richer and more realistic picture of household fuel use, though at an aggregated level. In collapsing the data, I compute the shares of households within the enumeration area that report the use of a particular fuel type.

Under the assumption that each country attempted to create enumeration areas that align with the United Nation's recommendations, analyzing my research question at the level of enumeration area is a viable option that will not endanger the validity of the DHS sampling methodology nor the quality of the data at hand. Given the small size and the delineation procedure of enumeration areas, coupled with the two-stage sampling of the DHS, aggregating to the enumeration level can proxy for the average household's energy profile within the tract of data.

After collapsing at the enumeration level, my dataset contains 22,991 observations, including between three hundred observations and 1,782 observations per country. The median number of enumeration areas per country is 868. The size of the population captured by an enumeration area varies by country, but typically falls between 100 and 300 households.

Methodology

The available data allows me to construct a cross-sectional dataset representing multiple time periods. I run a number of OLS regressions at the enumeration level including fixed effects for the country, region, and data collection phase. The dependent variable is represented by the share of primary energy used by households for cooking within the enumeration area. Cooking is the only energy-intensive activity universally asked about within the dataset, which is why the dependent variable measures only this use of fuel.

For simplicity reasons, in presenting the regression specifications below I represent the dependent variable as $ShareCookFuel_i$. In actuality, I ran each specification with three distinct dependent variables: $ShareTraditional_i$, $ShareTransitional_i$, $ShareModern_i$. These dependent variables draw from the survey question inquiring about the household's primary cooking fuel. Households select between seven to fifteen responses depending on the round of the survey. The options include dung, agricultural residue, straw shrubs or grass, firewood, coal/lignite, charcoal, kerosene, LPG/natural gas, biogas, electricity, other, or decline to answer. To simplify the dependent variable, I categorize these fuels into three types: traditional (dung, agricultural residues, straw shrubs or grass, and fuelwood), transitional (charcoal, coal, and kerosene), and modern (biogas, LPG or natural gas, and electricity). The divisions closely follow Van Der Kroon's classifications (2013). Aggregating all households' choices of primary cooking fuel results in enumeration area shares of primary cooking fuel use that represent the proportion of households that rely on traditional, transitional, or modern cooking fuels.

To explore the energy ladder hypothesis, the primary independent variable must measure the average economic standing of households in the enumeration area. A monetary measure of wealth is not reported within the DHS. Measuring income or expenditure poses difficulties for developing countries. Households may not earn a steady or monetary income. Innumeracy and a reliance on mental recall contribute to inaccuracy. For this reason, the DHS constructs a wealth index based on asset ownership and access to amenities and services, represented by the variable *WealthIndex* in the estimation equation below. The index includes the attributes of the home's physical construction, water and sanitation facilities, livestock and agricultural land holdings, furniture, vehicle ownership, electronics and appliances (Rutstein 2008). Taking the reported information on these items, DHS conducts a principal components analysis that calculates a ranking of households' economic status (Rutstein 2008). For the purposes of normality, within this regression the wealth index is standardized. Thus, the variable conveys relative wealth.

Consequently, the most naïve estimation strategy for modeling the energy ladder hypothesis simply regresses the DHS wealth index on each of the shares of primary cooking fuel, including fixed effects. The estimation strategy is as follows for enumeration area *i* of region *r* in country *c* at phase *p*:

$$ShareCookFuel_{ircp} = \beta_1 WealthIndex_{ircp} + \theta_r + \phi_c + P_p + \varepsilon_{ircp}$$

θ_r represents fixed effects at the region level, ϕ_c represents fixed effects at the country level, and P_p accounts for the phase or round of the survey. Standard errors are clustered at the region as identified within the DHS data.[1]

Beyond this highly simplified regression, I run several additional specifications that account for a number of factors that I believe to influence fuel choice. Firstly, I differentiate between urban and rural enumeration areas using a binary variable termed *Urban.* This variable draws from a survey question that classifies the residence as either urban or rural and is present in all surveys. An urban household might live in the capital or largest city, a smaller city, or even a town according to the classification. Because of the nature of enumeration areas, all residences within a single enumeration area should be classified in the same way. The inclusion of the *Urban* binary allows for differences in the average rates of each class of primary cooking fuel use between rural and urban areas. I also choose to interact any and all independent variables with *Urban.* This

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[1] DHS clusters at the sample frame, which is based on certain administrative levels. The level varies across country according to size and governmental structure, but the selection is clearly identified within the specific methodology document for the survey and the appropriate cluster is clearly identified within the data.

specification allows the effects of the independent variables to differ in magnitude or even direction between community types. In modifying the naïve OLS regression to simply include the binary variable, the regression specification for enumeration area *i* of region *r* in country *c* at phase *p* is:

$$ShareCookFuel_{ircp} = \beta_1 WealthIndex_{ircp} + \beta_2 Urban_{ircp} + \theta_r + \phi_c + P_p + \varepsilon_{ircp}$$

When additionally allowing for interaction terms, the regression specification for enumeration area *i* of region *r* in country *c* at phase *p* is:

$$ShareCookFuel_{ircp} = \beta_1 WealthIndex_{ircp} + \beta_2 \{WealthIndex_{ircp} \text{ x } Urban_{ircp}\} + \beta_3 Urban_{ircp} + \theta_r + \phi_c + P_p + \varepsilon_{ircp}$$

The specifications that include only the *Urban* binary appear in columns (1b), (2b), (3b), and (4b) within the regression tables presented in the results section. The specifications that include both the binary and the interaction terms appear in columns (1c), (2c), (3c), and (4c).

Secondly, I add a group of demographic variables to a set of regressions. *Educ* and *Age* correspond to the enumeration area average for the head of household. *HHSize* reports the enumeration area average number of household members. *Gender* measures the proportion of households headed by a male. The rationale for these variables' inclusion stems from the existing literature, as discussed in a previous section. With the addition of these demographic variables, the regression specification, ignoring the differentiation between rural and urban areas, appears as below for enumeration area *i* of region *r* in country *c* at phase *p*:

$$ShareCookFuel_{ircp}$$
$$= \beta_1 WealthIndex_{ircp} + \beta_2 Educ_{ircp} + \beta_3 Age_{ircp}$$
$$+ \beta_3 HHSize_{ircp} + \beta_4 Gender_{ircp} + \theta_r + \phi_c + P_p + \varepsilon_{ircp}$$

This particular regression appears in column (2a). The form of this regression that adds the *Urban* binary appears in (2b). The form of this regression that adds both the *Urban* binary and all possible interaction terms appears in (2c). In total, the set of regressions that include the demographic variables are (2a) – (2c) and (4a) – (4c).

Lastly, I add a group of variables measuring asset possession to a number of regressions. *AgLandOwnership* and *LivestockOwnership* report the enumeration area's rates of ownership of agricultural land and livestock, respectively. These variables are included because I believe both directly impact the availability of traditional cooking fuels. Households that own agricultural land have greater access to biomass, including crop residues and perhaps fuelwood. Households that raise livestock have greater access to dung and perhaps other forms of biomass if they own grazing land. Likely, greater accessibility to these traditional cooking fuels might lead to higher shares of traditional cooking fuel use. I add quadratic terms for both of these variables as well, to account for the possibility that thresholds of ownership rates exists beyond which increased rates of possession of agricultural land or livestock affects within an enumeration area affects primary cooking fuel choice differently than at lower levels.

ElectrificationRate measures the proportion of households that have electricity. Electrified households, by definition, have access to a modern cooking fuel. Therefore, enumeration areas with higher rates of electrification would likely report greater shares of modern cooking fuels.

Because electrification, land ownership and wealth ownership are accounted for within the wealth index, multicollinearity is present within the model. I maintain the inclusion of these variables within the model for a several reasons. As explained above, I believe them to have a direct impact on fuel choice, far more so than the ownership of other assets that appear in the wealth index (such as a radio or a bicycle), because these variables increase the availability of different fuels. Secondly, the large sample size of nearly 23,000 enumeration level observations greatly decreases variance, mitigating the inflationary effects of the high correlation between these variables. Adding the asset variables to the naïve OLS regression, the estimation strategy for enumeration area *i* of region *r* in country *c* at phase *p* becomes:

$$\begin{aligned} ShareCookFuel_{ircp} &= \beta_1 WealthIndex_{ircp} + \beta_2 AgLandOwnership_{ircp} \\ &+ \beta_3 AgLandOwnershipSq_{ircp} + \beta_4 LivestockOwnership_{ircp} \\ &+ \beta_5 LivestockOwnershipSq_{ircp} + \beta_6 ElectrificationRate_{ircp} \\ &+ \theta_r + \phi_c + P_p + \varepsilon_{ircp} \end{aligned}$$

This particular regression appears in column (3a). The form of this regression that adds the *Urban* binary appears in (3b). The form of this regression that adds both the *Urban* binary and all possible interaction terms appears in (3c). In total, the regression specifications including demographic variables appear in (3a) – (4c).

My preferred estimation strategy, however, incorporates both the demographic and asset characteristics discussed above as well as allows for rural and urban differences. I include all of the interaction terms between the *Urban* dummy and each independent variable as I believe that the magnitude of influence of factors may vary between urban and rural areas. For instance, in the case of education, we might assume that an additional year of schooling is more influential in determining primary cooking fuel choice in urban areas if the quality of schools is higher or if urban residents experience more opportunities to apply their education to purchasing decisions in larger markets than their rural peers. Therefore the final estimation strategy is as follows for enumeration area *i* of region *r* in country *c* at phase *p*:

$$
\begin{aligned}
&ShareCookFuel_{ircp} \\
&= \beta_1 WealthIndex_{ircp} + \beta_2\{WealthIndex_{ircp} \text{ x } Urban_{ircp}\} + \beta_3 Educ_{ircp} \\
&+ \beta_4\{Educ_{ircp} \text{ x } Urban_{ircp}\} + \beta_5 Age_{ircp} + \beta_6\{Age_{ircp} \text{ x } Urban_{ircp}\} \\
&+ \beta_7 Gender_{ircp} \\
&+ \beta_8\{Gender_{ircp} \text{x } Urban_{ircp}\} + \beta_9 HHSize_{ircp} + \beta_{10}\{HHSize_{ircp} \text{x } Urban_{ircp}\} \\
&+ \beta_{11} AgLandOwnership_{ircp} + \beta_{12}\{AgLandOwnership_{ircp} \text{ x } Urban_{ircp}\} \\
&+ \beta_{13} AgLandOwnershipSq_{ircp} + \beta_{14}\{AgLandOwnershipSq_{ircp} \text{ x } Urban_{ircp}\} \\
&+ \beta_{15} LivestockOwnership_{ircp} + \beta_{16}\{LivestockOwnership_{ircp} \text{ x } Urban_{ircp}\} \\
&+ \beta_{17} LivestockOwnershipSq_{ircp} \\
&+ \beta_{18}\{LivestockOwnershipSq_{ircp} \text{ x } Urban_{ircp}\} + \beta_{19} ElectrificationRate_{ircp} \\
&+ \beta_{20}\{ElectrificationRate_{ircp} \text{ x } Urban_{ircp}\} + \beta_{21} Urban_{ircp} + \theta_r + \phi_c + P_p \\
&+ \varepsilon_{ircp}
\end{aligned}
$$

Again, θ_r represents fixed effects at the region level, ϕ_c represents fixed effects at the country level, and P_p accounts for the phase or round of the survey. Standard errors are clustered at the region as identified within the DHS data. This specification appears in column (4c) of the regression tables presented in the results.

Chapter 6: Results

Summary Statistics of Household Composition

Table 2 below presents a number of household level summary statistics for the overall sample. Table 3 additionally breaks down the sample by rural and urban areas and indicates statistical differences. Table A-1, located within the Appendix, additionally presents the summary statistics broken down by country.

Table 2: Household Level Summary Statistics

Household-Level Summary Statistics					
Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Household Structure					
Household Size	591,791	5.08	3.09	1	25
Percent with 2 Adults of Opposite Sex	592,432	36.30	48.09	0	1
Percent with 3+ Unrelated Adults	592,432	35.72	47.92	0	1
Percent with One Adult	592,432	18.25	38.62	0	1
Household Head Characteristics					
Percent Male	592,429	18.25	0.43	0	1
Age of Household Head (All)	591,528	44.68	15.86	9	97
Age of Household Head (Males)	442,340	43.74	15.36	9	97
Age of Household Head (Females)	149,186	47.48	16.96	9	97
Years of Schooling (All)	542,425	4.67	4.94	0	25
Years of Schooling (Males)	405,553	4.98	5.04	0	25
Years of Schooling (Females)	136,869	3.74	4.51	0	23
Community Characteristics					
Percent Living in Urban Areas	592,432	32.24	46.74	0	1
Percent Living in Capital Cities	316,380	10.77	31.01	0	1
Percent Living in Small Cities	316,380	9.43	29.22	0	1
Percent Living in Towns	316,380	13.91	34.60	0	1
Percent Living in Countryside	316,380	65.89	47.41	0	1
House Construction					
Has Electricity	574,282	26.36	44.06	0	1
Percent with Thatch Roof	438,609	29.77	45.72	0	1
Percent with Cement Roof	438,609	50.52	50.00	0	1
Percent with Dirt Floors	553,503	47.98	49.96	0	1
Percent with Cement Floors	553,503	30.86	46.19	0	1
Percent with Dirt Walls	421,088	19.79	39.84	0	1
Percent with Cement Walls	421,088	7.74	26.72	0	1
Ownership Rates					
Percent Owning Agricultural Land	400,279	63.87	48.04	0	1
Percent Owning Livestock	364,471	54.48	49.80	0	1
Percent Owning a Cell Phone	475,640	47.38	49.93	0	1
Percent Owning a Radio	553,239	60.18	48.95	0	1
Percent Owning a TV	553,002	22.94	42.04	0	1
Percent Owning a Motorized Vehicle	552,414	15.32	36.01	0	1

The average household numbers five members. Most commonly, the relationship structure of the household involves two adults of opposite sexes and nearly three-quarters of household heads are married. Although, almost equally as common, three or more related adults inhabit the same household. Only one adult is present in nearly one-fifth of households. Three-quarters of all households are headed by a male. Of those female household heads, nearly 65 percent are not married and over 40 percent are the only adult living in the household. The mean age of the household head is 45 years. Female household heads are on average older than their male peers, 47 years old as compared to 44. The mean education level for household heads is roughly 4.7 years. Male and female household heads differ in their average educational attainment. Male household heads attain 1.25 more years of schooling on average, 5 years versus 3.75 years.

A sizeable majority, over two-thirds, of households lived in areas deemed rural according the survey. Of the subset of households for which more detailed residence data is available, nearly 11 percent live in the capital or largest city of their country, almost 10 percent live in a small or secondary city, and 14 percent live in a town.

All of demographic measures described above statistically differ at the five percent level between urban and rural households when performing t-tests for difference in means across these two community types. The results of these tests appear in Table 3. Kernel density plots comparing the distribution of demographic variables between rural and urban areas can be found in Figure A-1 of the Appendix. Urban households are on average slightly smaller, though the difference amounts to only 0.3 members. The household heads are less likely to be married and more likely to live alone or with two or more unrelated adults. Urban household heads are also slightly younger on average than those in rural areas, a difference of 2.3 years. Female household heads are more common by three percentage points in urban settings. The most significant difference emerges in educational attainment. Urban household heads and their spouses, if applicable, on average receive twice the years of schooling of their rural peers, a difference of 3.7 and 3.4 years for household heads and spouses, respectively.

Table 3: Differences in Summary Statistics Between Rural and Urban Areas

Variable	Rural Mean	Urban Mean	T-Statistic	P-Value	N
Male	76%	73%	26.01	0.00	592,429
HHH Age	45.435	43.096	53.13	0.00	591,528
HH Size	5.210	4.897	35.08	0.00	592,432
HHH Years of Schooling	3.487	7.185	-274.01	0.00	542,425
Number of Spouses	0.768	0.624	85.29	0.00	592,432
Spouse Years of Schooling	2.491	5.844	-224.74	0.00	352,281
Owns Agricultural Land	79%	32%	326.18	0.00	400,279
Owns Livestock	67%	28%	237.96	0.00	364,471
Has Electricity	10%	62%	-507.54	0.00	574,282
Owns a Cell Phone	34%	74%	-281.86	0.00	475,640
Owns a Motorcylce	10%	15%	-58.90	0.00	552,687
Owns a Vehicle	2%	11%	-151.52	0.00	552,548
Has a Thatch Roof	41%	7%	250.96	0.00	438,609
Has a Metal Roof	40%	73%	-219.47	0.00	438,609
Has Dirt Walls	26%	8%	142.36	0.00	421,088
Has Cement Walls	10%	37%	-221.99	0.00	421,088
Has Brick Walls	11%	12%	-8.01	0.00	421,088
Has Earth Floors	62%	19%	330.27	0.00	553,503
Has Cement Floors	20%	54%	-269.25	0.00	553,503
Cooks Over Open Fire	94%	64%	145.43	0.00	131,566
Cooks Over Open Stove	0.060	34%	-124.49	0.00	131,566
Cooks With Closed Stove	3%	9%	-16.28	0.00	114,081
Has a Kitchen	49%	59%	-32.14	0.00	113,294
Cooks in House	28%	40%	-74.03	0.00	359,076
Cooks in Separate Building	39%	23%	93.14	0.00	359,076
Cooks Outdoors	33%	36%	-18.92	0.00	359,076

Just over a quarter of all households in the sample have electricity. Three-quarters of electrified households are located in urban areas. The average home has two sleeping rooms. The most common wall materials are dirt in rural areas (reported in 20 percent of all households) and cement in urban areas (reported in 19 percent of all households). More than half of the sample's roofs are metal, the most common roofing material in urban areas; thirty percent have a thatch or palm roof, the most common roofing material in rural areas. Nearly half of all households report an earth or sand floor, the most common floor material in rural areas, while nearly 30 percent report a cement floor, the most common floor material in urban areas.

Nearly two-thirds of all households own agricultural land and more than half own livestock of some type. Significantly higher rates of ownership of these assets unsurprisingly occur in rural areas. The prevalence of agricultural and livestock ownership within rural areas exceeds more than twice that of urban areas. Kernel density plots comparing the distribution of these ownership variables, as well as the electrification rates between rural and urban areas can be found in Figure A-2 of the Appendix. Nearly half of the total sample own cell phones. More than 60 percent own a radio and nearly one-quarter own a television. Fifteen percent own a motorized vehicle (a motorcycle, a car or a truck).

In terms of cooking habits, nearly equal proportions of households overall cook in the house, in a separate building, and outdoors. However, urban households are relatively more likely (a difference of 12 percentage points) to report cooking in the house and rural households are relatively more likely to report cooking in a separate building (a difference of 15 percentage points). Likewise, urban households are more likely, by nine percentage points, to have a separate room designated as a kitchen. But, slightly more than half of all households have a separate room designated as a kitchen. Very few households' cooking areas contain a chimney or hood, which implies that a majority of households, and especially those members responsible for food preparation, likely face concentrations of indoor air pollutants (Mobarak et al. 2012). In rural areas, fewer than four percent of households have these ventilation measures while they are present eight percent of urban.

Overview of Use of Cooking Fuels

Fuelwood is by far the most commonly used cooking fuel within the sample. Figure A-3 in the appendix illustrates this as well as the distribution of households reporting all other fuel types. Over 70 percent of households, or 417,859 households, reported it as their primary cooking fuel. Fuelwood is the only fuel categorized as traditional according to my methodology in the five most common fuels overall. Second most prevalent is charcoal, a transitional cooking fuel, which over 13 percent, or 77,418 households, use. Another transitional cooking fuel, kerosene, follows but only 4.5 percent of households, 26,876, employ this type. Two modern cooking fuels, LPG/natural gas and electricity, round out the five most common fuels. LPG/natural gas is as common as kerosene, 26,072. Fewer households use electricity, 15,120 households, which constitutes less than three percent of the total sample. The number of households reporting each fuel type as their primary cooking energy appears in the last column of Table 3 below.

Wealth and Cooking Fuel Use

Table 4: Proportion of Cooking Fuel Users Belonging to Each Wealth Quintile

Proportion Reporting Fuel Type as Primary Cooking Fuel by Wealth Quintiles							
	Fuel Type	Poorest	Poorer	Middle	Richer	Richest	Total
Modern	Electricity	5 (0.03%)	4 (0.03%)	202 (1.34%)	4,709 (31.14%)	10,200 (67.46%)	15,120 (100%)
	LPG / Natural Gas	3 (0.01%)	131 (0.50%)	1,400 (5.37%)	5,914 (22.68%)	18,624 (71.43%)	26,072 (100%)
	Biogas	0 (0.00%)	9 (0.80%)	74 (6.56%)	244 (21.63%)	801 (71.01%)	1,128 (100%)
Transitional	Kerosene	20 (0.07%)	496 (1.85%)	2,127 (7.91%)	7,895 (29.38%)	16,338 (60.79%)	26,876 (100%)
	Coal / Lignite	8 (0.2%)	37 (0.93%)	88 (2.22%)	761 (19.23%)	3,064 (77.41%)	3,958 (100%)
	Charcoal	1,837 (2.37%)	4,376 (5.65%)	8,978 (11.60%)	19,806 (25.58%)	42,421 (54.79%)	77,418 (100%)
Traditional	Fuelwood	115,072 (27.54%)	104,989 (25.13%)	95,630 (22.89%)	72,075 (17.25%)	30,093 (7.20%)	417,859 (100%)
	Straw / Shrubs / Grass	3,995 (36.52%)	3,573 (32.66%)	2,144 (19.60%)	947 (8.66%)	280 (2.56%)	10,939 (100%)
	Agricultural Residue	189 (22.83%)	198 (23.91%)	190 (22.95%)	193 (23.31%)	58 (7.00%)	828 (100%)
	Animal Dung	868 (22.14%)	1,043 (26.60%)	994 (25.35%)	773 (19.71%)	243 (6.20%)	3,921 (100%)

Relationships between fuel types and wealth appear clearly within Table 3. Below the raw frequency of users of the particular fuel type the table reports the percentage of users belonging to each wealth quintile. Table 3 illustrates that traditional cooking fuel users disproportionately fall into the lower wealth quintiles, while users of transitional and modern cooking fuels most commonly occupy the highest wealth quintile. For instance, more than half of fuelwood and straw/shrub/grass users are classified within the poorest and poorer fifths. However, with the exception of straw/shrubs/grass, the percentage of users does not fall until the richest quintile, suggesting a persistence of traditional cooking fuels even among the relatively well-off. Still, the percentage of all traditional cooking fuel users falls with each classification of increasing economic status.

In contrast for all transitional and modern cooking fuels, a sizeable majority of users report a wealth index in the richest quintile. The shares of users in the highest wealth quintile are largest for coal/lignite, a transitional cooking fuel, and LPG/natural gas, a modern cooking fuel. An additional fifth or even a third of users of transitional or modern cooking fuel users fall into the fourth, or second most wealthy, quintile. The percentage of users that belong to the two lowest quartiles falls below one percent for all modern cooking fuels. For the most part, transitional cooking fuels show only marginally higher numbers for the poorest households of the sample. The proportion of charcoal users in the lowest quartiles is slightly higher, though still low. Eight percent of charcoal users occupy the two poorest quintiles and nearly 20 percent fall into the bottom three.

As the energy ladder hypothesis predicts, households in higher quintiles use cleaner and more efficient fuels. The distribution of wealth quintiles for traditional users skews heavily towards the poorer end and the distribution of wealth quintiles for both transitional and modern users skews heavily towards the wealthy end. Yet, a sizeable percentage of households in the richest or richer wealth quintiles still use fuelwood. In fact, more households in the wealthiest quintile use firewood than all three modern cooking fuels combined. In the second wealthiest quintile, fuelwood remains the most commonly reported cooking fuel. The divide between traditional and non-traditional cooking fuels appears strong, while disparities between transitional and modern are less consistent. This pattern is illustrated by Figure 2 below, as well as Figure A-4 in the appendix.

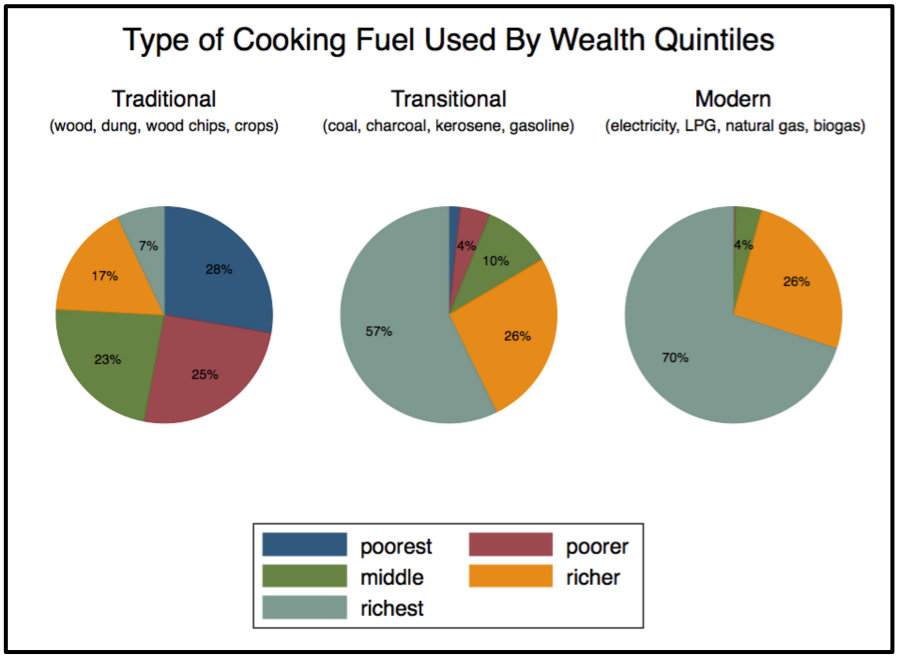

Figure 2: Primary Cooking Fuel by Wealth Quintile

<u>Community Type and Cooking Fuel Use</u>

Cross tabulations with the identification of rural versus urban households reveal disparities in the prevalence of different fuels and slightly different rankings of frequency. Urban and rural areas overlap considerably in their lists of most common fuels. For both rural and urban households, the same fuels occupy the top two spots: fuelwood as first and charcoal as second. Kerosene and LPG/natural gas also appear within the list of the top five fuels for both urban and rural households. Urban households, however, tend towards transitional and modern cooking fuels more than rural households. LPG/natural gas is the third most common fuel for urban households, but only the fifth most common for rural households. For rural areas, straw/shrubs/grass, a traditional cooking fuel often considered inferior even to wood, occupies the third spot. Electricity is the fifth most common fuel for urban areas, but does not appear on the list for rural areas. In both rural and urban areas, kerosene sits in the slot of the fourth most common fuel. This distribution can be seen below in Table 5.

Table 5: Most Commonly Reported Primary Cooking Fuels

Most Commonly Reported Primary Cooking Fuels

	Full Sample		Urban Households		Rural Households	
Fuel Type	**Freq.**	**Pct.**	**Freq.**	**Pct.**	**Freq.**	**Pct.**
Fuelwood	417,859	70.6	69,351	36.3	348,508	86.8
Charcoal	77,418	13.1	55,253	28.9	22,165	5.5
Kerosene	26,876	4.5	20,340	10.7	6,536	1.6
LPG / Natural Gas	26,072	4.4	22,218	11.6	3,854	1.0
Electricity	15,120	2.6	13,288	7.0	1,832	0.5
Straw / Shrubs / Grass	10,939	1.9	1,231	0.6	9,708	2.4
Total	574,284	97.0	181,681	95.2	392,603	97.8

One notable difference between rural and urban households is the distribution across fuel types. While in both more than 94 percent of households report using one of the five most common fuel types, urban households show a more equal distribution across the five types. The distribution also skews more towards transitional and modern cooking fuels for urban as compared to rural households. The proportion of urban households that report fuelwood as their primary cooking fuel, 36 percent, measures a little more than half of the proportion reported for the full sample. Urban households also report the other types within the five most common at much higher rates than their rural peers. The proportion that reported charcoal, LPG/natural gas, kerosene, and electricity is five times higher than the proportion in rural areas. Rural households, in contrast, generally rely more heavily on fuelwood, which nearly 85 percent report to be their primary cooking fuel. Combined, the next four most common fuels account for just 12 percent of all households. This pattern is visible in Figure A-5 within the appendix.

The trend between primary cooking fuel and degree of urbanization of the households' communities remains after breaking down the classification of place of residence further into capital city, small city, town and countryside. These results are detailed within Table A-4 in the appendix.

Regression Analysis

I discuss in detail below the results only of my preferred fixed-effects OLS regression organized according to each dependent variable: *ShareTraditional, ShareTransitional, ShareModern*. I consider a p-value of 0.05 or less to indicate statistical significance and an effect size of 0.2 standard deviations to constitute sizeable magnitude.

Share of Traditional Cooking Fuels

Table 6 presents the results for all OLS regressions described in the methodology section. The preferred specification appears in column (4c), which serves as the emphasis for this and later discussion. Overall, the preferred regression including the fixed effects explains nearly 85 percent of the variation in the share of traditional cooking fuels.

With each addition of a variable or group of variables, the standardized wealth index loses magnitude as well as significance. In the preferred regression, after controlling for all asset ownership and demographic variables, the wealth index is not statistically significant. Furthermore, removing the standardized wealth index from the regression specification, as presented in columns (5a) – (5c), only marginally alters the estimated coefficients of the other variables. In column (4c), however, the index is jointly significant with any of the asset variables with which it is correlated. Appendix IV provides additional clarification and justification for the inclusion of both the standardized wealth index and other asset variables despite the apparent multicollinearity.

The enumeration area's categorization of rural or urban strongly relates to its traditional cooking fuel shares. All else equal, the shares of traditional cooking fuels are 34 percentage points higher in rural enumeration areas than in urban ones. This difference amounts to nearly a one standard deviation increase in the share of traditional cooking fuels. While the coefficients for urban fluctuate considerable, they are consistently negative across all regressions. Additionally, a clear pattern emerges that the magnitude of the urban binary is consistently much larger in the regressions that additionally include the interaction terms.

Table 6: OLS Regressions for the Share of Traditional Cooking Fuels

	Share of Households Reporting Traditional Fuels as Primary Cooking Fuel								
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
Standardized Wealth Index	-0.152***	-0.083***	-0.076***	-0.070**	-0.045**	-0.066**	-0.027	-0.021	-0.005
	(-4.41)	(-4.04)	(-5.22)	(-2.23)	(-2.09)	(-2.89)	(-1.30)	(-1.16)	(-0.39)
Urban*Standardized Wealth Index			-0.013			0.029			-0.025
			(-0.42)			(1.02)			(-1.53)
Urban		-0.357***	-0.356***		-0.221***	-0.515***		-0.143***	-0.193***
		(-18.77)	(-17.52)		(-15.46)	(-7.12)		(-11.26)	(-5.23)
Proportion of Households With Male Head				0.135***	0.055***	-0.011			
				(5.53)	(2.86)	(-0.52)			
Urban*Proportion of Households With Male Head						0.248***			
						(5.55)			
Average Age of Household Heads				0.008***	0.006***	0.003***			
				(10.10)	(8.70)	(5.38)			
Urban*Average Age of Household Heads						0.005***			
						(4.09)			
Average Size of Households				0.014***	0.015***	0.013***			
				(3.85)	(4.84)	(4.07)			
Urban*Average Size of Households						0.005			
						(0.83)			
Average Years of Schooling for Household Heads				-0.063***	-0.045***	-0.028***			
				(-12.10)	(-12.83)	(-8.40)			
Urban*Average Years of Schooling for Household Heads						-0.030***			
						(-8.96)			
Proportion of Households Owning Agricultural Land							0.393***	0.348***	0.244**
							(4.430)	(4.060)	(3.280)
Urban*Proportion of Households Owning Agricultural Land									-0.053
									(-0.55)
Squared Proportion of Households Owning Agricultural Land							-0.121*	-0.139**	-0.085
							(-1.78)	(-2.09)	(-1.55)
Urban*Squared Proportion of Households Owning Agricultural Land									0.238***
									(2.700)
Proportion of Households Owning Livestock							0.723***	0.653***	0.620***
							(8.720)	(8.220)	(7.150)
Urban*Proportion of Households Owning Livestock									-0.156
									(-1.37)
Squared Proportion of Households Owning Livestock							-0.455***	-0.438***	-0.425***
							(-6.64)	(-6.67)	(-6.25)
Urban*Squared Proportion of Households Owning Livestock									0.259*
									(2.480)
Proportion of Households With Electricity							-0.345***	-0.289***	-0.277***
							(-8.64)	(-8.31)	(-8.63)
Urban*Proportion of Households With Electricity									0.002
									(0.050)
R-Squared	0.581	0.715	0.715	0.733	0.772	0.789	0.81	0.823	0.828
Number of Enumeration Areas	22,991	22,991	22,991	21,493	21,493	21,493	13,425	13,425	13,425

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Share of Households Reporting Traditional Fuels as Primary Cooking Fuel

	(4a)	(4b)	(4c)	(5a)	(5b)	(5c)
Standardized Wealth Index	-0.006	-0.004	-0.011			
	(-0.46)	(-0.34)	(-0.97)			
Urban*Standardized Wealth Index			0.003			
			(0.290)			
Urban		-0.114***	-0.339***		-0.114***	-0.330***
		(-10.43)	(-4.59)		(-10.45)	(-4.50)
Proportion of Households With Male Head	-0.004	-0.021	-0.067***	-0.004	-0.021	-0.066**
	(-0.23)	(-1.19)	(-3.08)	(-0.22)	(-1.19)	(-3.04)
Urban*Proportion of Households With Male Head			0.155***			0.151**
			(3.110)			(3.07)
Average Age of Household Heads	0.004***	0.004***	0.002***	0.004***	0.004***	0.002**
	(5.450)	(5.190)	(3.060)	(5.54)	(5.29)	(3.05)
Urban*Average Age of Household Heads			0.003**			0.003*
			(2.260)			(2.15)
Average Size of Households	0.007*	0.010***	0.003	0.007	0.010**	0.003
	(1.950)	(2.990)	(1.060)	(1.94)	(3.00)	(1.01)
Urban*Average Size of Households			0.020***			0.019***
			(3.510)			(3.49)
Average Years of Schooling for Household Heads	-0.032***	-0.029***	-0.016***	-0.033***	-0.029***	-0.017***
	(-10.47)	(-10.25)	(-5.28)	(-12.14)	(-11.78)	(-5.72)
Urban*Average Years of Schooling for Household Heads			-0.023***			-0.023***
			(-6.45)			(-6.29)
Proportion of Households Owning Agricultural Land	0.337***	0.307***	0.261***	0.338***	0.308***	0.264***
	(4.440)	(4.140)	(4.040)	(4.44)	(4.13)	(4.07)
Urban*Proportion of Households Owning Agricultural Land			-0.086			-0.091
			(-1.13)			(-1.18)
Squared Proportion of Households Owning Agricultural Land	-0.133**	-0.147***	-0.108**	-0.132*	-0.146*	-0.108*
	(-2.34)	(-2.61)	(-2.28)	(-2.32)	(-2.59)	(-2.27)
Urban*Squared Proportion of Households Owning Agricultural Land			0.175***			0.180*
			(2.390)			(2.46)
Proportion of Households Owning Livestock	0.641***	0.591***	0.515***	0.643***	0.592***	0.522***
	(8.920)	(8.550)	(5.570)	(8.85)	(8.50)	(5.61)
Urban*Proportion of Households Owning Livestock			-0.134			-0.139
			(-1.09)			(-1.13)
Squared Proportion of Households Owning Livestock	-0.435***	-0.424***	-0.358***	-0.435***	-0.424***	-0.361***
	(-7.01)	(-7.09)	(-5.09)	(-6.97)	(-7.06)	(-5.12)
Urban*Squared Proportion of Households Owning Livestock			0.171			0.175
			(1.620)			(1.65)
Proportion of Households With Electricity	-0.251***	-0.217***	-0.230***	-0.255***	-0.220***	-0.235***
	(-8.19)	(-7.43)	(-8.10)	(-8.95)	(-8.03)	(-8.53)
Urban*Proportion of Households With Electricity			0.061*			0.061
			(1.770)			(1.78)
R-Squared	0.837	0.845	0.857	0.837	0.845	0.857
Number of Enumeration Areas	13,275	13,275	13,275	13,275	13,275	13,275

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Enumeration areas with a high percentage of households that own agricultural land are more likely to report higher shares of traditional cooking fuel use. Across all specifications, the estimates of the effect are statistically significant and the hypothesis that the effect does not differ across rural and urban enumeration areas can be rejected as well. The coefficients remain relatively steady across all regressions. In the preferred specification, the effect size is not of substantial magnitude (based on the identified criteria of 0.2 standard deviations) for rural enumeration areas. That is, a one standard deviation increase in the percentage of households owning agricultural land leads to an increase of less than 0.2 standard deviations in the traditional fuel shares. The effect for urban enumeration area, which substantially exceeds that of rural areas, in contrast can be considered of substantial magnitude.

Interpreting the threshold effect of the quadratic term for agricultural land ownership based on the mean value of 63 percent, suggests a one percentage point increase from the mean corresponds with a 0.20 percentage point increase in the predicted share of traditional cooking fuels. A one standard deviation increase from the mean in the proportion of households that own agricultural land is associated with an increase of 0.28 standard deviations in the share of traditional cooking fuels. Due to the fact that the linear and quadratic term take the same sign, the effect size for urban enumeration areas increases with the ownership rate of agricultural land.

Overall, the effect of the livestock ownership rate and its quadratic are statistically significant but not of substantial magnitude. Moreover, while the effect is estimated to be larger in urban areas than rural areas, the difference between the two is not significant. Again, the interpretation uses the mean livestock ownership rate, 0.54, as a base because of the inclusion of the quadratic term. For a one percentage point increase in the proportion of households reporting livestock ownership from the mean, the increase in the share of traditional cooking fuels amounts to just 0.10 percentage points. But, a turning point exists at an ownership rate of 0.72, above which the effect of an increase in livestock ownership actually reduces the share of traditional cooking fuels. Table

7 below summarizes the overall effects and significance of both agricultural land and livestock ownership on the share of traditional cooking fuels.

Table 7: Summary of Effects of Rates of Agricultural Land and Livestock Ownership in Shares of Traditional Cooking Fuels

SHARE OF TRADITIONAL COOKING FUELS						
Variable	**Community Type**	**Point Estimate**	**Statistical Significance at 5 Percent Level**	**Joint Effect of Increase from Mean**	**Effect Size of Substantial Magnitude**	**Turning Point (if in range)**
Rate of Agricultural Land Ownership	Rural	0.261	Jointly Significant	0.10 pct. pt. increase	No	none
Squared Rate of Agricultural Land Ownership		-0.108				
Rate of Agricultural Land Ownership	Urban	-0.086	Jointly Significant Statistically Differs From Rural	0.20 pct. pt. increase	Yes	none
Squared Rate of Agricultural Land Ownership		0.175				
Rate of Livestock Ownership	Rural	0.515	Jointly Significant	0.10 pct. pt. increase	No	0.72
Squared Rate of Livestock Land Ownership		-0.358				
Rate of Livestock Ownership	Urban	-0.134	Not Jointly Significant Does Not Statistically Differ From Rural	0.001 pct. pt. decrease	No	0.78
Squared Rate of Livestock Land Ownership		0.171				

Enumeration areas with high rates of electrification are more likely to have much lower shares of traditional cooking fuel use. The estimated effect of electrification rates is statistically significant, but the hypothesis that the effect size differs between rural and urban areas cannot be rejected. A one percentage point increase in the rate of electrification corresponds to a 0.23 percentage point decrease in the share of traditional cooking fuels for rural enumeration areas. Evaluated in terms of standard deviations the effect is of substantial magnitude.

The estimates for the demographic variables are less consistent than the asset variables across regressions. The proportion of female-headed households, for instance, shows inconsistency in signs, effect size, and statistical significance. The estimates of the effect of other demographic variables fluctuate as well, but to a lesser extent. Moreover, the effects sizes, with the exception of the household head's years of schooling are small by comparison to those of the asset variables.

The average age of household heads is positively associated with the share of traditional cooking fuels. The estimates are statistically significant for both rural and urban areas respectively in the preferred specification. The effect of age is estimated to be twice as large in urban areas as rural areas, though the difference between rural and urban areas is not statistically significant. Moreover, the effect size is not of sizable magnitude.

Larger average household size corresponds to higher shares of traditional cooking fuels, though the estimated effect is statistically significant only for urban areas. The difference between the effects for rural and urban enumeration areas is significant as well. An increase of one in the average household size increases the share of traditional cooking fuel in urban enumeration areas by 2.3 percentage points.

A one percent increase in the proportion of female-headed households corresponds to a rise of 0.067 percentage points in the share of traditional cooking fuels for rural enumeration areas. The effect is reversed for urban enumeration areas, where a one percent increase in the proportion of female-headed households corresponds to a decrease of 0.088 percentage points in the share of traditional cooking fuels.

The average years of schooling for household heads is negatively associated with the share of traditional cooking fuels and the effects of education boast the greatest magnitude of any trait included in the regression. The effects for both rural and urban are significant, as is the difference between the effect for rural and urban enumeration areas. The effect of education emerges as nearly 2.5 times larger in urban versus rural enumeration areas. A one year increase in the household heads' average educational attainment corresponds to a decrease of 1.6 percentage points in the share of traditional cooking fuels for rural enumeration areas and a decrease of 3.9 percentage points for urban enumeration areas.

Share of Transitional Cooking Fuels

Table 8 presents the results for all OLS regressions described in the methodology section. The preferred specification again appears in column (4c). The preferred specification explains less of the variation in the share of transitional cooking fuels than it did for traditional cooking fuels, but nonetheless still boasts an R-squared measure of 72 percent.

Just as for traditional cooking fuel shares, with each addition of a variable or group of variables, the standardized wealth index loses magnitude as well as statistical significance. Again in the preferred regression, after controlling for all asset ownership and demographic variables, the wealth index is not statistically significant and removing the standardized wealth index from the regression specification, as presented in columns (5a) – (5c) only marginally alters the estimated effects of the other variables. The standardized wealth index is jointly significant with any of the asset variables with which it is correlated. Appendix IV provides additional description of the multicollinearity embedded in the model and the justification for the inclusion of both the standardized wealth index and other asset variables.

Table 8: OLS Regressions for the Share of Transitional Cooking Fuels

	Share of Households Reporting Transitional Fuels as Primary Cooking Fuel								
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
Standardized Wealth Index	0.094***	0.044***	0.055***	0.054**	0.033**	0.050***	0.023*	0.019*	0.015
	(4.16)	(3.78)	(4.95)	(2.46)	(2.46)	(3.18)	(1.880)	(1.780)	(1.310)
Urban*Standardized Wealth Index			-0.021			-0.022			0.007
			(-1.49)			(-1.18)			(0.590)
Urban		0.260***	0.261***		0.188***	0.775***		0.114***	0.177***
		(17.35)	(17.44)		(13.31)	(8.56)		(7.950)	(4.690)
Proportion of Households With Male Head				-0.130***	-0.062***	-0.047*			
				(-5.36)	(-2.93)	(-1.96)			
Urban*Proportion of Households With Male Head						-0.054			
						(-0.99)			
Average Age of Household Heads				-0.006***	-0.005***	0.000			
				(-6.48)	(-5.05)	(-0.58)			
Urban*Average Age of Household Heads						-0.011***			
						(-7.02)			
Average Size of Households				-0.007*	-0.008**	-0.002			
				(-1.76)	(-2.29)	(-0.66)			
Urban*Average Size of Households						-0.011			
						(-1.76)			
Average Years of Schooling for Household Heads				0.036***	0.021***	0.019***			
				(8.07)	(5.71)	(6.71)			
Urban*Average Years of Schooling for Household Heads						0.002			
						(0.37)			
Proportion of Households Owning Agricultural Land							-0.315***	-0.279***	-0.382***
							(-3.43)	(-3.09)	(-4.94)
Urban*Proportion of Households Owning Agricultural Land									0.333***
									(2.700)
Squared Proportion of Households Owning Agricultural Land							0.018	0.032	0.146***
							(0.230)	(0.430)	(2.600)
Urban*Squared Proportion of Households Owning Agricultural Land									-0.400***
									(-3.64)
Proportion of Households Owning Livestock							-0.464***	-0.409***	-0.352***
							(-5.59)	(-4.87)	(-4.03)
Urban*Proportion of Households Owning Livestock									0.115
									(1.010)
Squared Proportion of Households Owning Livestock							0.313***	0.299***	0.285***
							(4.470)	(4.290)	(4.160)
Urban*Squared Proportion of Households Owning Livestock									-0.358***
									(-3.27)
Proportion of Households With Electricity							0.131***	0.086***	0.153***
							(4.810)	(3.420)	(6.430)
Urban*Proportion of Households With Electricity									-0.151***
									(-4.10)
R-Squared	0.506	0.614	0.615	0.604	0.646	0.657	0.692	0.705	0.715
Number of Enumeration Areas	22,991	22,991	22,991	21,493	21,493	21,493	13,425	13,425	13,425

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Share of Households Reporting Transitional Fuels as Primary Cooking Fuel

	(4a)	(4b)	(4c)	(5a)	(5b)	(5c)
Standardized Wealth Index	0.012 (1.360)	0.01 (1.270)	0.007 (0.740)			
Urban*Standardized Wealth Index			0.008 (0.610)			
Urban		0.096*** (7.110)	0.440*** (4.660)		0.097*** (7.15)	0.421*** (4.56)
Proportion of Households With Male Head	-0.03 (-1.22)	-0.015 (-0.63)	-0.028 (-0.97)	-0.030 (-1.22)	-0.016 (-0.63)	-0.030 (-1.04)
Urban*Proportion of Households With Male Head			0.066 (1.050)			0.073 (1.15)
Average Age of Household Heads	-0.002** (-1.97)	-0.002* (-1.68)	0.001 (0.920)	-0.002 (-1.84)	-0.001 (-1.56)	0.001 (0.97)
Urban*Average Age of Household Heads			-0.007*** (-3.56)			-0.006*** (-3.52)
Average Size of Households	0.003 (0.760)	0.000 (0.110)	0.004 (0.870)	0.003 (0.83)	0.001 (0.17)	0.004 (0.83)
Urban*Average Size of Households			-0.011 (-1.30)			-0.01 (-1.20)
Average Years of Schooling for Household Heads	0.015*** (4.920)	0.013*** (4.150)	0.014*** (4.570)	0.016*** (5.44)	0.013*** (4.60)	0.015*** (4.94)
Urban*Average Years of Schooling for Household Heads			-0.005 (-1.01)			-0.004 (-0.97)
Proportion of Households Owning Agricultural Land	-0.274** (-3.17)	-0.249*** (-2.88)	-0.385*** (-5.19)	-0.276** (-3.18)	-0.251** (-2.89)	-0.388*** (-5.21)
Urban*Proportion of Households Owning Agricultural Land			0.337*** (2.900)			0.342** (2.92)
Squared Proportion of Households Owning Agricultural Land	0.012 (0.160)	0.023 (0.330)	0.154*** (2.940)	0.009 (0.13)	0.021 (0.30)	0.155** (2.95)
Urban*Squared Proportion of Households Owning Agricultural Land			-0.358*** (-3.52)			-0.366*** (-3.57)
Proportion of Households Owning Livestock	-0.428*** (-5.47)	-0.386*** (-4.86)	-0.344*** (-4.18)	-0.432*** (-5.50)	-0.389*** (-4.90)	-0.349*** (-4.21)
Urban*Proportion of Households Owning Livestock			0.142 (1.190)			0.144 (1.21)
Squared Proportion of Households Owning Livestock	0.301*** (4.510)	0.292*** (4.360)	0.287*** (4.460)	0.302*** (4.50)	0.292*** (4.36)	0.289*** (4.47)
Urban*Squared Proportion of Households Owning Livestock			-0.361*** (-3.21)			-0.365** (-3.23)
Proportion of Households With Electricity	0.087*** (3.420)	0.058*** (2.380)	0.112*** (4.640)	0.095*** (3.89)	0.065** (2.75)	0.115*** (4.84)
Urban*Proportion of Households With Electricity			-0.115*** (-3.04)			-0.110** (-2.91)
R-Squared	0.699	0.709	0.721	0.699	0.708	0.72
Number of Enumeration Areas	13,275	13,275	13,275	13,275	13,275	13,275

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

The urban binary exhibits a similar trend across the regressions as it did for traditional cooking fuels, though the effect is now positive for transitional cooking fuel shares. Whether the enumeration area can be considered rural or urban strongly relates to the share of transitional cooking fuels. All else equal, an urban area's transitional cooking fuel shares are 44 points higher than that of a rural enumeration area. This differential is equivalent to nearly 1.5 standard deviations in the share of transitional cooking fuels and is statistically significant. The coefficients fluctuate considerably. Just as for traditional fuels, the magnitude of the urban binary in the regressions that include the interaction terms drastically exceeds the magnitude in the regressions without them.

The proportion of households within an enumeration area that owns agricultural land is negatively related to the share of transitional cooking fuels. For rural enumeration areas, the effect of the agricultural land ownership rate and its quadratic are jointly statistically significant but not significant in magnitude. No turning point exists within the possible range of values, that is, zero to one; the effect grows with the proportion of households owning agricultural land. The hypothesis that the effect does not differ across community types can be rejected. As for traditional cooking fuels, the effect size of agricultural ownership within urban enumeration areas exceeds that of rural ones. For urban enumeration areas, a one percentage point increase in the rates of agricultural land ownership starting at the mean results in a 0.3 percentage point decrease in the share of transitional cooking fuels. A one standard deviation increase in agricultural land ownership corresponds to a decrease of 0.32 standard deviations in the share of transitional cooking fuel. The estimated effect of agricultural land ownership rate and its quadratic are jointly significant for urban areas as well.

Similar to traditional cooking fuels, the effect of the rate of livestock ownership is slightly smaller than that of agricultural land. For rural areas, while the effect is statistically significant, it is not of substantial magnitude. The hypothesis that no difference in effect size exists between rural and urban enumeration areas can be rejected. Indeed, the effect size is greater for urban enumeration areas than rural ones. Starting at the mean of 0.54, a one percentage point increase in the proportion of households reporting livestock ownership corresponds to a 0.03 percentage point decrease in the share of transitional cooking fuels for rural households. An increase of one standard deviation from the mean results in a decrease of 0.29 standard deviations for urban enumeration areas. No turning point exists, but rather the effect size inflates with higher rates of livestock ownership. Table 9 below summarizes the overall effects and significance of both agricultural land and livestock ownership of the share of traditional cooking fuels.

Table 9: Summary of Effects of Rates Agricultural Land and Livestock Ownership on Transitional Cooking Fuels

SHARE OF TRANSITIONAL COOKING FUELS						
Variable	Community Type	Point Estimate	Statistical Significance at 5 Percent Level	Joint Effect of Increase from Mean	Effect Size of Substantial Magnitude	Turning Point (if in range)
Rate of Agricultural Land Ownership	Rural	-0.385	Jointly Significant	0.20 pct. pt. decrease	No	none
Squared Rate of Agricultural Land Ownership		0.154				
Rate of Agricultural Land Ownership	Urban	0.337	Jointly Significant Statistically Differs From Rural	0.30 pct. pt. decrease	Yes	none
Squared Rate of Agricultural Land Ownership		-0.358				
Rate of Livestock Ownership	Rural	-0.344	Jointly Significant	0.02 pct. pt. decrease	No	0.6
Squared Rate of Livestock Land Ownership		0.287				
Rate of Livestock Ownership	Urban	0.142	Jointly Significant Statistically Differs From Rural	0.03 pct. pt. decrease	Yes	none
Squared Rate of Livestock Land Ownership		-0.361				

Rates of electrification exhibit an inconsistent relationship with shares of transitional cooking fuels across rural and urban areas. The effect size for rural enumeration areas substantially exceeds that for urban households. A one percentage point increase in the rate of electrification corresponds to a 0.11 percentage point increase in the share of transitional cooking fuels for rural enumeration areas. For urban enumeration areas, the effect is essentially zero. The estimates for both rural and urban are statistically significant, and the hypothesis that the effects are equal across the two community types can be rejected.

Whereas the estimated effects of asset variables display consistency in their direction and their magnitude across regressions, the demographic variables change greatly. For instance, average age of household heads for both rural and urban areas takes a different sign in the preferred regressions compared to all other specifications. Only the average years of schooling and the proportion of households headed by females in rural areas maintain the same direction of effect for all regressions.

Moreover, few demographic variables exert a statistically significant effect on the share of transitional cooking fuels. Household size and the share of households headed by women are not significant for either rural or urban areas. Average age of household heads is significant only for urban areas. A higher average age for household heads negatively relates to the share of transitional cooking fuels within urban enumeration areas, but is not of substantial magnitude. Average years of schooling is significant overall, but the difference between rural and urban areas is not statistically significant. Average years of schooling that household heads attain positively relates to the share of transitional cooking fuels. A one year increase in the household heads' average educational attainment corresponds to an increase of 1.4 percentage points in the share of transitional cooking fuel for both rural and urban areas, contrary to the effect of schooling for the share of traditional fuels.

Share of Modern Cooking Fuels

Table 10 presents the results for all OLS regressions described in the methodology section. The preferred specification appears in column (4c), which serves as the emphasis for this and later discussion. The preferred specification explains 76% of the variation in the shares of modern cooking fuels.

Similar to traditional and transitional cooking fuel shares, the wealth index is not statistically significant in the preferred specification. In fact, the standardized wealth index is not significant in any regression that includes the asset variables, the demographic variables or both. The standardized wealth index is jointly significant with the asset variables with which it is correlated. The estimate for the standardized wealth index also fluctuates substantially in terms of both direction and magnitude, whereas it maintained a consistent sign for both shares of traditional and transitional cooking fuels. Furthermore, removing the standardized wealth index from the regression specification, as presented in columns (5a) – (5c) only marginally alters the estimated effects of the other variables.

Only for the share of modern cooking fuels is the indicator for whether the enumeration area is rural or urban not statistically significant. The trend in the effects of the urban binary across specifications also breaks from that of traditional and transitional cooking fuel shares. The coefficients fluctuate considerably not only in terms of magnitude, but also direction with no clear pattern.

Table 10: OLS Regressions for the Share of Modern Cooking Fuels

	Share of Households Reporting Modern Fuels as Primary Cooking Fuel								
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
Standardized Wealth Index	0.057***	0.039***	0.020***	0.016	0.012	0.016*	0.003	0.002	-0.009*
	(4.260)	(3.620)	(3.210)	(1.600)	(1.400)	(1.800)	(0.370)	(0.260)	(-1.69)
Urban*Standardized Wealth Index			0.034			-0.007			0.018
			(1.620)			(-0.57)			(1.590)
Urban		0.097***	0.095***		0.033***	-0.259***		0.030***	0.017
		(7.400)	(6.550)		(3.690)	(-3.42)		(3.340)	(0.580)
Proportion of Households With Male Head				-0.005	0.007	0.058***			
				(-0.26)	(0.410)	(2.980)			
Urban*Proportion of Households With Male Head						-0.194***			
						(-4.98)			
Average Age of Household Heads				-0.002**	-0.001**	-0.003***			
				(-2.24)	(-1.98)	(-4.77)			
Urban*Average Age of Household Heads						0.006***			
						(4.240)			
Average Size of Households				-0.007***	-0.007***	-0.010***			
				(-2.96)	(-3.08)	(-3.61)			
Urban*Average Size of Households						0.006			
						(0.950)			
Average Years of Schooling for Household Heads				0.026***	0.024***	0.009***			
				(8.760)	(8.180)	(4.600)			
Urban*Average Years of Schooling for Household Heads						0.028***			
						(9.380)			
Proportion of Households Owning Agricultural Land							-0.078	-0.069	0.138*
							(-1.64)	(-1.45)	(1.920)
Urban*Proportion of Households Owning Agricultural Land									-0.279***
									(-2.84)
Squared Proportion of Households Owning Agricultural Land							0.103***	0.107***	-0.06
							(2.740)	(2.830)	(-1.33)
Urban*Squared Proportion of Households Owning Agricultural Land									0.162**
									(2.120)
Proportion of Households Owning Livestock							-0.258***	-0.244***	-0.268***
							(-4.26)	(-4.19)	(-4.79)
Urban*Proportion of Households Owning Livestock									0.041
									(0.430)
Squared Proportion of Households Owning Livestock							0.142***	0.138***	0.140***
							(2.810)	(2.790)	(3.020)
Urban*Squared Proportion of Households Owning Livestock									0.099
									(1.170)
Proportion of Households With Electricity							0.214***	0.203***	0.124***
							(5.720)	(5.520)	(5.830)
Urban*Proportion of Households With Electricity									0.149***
									(4.470)
R-Squared	0.633	0.661	0.665	0.681	0.683	0.717	0.708	0.709	0.721
Number of Enumeration Areas	22,991	22,991	22,991	21,493	21,493	21,493	13,425	13,425	13,425

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Share of Households Reporting Modern Fuels as Primary Cooking Fuel

	(4a)	(4b)	(4c)	(5a)	(5b)	(5c)
Standardized Wealth Index	-0.006	-0.006	0.004			
	(-0.94)	(-1.03)	(0.540)			
Urban*Standardized Wealth Index			-0.011			
			(-1.16)			
Urban		0.017*	-0.100		0.017	-0.091
		(1.940)	(-1.22)		(1.88)	(-1.13)
Proportion of Households With Male Head	0.034	0.037	0.095***	0.034	0.037	0.096***
	(1.430)	(1.570)	(3.580)	(1.44)	(1.57)	(3.63)
Urban*Proportion of Households With Male Head			-0.221***			-0.224***
			(-4.94)			(-5.10)
Average Age of Household Heads	-0.002***	-0.002***	-0.003***	-0.002**	-0.002**	-0.003***
	(-3.07)	(-3.06)	(-3.83)	(-3.15)	(-3.14)	(-3.85)
Urban*Average Age of Household Heads			0.004***			0.004*
			(2.420)			(2.40)
Average Size of Households	-0.010***	-0.010***	-0.007**	-0.010***	-0.011***	-0.006*
	(-3.49)	(-3.71)	(-2.10)	(-3.54)	(-3.76)	(-2.02)
Urban*Average Size of Households			-0.009			-0.009
			(-1.28)			(-1.34)
Average Years of Schooling for Household Heads	0.017***	0.016***	0.002	0.016***	0.016***	0.002
	(5.780)	(5.600)	(0.760)	-5.84	-5.63	(0.75)
Urban*Average Years of Schooling for Household Heads			0.028***			0.027***
			(8.250)			(8.39)
Proportion of Households Owning Agricultural Land	-0.063	-0.058	0.124**	-0.062	-0.057	0.124*
	(-1.31)	(-1.22)	(2.000)	(-1.29)	(-1.21)	(1.99)
Urban*Proportion of Households Owning Agricultural Land			-0.251***			-0.251**
			(-2.87)			(-2.85)
Squared Proportion of Households Owning Agricultural Land	0.121***	0.123***	-0.047	0.122**	0.124**	-0.047
	(3.110)	(3.160)	(-1.20)	-3.13	-3.18	(-1.21)
Urban*Squared Proportion of Households Owning Agricultural Land			0.182**			0.186**
			(2.580)			(2.60)
Proportion of Households Owning Livestock	-0.212***	-0.205***	-0.171***	-0.210***	-0.203***	-0.173**
	(-3.78)	(-3.72)	(-3.08)	(-3.75)	(-3.69)	(-3.11)
Urban*Proportion of Households Owning Livestock			-0.008			-0.005
			(-0.08)			(-0.06)
Squared Proportion of Households Owning Livestock	0.134***	0.133***	0.072*	0.134**	0.132**	0.072
	(2.740)	(2.730)	(1.650)	(2.73)	(2.73)	(1.67)
Urban*Squared Proportion of Households Owning Livestock			0.190**			0.190*
			(2.400)			(2.40)
Proportion of Households With Electricity	0.164***	0.159***	0.118***	0.160***	0.155***	0.120***
	(4.840)	(4.670)	(5.340)	(4.97)	(4.79)	(5.39)
Urban*Proportion of Households With Electricity			0.055*			0.049
			(1.660)			(1.53)
R-Squared	0.728	0.729	0.763	0.728	0.728	0.763
Number of Enumeration Areas	13,275	13,275	13,275	13275	13275	13275

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

The relationship between modern cooking fuels and the proportion of households owning agricultural land or livestock is less consistent than for the two other fuel shares. The relationship between ownership of agricultural land appears quite different, in terms of magnitude and direction, in urban enumeration areas as compared to rural enumeration areas, and the hypothesis that the effect size does not vary between them can be rejected. For both urban and rural enumeration areas, the agricultural land ownership variable and its quadratic are jointly significant. For rural enumeration areas, the effect is positive, though very close to zero. For urban enumeration areas, a one percent increase from the mean rate leads to a decrease of 0.14 percentage points. Interpreting this effect through standard deviations, an increase of one standard deviation from the mean ownership rate corresponds to a decrease of 0.22 standard deviations in the share of modern cooking fuels. A turning point exists below the mean, at 0.47. Below this threshold, the effect of the agricultural land ownership rate positively relates to the share of modern cooking fuels. Furthermore, the effect of livestock ownership on the share of modern cooking fuels is the one asset variable that switches signs across regression specifications. All other estimates for asset variables display consistency in direction for modern cooking fuel shares as well as for the two other fuel shares.

For the ownership rates of livestock, too, the effects diverge in size and direction between rural and urban enumeration areas. For both community types, the estimates are statistically significant and the hypothesis that the effect size does not vary between them can be rejected. In rural enumeration areas, a one percentage point increase from the mean rate of livestock ownership is associated with a slight decrease in the share of modern coking fuels. The effect size is not of substantial magnitude but does consistently increase with ownership rates. For urban enumeration areas, the effect is much more sizable and livestock ownership affects the share of modern cooking fuels differently. A one percentage point increase from the mean rate of livestock ownership is associated with an increase of 0.11 percentage points in the share of modern cooking fuels. Interpreting this through standard deviations, a one standard deviation increase in the livestock ownership rate from the mean corresponds with an increase of 0.26 standard deviations in the share of modern cooking fuels. A turning point exists and falls below the mean at 0.33. Below this rate of livestock ownership, the effect on the modern cooking fuel share is negative. Table 11 below summarizes the effects of both livestock and agricultural land on the shares of modern fuels.

Table 11: Summary of Effects of Rates of Agricultural Land and Livestock Ownership on Shares of Modern Cooking Fuels

SHARE OF MODERN COOKING FUELS						
Variable	Community Type	Point Estimate	Statistical Significance at 5 Percent Level	Joint Effect of Increase from Mean	Effect Size of Substantial Magnitude	Turning Point (if in range)
Rate of Agricultural Land Ownership	Rural	0.124	Jointly Significant	0.06 pct. pt. increase	No	none
Squared Rate of Agricultural Land Ownership		-0.047				
Rate of Agricultural Land Ownership	Urban	-0.251	Jointly Significant Statistically Differs From Rural	0.14 pct. pt. decrease	Yes	0.47
Squared Rate of Agricultural Land Ownership		0.182				
Rate of Livestock Ownership	Rural	-0.171	Jointly Significant	0.08 pct. pt. increase	No	0.6
Squared Rate of Livestock Land Ownership		0.072				
Rate of Livestock Ownership	Urban	-0.008	Jointly Significant Statistically Differs From Rural	0.11 pct. pt. decrease	Yes	0.33
Squared Rate of Livestock Land Ownership		0.190				

Not surprisingly, the rate of electrification is positively and significantly related to the shares of modern cooking fuels for both rural and urban enumeration areas. A one percentage point increase in the rate of electrification corresponds to a 0.12 percentage point increase in the share of modern cooking fuels for rural enumeration areas. The estimated effect size for urban enumeration areas exceeds that for rural areas, but the difference is not statistically significant.

The effects of the demographic variables are consistent in direction, though less so in magnitude. In this way, the estimates appear to follow a trend more similar to traditional cooking fuel shares than transitional. The estimates for each of the demographic variables on shares of modern cooking fuels display the opposite signs for traditional fuel shares, however.

Average years of schooling attained by household heads is positively associated with the share of modern cooking fuels; however, this effect is significant only for urban areas. A one year increase in the household heads' average educational attainment corresponds to an increase of three percentage points in the share of modern cooking fuels for urban enumeration areas, the largest effect size of any demographic variable across all specifications and fuel types. In standard deviations, an increase of one standard deviation in the average years of schooling corresponds to an increase of 0.5 standard deviations in modern cooking fuel use.

The average age of household heads is negatively associated with the share of modern cooking fuels; enumeration areas with younger household heads on average exhibit higher shares of modern cooking fuels, similar to transitional cooking fuels. The hypothesis that the effect differs between rural and urban households cannot be rejected. An increase in the average age of household heads of one year is estimated to decrease the share of modern cooking fuels in by 0.3 percentage points.

Larger average household size is negatively associated with the share of modern cooking fuels, but only in urban areas is this variable statistically significant. A one member increase in the average household size decreases the share of modern cooking fuel in urban enumeration areas by 1.6 percentage points.

Just as for traditional and transitional cooking fuel shares, the estimated effect of the proportion of households headed by a woman assumes a different direction for rural and urban areas. But, the signs depart from the estimates for the other two fuel types: a higher share of female-headed households positively relates to modern cooking fuel shares in urban areas, but negatively relates to modern cooking fuel shares in rural areas. While the effects are statistically significant for both urban and rural areas, neither estimate is of substantial magnitude.

Chapter 7: Discussion

The Validity of Modeling Household Energy Choice Using the Energy Ladder

In simply considering the trends within the data, the energy ladder appears to have some validity for the sample, as a clear association between wealth and fuel type exists. The shares of transitional and modern cooking fuels increase with wealth quintiles while the share of traditional cooking fuels falls. Less than two percent of the poorest households use a transitional or modern cooking fuel; less than five percent of the households in the second lowest wealth quintile use a transitional or modern cooking fuel to cook. But, wealth seems to render substantial influence in increasing modern cooking fuel use only for the richest enumeration areas. Rates of use of all non-traditional cooking fuels nearly double between the second wealthiest and wealthiest quintiles, and only in the top quintile is fuelwood not the most common fuel.

The regression analysis, however, only partially confirms a relationship between wealth and fuel use. After controlling for all asset and demographic variables, the standardized wealth index is jointly significant with the ownership and/or electrification variables. But the wealth index variable is not statistically significant on its own for any cooking fuel share within the preferred regression specification. Beyond wealth, the effects of the asset and demographic variables display high statistical significance, suggesting that other factors influence fuel use to a greater extent than the standardized wealth index. I present below patterns in effects across fuel types and possible explanations for the directions of the estimates for each of the variables included in the regression. I additionally note the extent to which the effects align with previous research when applicable.

Asset Ownership

The regression estimates for the impacts of the proportion of households owning livestock or agricultural land (in conjunction with their quadratic) as well as the proportion of electrified households are statistically significant across all fuel types. The relationships between the asset variables and fuel shares starkly diverge between traditional and transitional cooking fuel shares, but the consistency of the relationship between fuel shares and asset ownership deteriorates when examining modern cooking fuel use. Within the context of wealth and the energy ladder, we would expect the share of modern cooking fuels to respond to the asset variables in a way similar to transitional cooking fuels, but this does not occur within the regression analysis. The variation of the direction of the effects between agricultural land and livestock ownership for the share of modern cooking fuels contradicts this expectation and, to some extent, undermines the assumption of a monotonic relationship between assets and fuel use.

For example, whereas traditional cooking fuel shares increase with higher ownership rates of agricultural land, the share of transitional cooking fuels falls. For modern cooking fuels, the turning point means the direction of the effect differs within distinct ranges of data and thus for some interval the estimate aligns with the direction of the effect for traditional fuel shares and on another interval the effect aligns with that of transitional fuel shares. The effect of livestock ownership shares similarities with agricultural land ownership for transitional and traditional cooking fuels, but again the relationship becomes more complicated for modern cooking fuels. Livestock ownership rates are positively associated with modern cooking fuel shares for urban enumeration areas but the association is negative in rural enumeration areas. The effects of the electrification rate, though, do conform to expectation. The shares of both transitional and modern cooking fuels rise with higher electrification rates while traditional cooking fuel shares diminish.

Forgiving the inconsistencies with respect to modern cooking fuel shares, two possible mechanisms could be driving the relationship between the asset variables and fuel use: wealth effects, fuel availability, or a combination of the two. These two different hypotheses have very different consequences. Fuel availability can be seen as a supply side influence. Wealth effects, in contrast, represent a demand side factor. Unfortunately, the effects cannot be disentangled using the data and methodology of this thesis.

Related to wealth, ownership of agricultural land or livestock may indicate a subsistence lifestyle. These households may earn low incomes or face liquidity constraints, both of which would influence fuel shares by forcing a household to collect rather than buy fuels or by limiting a household's ability to purchase the necessary combustion equipment for using transitional or modern cooking fuels. Electrification also reveals a household's economic standing and therefore could likewise represent the effect of wealth. In terms of accessing fuel, electrification increases the availability of modern cooking fuels by definition.

On the other hand, households that own agricultural land and livestock can more easily and freely obtain wood, dung, or other plant-based fuels, increasing the availability of traditional cooking fuels. Households that do not own these assets may instead need to purchase traditional cooking fuels or face longer collection times. The fact that the effect size for the ownership rate of agricultural land exceeds the effect size for livestock may support the possibility that these variables represent fuel availability as more households use plant-based traditional cooking fuels than dung.

The significance of the urban or rural classification variable might also reflect the influence of fuel availability. An enumeration area's identification as urban substantially decreases the share of traditional cooking fuels and increases the share of transitional cooking fuels, in keeping with the literature (Goldemberg 2000; Van Der Kroon et al. 2013). Likely, markets are larger and more developed in denser and more populous areas, meaning that an enumeration area's classification as urban corresponds to greater availability of transitional and modern cooking fuels.

Household Demographics

Neither the availability of the fuel source nor wealth entirely determines fuel choice. Even a majority of urban electrified households in the highest wealth quintile still identify a traditional or transitional cooking fuel as their primary source. This fact suggests that preferences or household characteristics may also exert influence.

Overall, the demographic variables included the regressions do show statistical significance, even if not consistently for all fuel shares or across both rural and urban enumeration areas. Age and education are significant across all fuel shares for urban and rural enumeration areas. The proportion of female household heads and the size of households frequently carry statistical significance for both modern and transitional cooking fuels.

In alignment with the monotonic relationship proposed by the energy ladder, the direction of effects of demographic variables generally differs between the shares of traditional and transitional, as well as between shares of traditional and modern. The regressions estimating transitional and modern shares display the same sign on the proportion of female-headed households, as well as education and household size in rural enumeration areas. The estimates assume the opposite direction for traditional fuels. This suggests that perhaps the move away from traditional is different than that of the switch from transitional to modern, or that the factors affecting transitional and modern cooking fuel use differ from that influencing traditional cooking fuel use. In general, the regression with the share of transitional cooking fuels shows the fewest demographic variables as significant. Only education and the average age of household heads in urban areas alone appear to be associated with changes in transitional cooking fuel shares. Furthermore, the R-squared value of the preferred specification value is lowest when selecting transitional cooking fuel share as the dependent variable. The regression explains the largest share of the variation in traditional cooking fuels, nearly 86 percent, compared to the other two dependent variables. Seventy-six percent of the variation in the share of modern cooking fuels is explained by the OLS regression. Slightly less variation is explained by the regression for transitional cooking fuels, 72 percent.

A higher than average number of years of household heads' schooling corresponds to higher shares of transitional and modern cooking fuels and lower sharers of traditional. This finding aligns firmly with the literature. Household heads with more years of schooling may be more informed about fuels and their linkage to health. Or, they may be more able to recognize the trade-offs between fuel types and consequently choose more efficient fuels for reasons of long-term costs, as Van Der Kroon et al. (2013) propose. Heltberg (2004) suggests instead that education affects fuel choice through the resulting labor outcomes. Schooling increases the relative opportunity cost of gathering fuels and consequently encourages more educated households to purchase fuels (Heltberg 2004). Alternatively, household heads with more education may be more likely to hold a salaried occupation and therefore participate in the formal economy. Consequently, these individuals possess superior market access relative to their less educated peers and can more easily purchase transitional or modern cooking fuels.

Across urban and rural areas, the average size of households is significant with respect to share of modern cooking fuels. But, only in urban enumeration areas is it significant for traditional cooking fuels. Larger average household sizes correspond to larger traditional cooking fuel shares and smaller modern cooking fuel shares. This association could be explained by the availability of labor for gathering traditional solid fuels, which leads larger households to rely more on collected sources of cooking energy. Both my regressions and previous literature present mixed evidence on the effects of household size on fuel choice. Partially, the estimated effect aligns with Hosier and Dowd's (1987) conclusion that larger households are less likely to utilize electricity, and with the finding of Knight and Rosa (2012) that smaller households use less biomass per capita.

The effect of the average age of household head shows a slightly inconsistent pattern across fuel types. For traditional cooking fuels, enumeration areas with an older population of household heads report higher shares. This relationship aligns with the previous claim of Van Der Kroon et al. (2011) that solid fuel use positively correlates with age. That the association between average household head age and transitional cooking fuels in urban areas and modern cooking fuels in rural areas is negative also supports this conclusion. Age could deter use of transitional and modern cooking fuels by increasing risk aversion or decreasing the likelihood of adopting technology (Van Der Kroon et al. 2011). But, for transitional cooking fuels in rural areas and modern cooking fuels in urban areas the trend breaks, undermining this argument. A possible justification for the positive effect of age on modern cooking fuel shares in urban areas could be older household heads have accumulated of learning experiences and greater exposure to different fuels over their lifetime, encouraging their recognition of the benefits of modern fuels. The fact that many more households in urban areas use modern cooking fuels than rural areas could explain why the sign differs between the two: rural household heads face fewer opportunities to engage with modern cooking fuels.

The relationship between the proportion of female household heads and both modern and traditional cooking fuels differs between rural and urban enumeration areas; no statistically significant gender effect occurs for the shares of transitional cooking fuels. The effect of gender is stronger in urban areas than in rural areas and presents a sign consistent with the literature; urban enumeration areas with higher proportions of female-headed households report higher shares of modern cooking fuels and lower shares of traditional cooking fuels. Since women typically hold the responsibility of fuel collection and bear the disease burden of using traditional cooking fuels, likely the use of cleaner, more efficient fuels will be higher where women hold greater power in determining fuel use. The effect for rural enumeration areas, however, actually departs from the relationship between females and fuel use discussed in previous research. In rural areas, the proportion of households headed by women is negatively related to modern cooking fuels but positively related to traditional cooking fuels. Thus, the impact of this variable remains slightly ambiguous overall, but the difference in the effects between rural and urban areas is clear.

The difference in effect sizes between rural and urban areas should be noted. For all of the demographic variables, except for the effect of education on the share of transitional cooking fuels, the estimates for urban enumeration areas exceed that for rural enumeration areas. Again assuming that markets are more complete and so fuel is more readily accessible in urban areas, this pattern could imply that with greater availability of choices, preferences may play a larger role in determining a household's fuel. But, overall the effects of the demographic variables as estimated by the regression are relatively small. Across all regression specifications, only education emerges as a demographic variable that exerts a sizeable magnitude on all fuel shares.

In conclusion, the regression did identify some important factors to fuel use spanning both asset ownership and demographic characteristics, in particular education. This suggests that wealth, fuel availability and preferences likely all matter to some extent. The following sections discuss the limitations and implications of these results.

Limitations

Unfortunately, the validity of the proposed channels cannot be determined with the available data and chosen methodology. Moreover, for the reasons discussed in this section, reverse causality and endogeneity could undermine the validity of the regressions. Data constraints, in particular, weaken the analysis.

Endogeneity

Reverse causality could be a possibility with respect to the relationship between wealth and fuel types. Using cleaner and more efficient fuels reduces the associated health risks of traditional cooking fuels, which in turn could increase some of the dependent variables. Healthier individuals are more productive, so they may secure greater wealth and asset ownership, including land and livestock, or electricity. In the long term, healthier household heads could lead to a more educated population with a longer lifespan. But, this concern is partially mitigated by the separation between the person most directly affected by the fuel choice and the person measured by the dependent variables. Women disproportionately bear the disease burden associated with traditional cooking fuel use but a majority of household heads within the sample are men.

Omitted variable bias could be driving some of the statistically significant relationships observed within the regression analysis. For instance, we might be concerned that attitudes or knowledge about health could be driving both the share of fuels and the average age of household heads, if we believe that healthier enumeration areas lead to longer average life spans. But, since no variable in the regression measures health knowledge, endogeneity could arise if this unobserved variable is related to the included variables in the regression. The independent variables correlated with this missing independent variable then partially pick up some of the effect of the omitted variable, introducing bias into the estimates (Wooldridge 2006). Other variables that are omitted to data availability but that could threaten the validity of the regression are mentioned in the subsequent section.

A last possible threat related to endogeneity is confounding between the wealth index and the other asset variables. The instability in coefficients across specifications, as discussed in previous sections, indicates that this problem may be embedded within the regression. In particular, the magnitude, and at times even the directional effect, of the standardized wealth index varies considerably across regression specifications for each cooking fuel shares. The greatest change to the estimate for the effect of the wealth index occurs when the asset variables are added in the third series of regressions, (3a) – (3c). Likely, in regressions without the asset variables—such as (1a) – (2c)—the estimate of the standardized wealth index is inflated because it partially captures the effect of the asset variables with which is it correlated but are omitted from these models. Considering that the estimates on the asset variables change very little between regressions with the wealth variable and without it—which can be seen by comparing (4a) – (4c) to (5a) – (5c)—it is less likely that the estimated of variables are partially picking up the effect of the standardized wealth index. This threat largely stems from the fact that wealth, as measured within this research, is a function of the other asset variables of interest.

Data Constraints

A lack of data perhaps imposes the greatest limitations on this research. DHS data allowed me to test the energy ladder hypothesis using a large scale data set. The value of DHS data draws from the consistency of the surveys across phases and countries, the number of countries and survey rounds completed, as well as its accessibility to independent researchers. Although DHS data provides a wealth of information of household structure and demographics, the survey offers minimal insight into the environmental, social, or economic context in which the households live. A number of factors related to the household's community could encourage or impede the adoption of transitional or modern cooking fuels. In particular, DHS lacks information on aspects that determine supply.

Unfortunately, DHS datasets contain virtually no information about market access of any kind. For instance, the source of the fuel is not identified. Fuelwood, therefore, may be collected or purchased. Charcoal may similarly be produced within the household or purchased. The data does not allow for this distinction to be made. Moreover, the data does not provide information concerning the extent of households' integration or participation in the formal economy, proximity to markets in general, nor the availability or completeness of fuel markets. We additionally lack data on relative prices, elasticity of supply, or the consistency of supply. Likewise, the DHS surveys also lack important data related to demand. The quantity of fuel used is not reported nor are costs, monetary or non-monetary. On a more theoretical level, no survey questions measure willingness to pay. Other demand constraints that are not addressed within the data include availability of credit, degree of liquidity, knowledge of benefits of cleaner and more efficient fuels.

Country-Level Estimates

The estimates presented within this thesis represent 26 countries throughout sub-Saharan Africa. While the country fixed effects within the model do account for overall variability between nations, the possibility exists that the coefficient effects differ enough between countries that country-level regressions should be executed. Tables displaying individual country regressions are provided in Appendix IV. Running these regressions reveals that the model fits some nations substantially better than others, but this also depends on the fuel type. Considerable variation exists in the degree to which the country-level estimates align with the effects taken from the regression using the full sample. However, a full analysis of country-specific differences is beyond the scope of this research and the capacity of the dataset. Fixed effects only roughly approximate for cross-country differences. Of greater utility would be data on country, or even regional, conditions that would affect fuel availability such as forest cover, the stability of the power grid, or the location of the supply of transitional and modern fuels.

Recommendations

Given the identification and data concerns of this paper, my foremost recommendation is further research. Existing literature, as well as this thesis, identifies a number of factors that relate to fuel use. The literature, by way of motivation, also underscores the high rates of reliance on biomass and other traditional fuels. Few studies, however, examine strategies for encouraging households to switch their primary cooking fuel to a more modern type or to use modern cooking fuels in greater shares. With a lack of concrete research to build on, policies aimed at encouraging the adoption of fuel saving technologies or cleaner fuels may experience only limited success. Traditional cooking fuel subsidies exemplify this possibility, often proving to be inefficient or unsustainable (Barnes and Halpern 2000).

Furthermore, causal estimation techniques have improved greatly since the emergence of the energy ladder hypothesis and subsequent focus on the need for adoption of cleaner, more efficient fuels decades ago. For instance, randomized control trials gained wide recognition and acceptance as a means to estimate impacts with high internal validity. But, very few studies utilize this or other quasi-experimental econometric methods in the context of improving the cleanliness and efficiency of a household's fuel.

The few exceptions to this generalization concentrate on cookstoves, and even then, most of the research focuses on health rather than encouraging adoption (Duflo, Greenstone and Hanna 2008). However, several researchers undertook randomized evaluations on this topic in the last few years. Levine et al.

(2012) offered a number of incentives in various combinations to residents in Kampala, Uganda in efforts to induce more purchases of improved charcoal stoves. Enumerators offered households a randomly determined combination of incentives that could include a free trial, a right to return, and an option to pay in increments. Mobarak et al.'s (2012) randomized evaluation in rural Bangladesh offered one of two types of improved cookstoves at either full price or a 50 percent subsidy. Hanna, Greenstone, and Duflo (2012) evaluate an NGO-driven initiative in Orissa, India that subsidized about 95 percent of the cost of cookstoves to 15,000 households. In no study was the adoption of cookstoves universal, and Hanna, Greenstone and Duflo additionally note that large numbers of households eventually abandoned the technology. This result points to a need for further research to identify factors that deter long-term adoption.

Given the lack of evidence on feasible interventions that successfully encourage households to shift from traditional cooking fuels, I advocate that further research precede policy interventions. More specifically, I recommend research that robustly identifies successful incentive strategies to increase the prevalence of households that adopt non-solid fuels. Increasing our understanding of the supply and demand factors that influence fuel choice is crucial, particularly for informing a sustainable cost-effective policy. Policymakers need to know whether the barriers stem from supply or demand so they can determine the individuals or groups the policy should target. The policymakers also need to understand whether market failures, either on the producer or consumer side, or simply preferences, strictly on the consumer side, contribute to the high rates of traditional cooking fuel use. The health, environmental, and economic consequences merit further work on the determinants of fuel choice and the most effective means to encourage adoption of cleaner and more efficient fuels.

Appendices

Appendix I: Summary Statistics by Country

Table A-1: Summary Statistics by Country

Country	Household Size	Percentage of Male HHH	Age of HHH	Number of Spouses	HHH Educational Attainment	Share of Electrified Households	Share of HH with Agricultural Land	Holdings of Agricultural Land (ha)	Share of HH with Livestock	Number of Cattle
SAMPLE MEAN	5.11	0.75	44.68	0.72	4.67	0.26	0.64	99.67	0.55	3.31
ST. DEV.	(3.22)	(.43)	(4.94)	(.61)	(4.94)	(.44)	(.48)	(251.61)	(.50)	(11.99)
Angola	5.17	0.78	41.76	0.73		0.36				
	(2.63)	(.42)	(14.87)	(.45)		(.48)				
Burkina Faso	6.07	0.9	45.48	1.12	1.65	0.14	0.79	0.79	0.77	10.69
	(3.94)	(.3)	(15.9)	(.83)	(3.67)	(.34)	(.41)	(.41)	(.42)	(15.99)
Benin	5.12	0.78	44.64	0.79	3.11	0.34	0.53	0.53	0.3	1.2
	(3.15)	(.42)	(15.61)	(.68)	(4.51)	(.47)	(.5)	(.5)	(.46)	(8.55)
Burundi	4.88	0.74	43.07	0.68	3	0.11	0.81	0.81	0.57	
	(2.39)	(.44)	(15.64)	(.47)	(4.1)	(.31)	(.39)	(.39)	(.49)	
DRC	5.33	0.76	43.24	0.7	6.86	0.13	0.64	0.64	0.51	
	(2.91)	(.42)	(14.6)	(.5)	(4.65)	(.33)	(.48)	(.48)	(.5)	
Congo	4.74	0.77	44.16	0.65	7.41	0.26	0.57	0.57	0.33	
	(2.91)	(.42)	(14.62)	(.53)	(4.62)	(.44)	(.5)	(.5)	(.47)	
Camaroon	5.05	0.75	44.84	0.65	5.88	0.5	0.67	0.67	0.42	0.4
	(3.57)	(.43)	(16.08)	(.67)	(4.68)	(.5)	(.47)	(.47)	(.49)	(4.91)
Ethiopia	4.78	0.73	43.44	0.67	2.83	0.29	0.61	0.61	0.68	
	(2.45)	(.44)	(16.01)	(.48)	(4.4)	(.46)	(.49)	(.49)	(.47)	
Ghana	4.06	0.69	44.61	0.54	6.3	0.51	0.5	0.5	0.44	0.34
	(2.7)	(.46)	(16.08)	(.59)	(5.43)	(.5)	(.5)	(.5)	(.5)	(2.91)
Guinea	6.22	0.83	49.24	1.05	2.49	0.23	0.64	0.64	0.55	
	(3.62)	(.38)	(15.23)	(.77)	(4.9)	(.42)	(.48)	(.48)	(.5)	
Kenya	4.32	0.68	43.3	0.54	6.9	0.23	0.62	0.62	0.64	1.36
	(2.52)	(.47)	(15.73)	(.51)	(5.05)	(.42)	(.49)	(.49)	(.48)	(5.8)
Liberia	5.08	0.69	42.21	0.57		0.02	0.34	0.34	0.31	
	(3.1)	(.46)	(14.92)	(.52)		(.15)	(.48)	(.48)	(.46)	
Lesotho	4.73	0.64	49.81	0.5	4.87	0.1	0.57	0.57	0.56	1.84
	(2.66)	(.48)	(16.75)	(.5)	(4.19)	(.3)	(.5)	(.5)	(.5)	(6.89)
Madagascar	4.72	0.76	42.96	0.7	4.17	0.21	0.72	0.72	0.64	2.25
	(2.47)	(.43)	(15.51)	(.46)	(4.01)	(.41)	(.45)	(.45)	(.48)	(7.87)
Mali	5.71	0.89	46.11	1.04	1.77	0.22	0.67	0.67	0.62	14.11
	(3.15)	(.31)	(15.24)	(.63)	(3.92)	(.42)	(.47)	(.47)	(.48)	(25.6)
Malawi	4.67	0.73	42.99	0.68	5.03	0.07	0.83	0.83	0.63	0.36
	(2.29)	(.45)	(16.46)	(.48)	(4.08)	(.25)	(.37)	(.37)	(.48)	(2.34)
Mozambique	4.81	0.67	43.47	0.66	3.52	0.19	0.72	0.72	0.52	
	(2.77)	(.47)	(15.55)	(.54)	(3.67)	(.39)	(.45)	(.45)	(.5)	
Nigeria	4.62	0.81	44.85	0.76	6.28	0.51	0.63	0.63	0.52	
	(3.13)	(.39)	(16.23)	(.68)	(5.78)	(.5)	(.48)	(.48)	(.5)	
Niger	6.08	0.84	45.59	0.97	1.58	0.2	0.72	0.72	0.71	
	(3.56)	(.37)	(15.25)	(.65)	(3.73)	(.4)	(.45)	(.45)	(.46)	
Namibia	4.42	0.57	46.29	0.4	6.84	0.45	0.33	0.33	0.47	7.61
	(3.05)	(.49)	(16.89)	(.49)	(4.94)	(.5)	(.47)	(.47)	(.5)	(20.95)
Rwanda	4.56	0.67	43.55	0.58	3.42	0.07				
	(2.23)	(.47)	(15.64)	(.49)	(3.64)	(.26)				
Sierra Leone	5.89	0.73	45.64	0.8	3.22	0.13	0.58	0.58	0.51	
	(3.01)	(.44)	(14.84)	(.6)	(4.98)	(.33)	(.49)	(.49)	(.5)	
Senegal	9.57	0.81	50.91	0.97	1.94	0.39				
	(6.22)	(.4)	(14.56)	(.77)	(3.96)	(.49)				
Tanzania	5.18	0.76	45.46	0.72	5	0.13	0.74	0.74		
	(3)	(.43)	(15.71)	(.49)	(4)	(.33)	(.44)	(.44)		
Uganda	5.05	0.69	42.08	0.6	5.65	0.14	0.74	0.74	0.6	1.05
	(2.81)	(.46)	(15.62)	(.51)	(4.61)	(.34)	(.44)	(.44)	(.49)	(4.87)
Zimbabwe	4.45	0.58	44.07	0.51	7.45	0.37	0.64	0.64	0.62	2.28
	(2.45)	(.49)	(16.62)	(.52)	(4.04)	(.48)	(.48)	(.48)	(.49)	(6.46)

Country	Number of Goats	Number of Horses, Donkeys, or Mules	Share of HH with Cell Phone	Share of HH with Radio	Share of HH with a Bicycle	Share of HH With Designated Kitchen	Share of HH With Stove	Share of HH With Chimney	Share of HH Using Traditional Fuels	Share of HH Using Transitional Fuels	Share of HH Using Modern Fuels
SAMPLE MEAN ST. DEV.	2.02 (7.34)	0.26 (2.67)	0.46 (.5)	0.61 (.49)	0.14 (.35)	0.53 (.5)	0.125 (0.33)	0.004 (0.065)	0.74 (.44)	0.19 (.39)	0.07 (.26)
Angola			0.46 (.5)	0.61 (.49)	0.14 (.35)				0.44 (.5)	0.17 (.38)	0.44 (.5)
Burkina Faso	3.88 (6.7)	0.66 (1.39)	0.6 (.49)	0.68 (.47)	0.82 (.39)	0.27 (.45)			0.91 (.29)	0.05 (.22)	0.91 (.29)
Benin	1.12 (5.86)	0.14 (3.29)	0.46 (.5)	0.68 (.47)	0.34 (.47)	0.42 (.49)			0.73 (.44)	0.23 (.42)	0.73 (.44)
Burundi	1.06 (2.31)	0.01 (.82)	0.29 (.45)	0.54 (.5)	0.2 (.4)	0.32 (.47)			0.84 (.36)	0.16 (.36)	0.84 (.36)
DRC	0.6 (2.17)	0 (.15)	0.31 (.46)	0.42 (.49)	0.24 (.43)	0.4 (.49)			0.74 (.44)	0.23 (.42)	0.74 (.44)
Congo	0.23 (1.77)		0.59 (.49)	0.6 (.49)	0.05 (.22)	0.35 (.48)			0.59 (.49)	0.32 (.47)	0.59 (.49)
Camaroon	1.14 (4.72)	0.08 (1.61)	0.65 (.48)	0.59 (.49)	0.14 (.35)	0.48 (.5)	1.04 (.27)	0.02 (.18)	0.76 (.43)	0.09 (.29)	0.76 (.43)
Ethiopia	2.6 (8.58)	0.35 (.76)	0.32 (.47)	0.41 (.49)	0.02 (.15)	0.15 (.36)			0.81 (.39)	0.18 (.38)	0.81 (.39)
Ghana	1.32 (3.88)	0.02 (.3)	0.54 (.5)	0.72 (.45)	0.3 (.46)	0.6 (.49)	1.41 (.5)		0.56 (.5)	0.33 (.47)	0.56 (.5)
Guinea	1.22 (3.51)	0.02 (.37)	0.67 (.47)	0.64 (.48)	0.24 (.43)	0.27 (.44)			0.38 (.49)	0.62 (.49)	0.38 (.49)
Kenya	3.07 (9.96)	0.22 (2.26)	0.6 (.49)	0.72 (.45)	0.28 (.45)	0.42 (.49)			0.62 (.49)	0.31 (.46)	0.62 (.49)
Liberia	0.27 (1.43)		0.44 (.5)	0.49 (.5)	0.02 (.15)				0.64 (.48)	0.35 (.48)	0.64 (.48)
Lesotho	3.26 (12.16)	0.68 (3.14)	0.59 (.49)	0.55 (.5)	0.02 (.15)	0.45 (.5)	1.28 (.68)	0.02 (.16)	0.65 (.48)	0.12 (.33)	0.65 (.48)
Madagascar	0.3 (3)	0 (.19)	0.3 (.46)	0.57 (.5)	0.21 (.41)	0.61 (.49)	1.01 (.13)	0.04 (.22)	0.72 (.45)	0.27 (.44)	0.72 (.45)
Mali	3.62 (11.37)	1.31 (6.39)	0.42 (.49)	0.72 (.45)	0.49 (.5)	0.57 (.5)			0.85 (.36)	0.14 (.35)	0.85 (.36)
Malawi	1.12 (3.01)		0.37 (.48)	0.56 (.5)	0.43 (.5)	0.53 (.5)	1.07 (.27)	0.02 (.15)	0.91 (.28)	0.08 (.26)	0.91 (.28)
Mozambique	1.08 (4.68)	0.04 (1.87)	0.43 (.5)	0.54 (.5)	0.33 (.47)	0.47 (.5)			0.78 (.41)	0.18 (.38)	0.78 (.41)
Nigeria	2.08 (4.96)	0.08 (.71)	0.62 (.49)	0.7 (.46)	0.21 (.4)	0.63 (.48)	1.21 (.44)	0.07 (.34)	0.72 (.45)	0.26 (.44)	0.72 (.45)
Niger	3.05 (6.36)	0.49 (2.26)	0.38 (.48)	0.54 (.5)	0.12 (.32)	0.36 (.48)			0.95 (.23)	0.03 (.17)	0.95 (.23)
Namibia	8.52 (20.72)	1.49 (8.09)	0.69 (.46)	0.72 (.45)	0.14 (.35)	0.84 (.37)	1.07 (.33)	0.04 (.25)	0.59 (.49)	0.03 (.17)	0.59 (.49)
Rwanda			0.16 (.37)	0.52 (.5)	0.12 (.32)				0.9 (.3)	0.1 (.3)	0.9 (.3)
Sierra Leone	0.57 (2.29)	0 (.06)	0.48 (.5)	0.6 (.49)	0.09 (.29)	0.41 (.49)	1.16 (.54)	0.13 (.49)	0.81 (.39)	0.19 (.39)	0.81 (.39)
Senegal			0.72 (.45)	0.81 (.39)	0.18 (.38)				0.64 (.48)	0.12 (.32)	0.64 (.48)
Tanzania			0.47 (.5)	0.61 (.49)	0.4 (.49)				0.81 (.39)	0.19 (.39)	0.81 (.39)
Uganda	1.56 (4.41)	0.02 (.3)	0.38 (.49)	0.6 (.49)	0.35 (.48)	0.33 (.47)	1.16 (.38)	0.05 (.22)	0.76 (.42)	0.23 (.42)	0.76 (.42)
Zimbabwe	2.01 (5.45)	0.32 (2.38)	0.38 (.48)	0.43 (.49)	0.24 (.43)	0.58 (.49)	1.04 (.26)		0.68 (.47)	0.01 (.1)	0.68 (.47)

Appendix II: Graphs of Variables of Interest

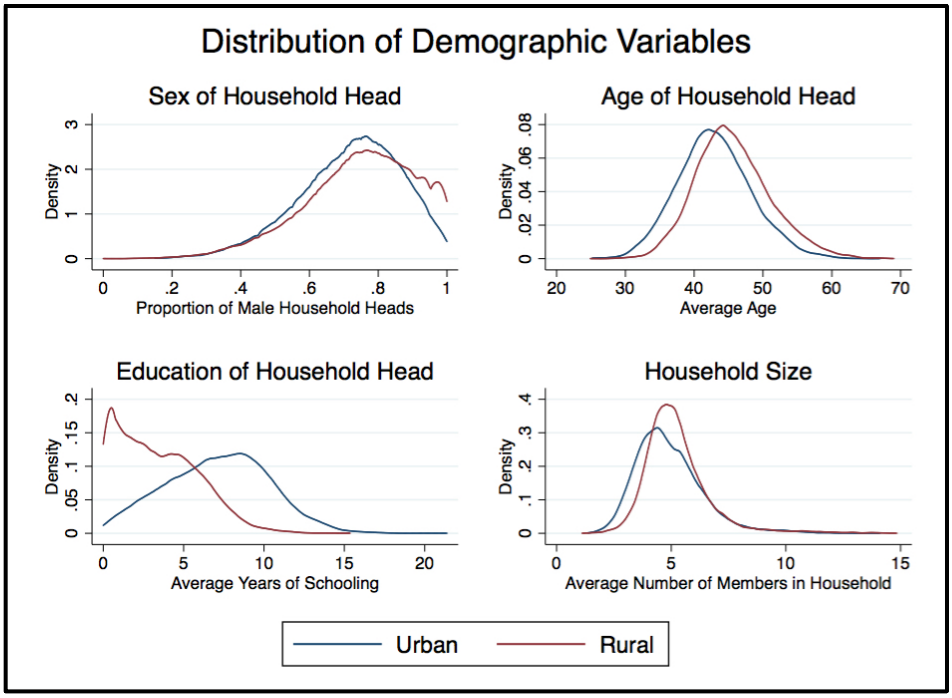

Figure A-1: Kernel Density Distributions of Demographic Variables

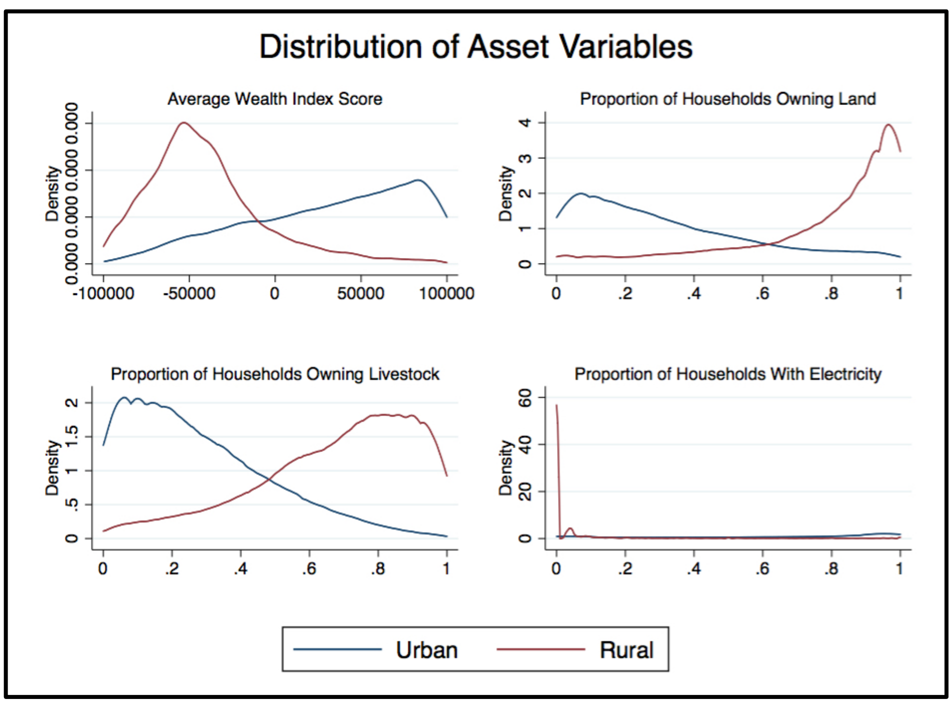

Figure A-2: Kernel Density Distributions of Asset Variables

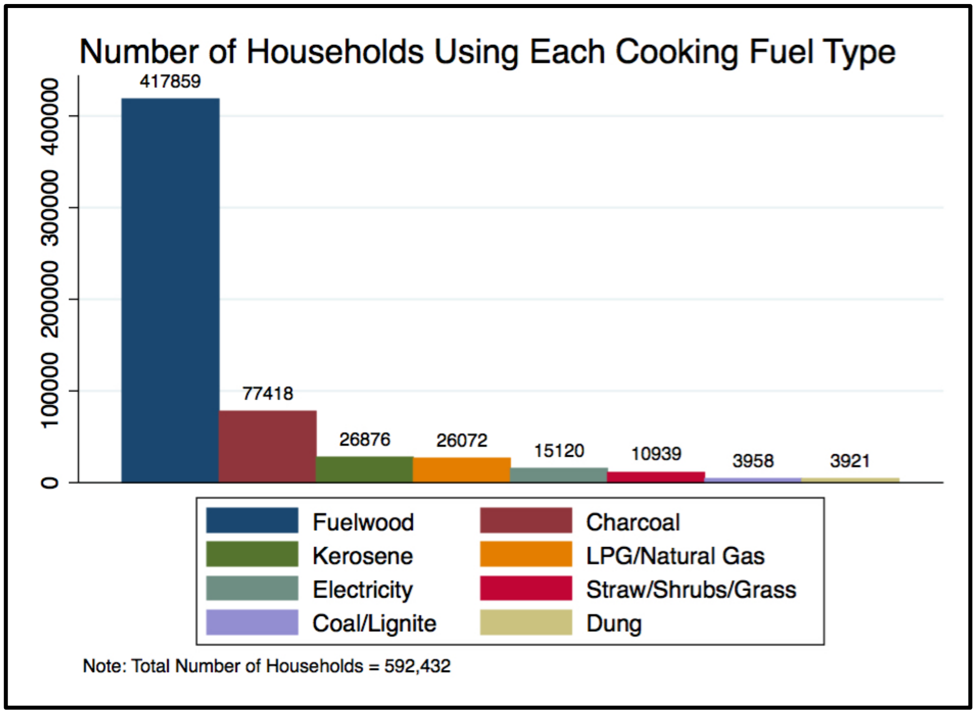

Figure A-3: Distribution of Number of Household Reporting Use of Types of Cooking Fuels

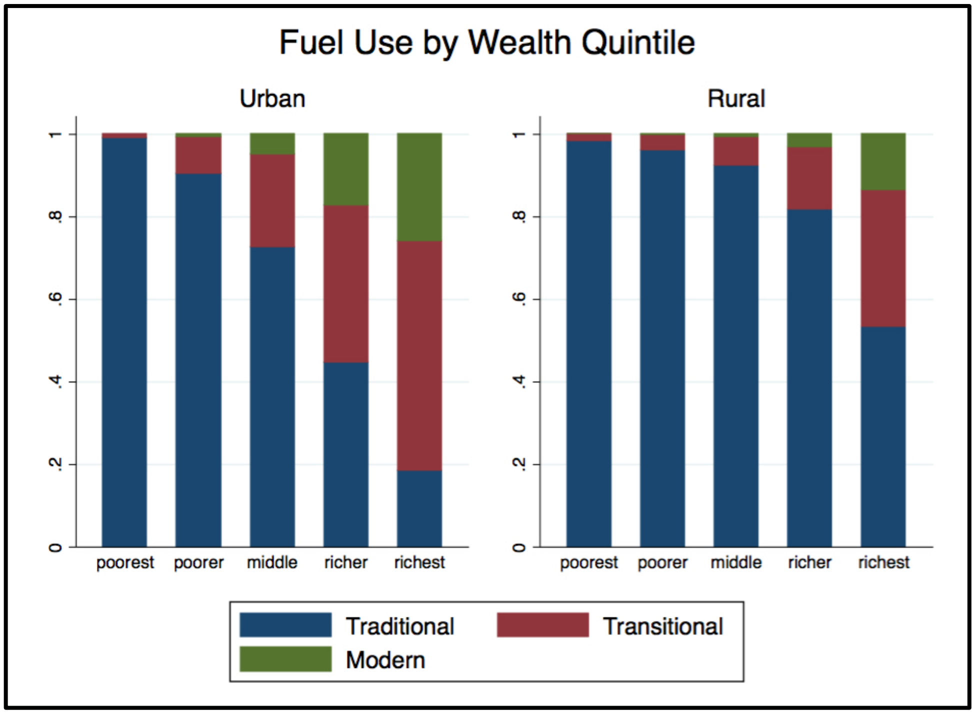

Figure A-4: Rates of Use of Cooking Fuel Types by Wealth Quintiles

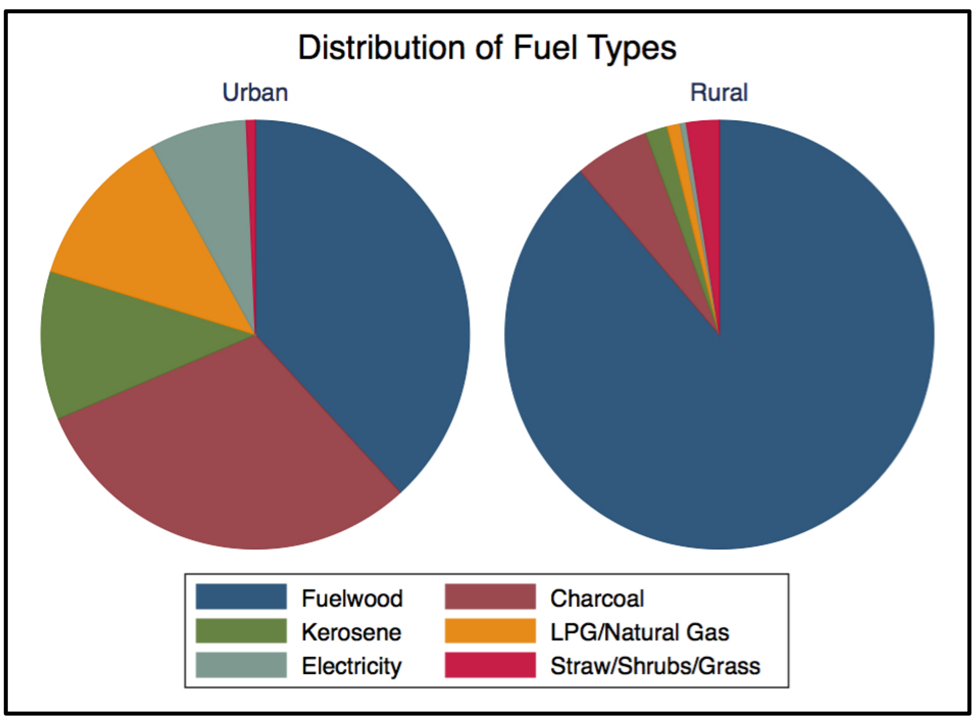

Figure A-5: Distribution of Number of Households Reporting Select Fuel Types

Urbanization and Patterns of Cooking Fuel Use

The pattern between primary cooking fuel and degree of urbanization of the households' communities remains after breaking down the classification of place of residence further into capital city, small city, town and countryside. A monotonic relationship holds for all fuels types in relation to the density of locales. For each traditional cooking fuel, the percentage of households reporting use decreases with the size of the community: the lowest share of households that rely on fuels such as fuelwood, straw/shrubs/grass, and dung live in the capital or largest cities of the nation and the highest share of households live in the countryside. The reverse trend is observable for all transitional and modern cooking fuels. The higher shares of households utilizing electricity, LPG/natural gas, charcoal, coal and even kerosene occur in the largest cities and lower shares occur in the countryside. One cooking fuel type violates the relationship between rates of use and community size that exists for the all other transitional and modern cooking fuels; the share of households using electricity in towns exceeds that of the share in small cities. Table A-2 illustrates this pattern below.

Table A-2: Most Commonly Reported Cooking Fuels by Location of Residence

Most Commonly Reported Primary Cooking Fuels

Capital City Households		
Fuel Type	**Frequency**	**Percent**
Charcoal	12,460	36.6
Fuelwood	6,779	19.9
LPG / Natural Gas	5,714	16.8
Kerosene	3,593	10.6
Electricity	2,665	7.8
Total	31,211	91.6

Small City Households		
Fuel Type	**Frequency**	**Percent**
Fuelwood	14,554	48.8
Charcoal	7,984	26.8
LPG / Natural Gas	2,765	9.3
Electricity	1,210	4.1
Kerosene	1,106	3.7
Total	27,619	92.6

Town Households		
Fuel Type	**Frequency**	**Percent**
Fuelwood	28,162	64.0
Charcoal	7,351	16.7
Electricity	2,871	6.5
LPG / Natural Gas	2,473	5.6
Kerosene	1,148	2.6
Total	42,005	95.5

Countryside Households		
Fuel Type	**Frequency**	**Percent**
Fuelwood	181,890	87.3
Charcoal	13,000	6.2
Straw / Shrubs / Grass	6,613	3.2
Animal Dung	1,593	0.8
LPG / Natural Gas	1,428	0.7
Total	204,524	98.2

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Similar to the comparison between rural and urban areas, the distribution of the shares is less skewed in the larger community types. The share of households relying on the most common fuel is highest in the countryside, over 87.3 percent reported using fuelwood, and lowest in the capital city where 36.6 percent reported charcoal as their primary cooking fuel. The total proportion of households that use one of the five most common fuels also falls with community size.

Appendix IV: Discussion of Multicollinearity Concerns

As mentioned with the text, the standardized wealth index is a function of a number of variables recording asset ownership. Agricultural land ownership, livestock ownership, and whether the household has electricity are included within the wealth index. Consequently, correlation exists between these variables and the standardized wealth index as displayed in Table A-3. The variable(s) most strongly correlated with the standardized wealth index are the proportion of households with electricity and its interaction with the urban binary, with a correlation coefficient of 0.517.

As a result, multicollinearity is a possible concern for the all-inclusive regressions within this thesis. While multicollinearity does not bias the estimated coefficients within the regression, its presence does greatly inflate the standard errors. Table A-4 presents the variance inflation factors (VIF) for each of the independent variables. All but one of the asset related variables show a VIF above 10, a common threshold for evaluating the presence of multicollinearity (Wooldridge 2006). Interestingly, the sole wealth-related variable that falls below a VIF of 10 is the standardized wealth index, which provides slight evidence that including the wealth index from the regression is not entirely problematic. Moreover, we expect some VIF to be high since a number of the variables are quadratics and/or interacted with a binary variable.

Table A-3: Correlation Matrix of Wealth-Related Variables

	Wealth Index	Urb.*Wealth Index	Urb.	Prop. of HH Owning Agricultural Land	Urb.*Prop. of HH Owning Agricultural Land	Sq. Prop. of HH Owning Agricultural Land	Urb.*Sq. Prop. of HH Owning Agricultural Land	Prop. of HH Owning Livestock	Urb.*Prop. of HH Owning Livestock	Sq. Prop. of HH Owning Livestock	Urb.*Sq. Prop. of HH Owning Livestock	Prop. of HH With Electricity	Urb.*Prop. of HH With Electricity
Wealth Index	1.000												
Urb.*Wealth Index	0.851	1.000											
Urb.	0.478	0.394	1										
Prop. of HH Owning Agricultural Land	-0.477	-0.366	-0.676	1.000									
Urb.*Prop. of HH Owning Agricultural Land	0.200	0.103	0.692	-0.144	1.000								
Sq. Prop. of HH Owning Agricultural Land	-0.466	-0.343	-0.666	0.976	-0.212	1.000							
Urb.*Sq. Prop. of HH Owning Agricultural Land	0.080	-0.007	0.494	0.036	0.939	-0.014	1.000						
Prop. of HH Owning Livestock	-0.461	-0.337	-0.641	0.741	-0.232	0.736	-0.072	1.000					
Urb.*Prop. of HH Owning Livestock	0.233	0.138	0.722	-0.273	0.845	-0.314	0.756	-0.170	1.000				
Sq. Prop. of HH Owning Livestock	-0.432	-0.298	-0.599	0.679	-0.263	0.697	-0.108	0.969	-0.227	1.000			
Urb.*Sq. Prop. of HH Owning Livestock	0.106	0.023	0.512	-0.090	0.767	-0.127	0.766	0.015	0.930	-0.036	1.000		
Prop. of HH With Electricity	0.517	0.408	0.685	-0.669	0.321	-0.663	0.145	-0.653	0.338	-0.607	0.159	1.000	

Table A - 4: Variance Inflation Factors of Independent Variables

Variable	VIF	1/VIF
Urban	161.74	0.006183
Urban*Age	91.57	0.010921
AglandOwnership	74.34	0.013453
LivestockOwnership	72.25	0.013841
AglandOwnershipSq	60.06	0.016649
Urban*AglandOwnership	56.84	0.017594
Urban*LivestockOwnership	53.23	0.018785
LivestockOwnershipSq	52.25	0.019137
Urban*AglandOwnershipSq	29.94	0.033405
Urban*Gender	28.71	0.034831
Urban*HHSize	26.55	0.03767
Urban*LivestockOwnershipSq	23.59	0.042392
Urban_Educ	16.84	0.059369
Urban*Electric	12.62	0.079265
Urban*St. WealthIndex	11.37	0.087939
St. Wealth Index	9.84	0.101625
Educ	7.86	0.127276
Electric	7.43	0.134577
HHSize	2.88	0.347105
Gender	2.77	0.361217
Age	2.5	0.400727

Appendix V: Supplementary Regression Tables

Country-Specific Regressions

Table A-5: Preferred OLS Regressions for Each Country within Sample

	Share of Households Reporting Traditional Fuels as Primary Cooking Fuel									
	Burkina Faso	Benin	Burundi	DRC	Congo	Cameroon	Ethiopia	Ghana	Guinea	Kenya
Standardized Wealth Index	-0.036	-0.360**	-0.322*	-0.881**	-0.484**	-0.254***	-0.245***	-0.659***	-0.103	-0.617***
	(-1.29)	(-3.61)	(-3.24)	(-3.40)	(-3.56)	(-5.84)	(-5.83)	(-5.11)	(-2.18)	(-6.62)
Urban*Standardized Wealth Index	-0.245**	-0.139	0.172	0.181	0.483**	-0.396**	-0.483**	0.308	-0.822***	-0.026
	(-3.79)	(-1.33)	1.010	0.680	3.560	(-4.17)	(-3.73)	1.660	(-7.42)	(-0.13)
Urban	-0.275	0.025	-0.649*	-0.266	0.203	-0.307	-0.634*	0.128	-0.182	-0.313*
	(-1.36)	0.230	(-4.33)	(-0.77)	0.640	(-2.11)	(-2.83)	0.470	(-0.70)	(-2.56)
Proportion of Households With Female Head	0.004	0.044	-0.038	-0.127	-0.029	0.058	-0.001	0.053	-0.052	-0.122
	0.170	1.440	(-2.06)	(-1.33)	(-0.27)	1.350	(-0.06)	0.620	(-0.80)	(-2.11)
Urban*Proportion of Households With Female Head	0.119	-0.125	-0.090	0.163	-0.128	0.005	0.119	-0.117	-0.059	-0.011
	1.020	(-1.20)	(-0.67)	0.780	(-0.83)	0.040	0.900	(-1.18)	(-0.53)	(-0.13)
Average Age of Household Heads	0.000	0.004**	0.001	0.002	0.006	0.002**	0.000	0.003	0.000	0.004
	(-0.29)	3.250	1.680	1.160	2.010	3.270	-0.290	1.570	-0.340	1.880
Urban*Average Age of Household Heads	0.005*	-0.003	0.016*	0.004	-0.004	0.005*	0.006	-0.001	0.001	0.002
	2.330	(-1.32)	4.080	0.680	(-0.98)	2.500	1.880	(-0.48)	0.430	1.280
Average Size of Households	0.003	0.005	0.003	0.043	-0.002	0.004	0.009	0.004	0.002	-0.014
	1.080	0.830	1.830	1.450	(-0.19)	1.000	2.090	0.340	0.390	(-1.06)
Urban*Average Size of Households	0.012	0.011	0.029	-0.072*	0.021	0.041**	0.027	0.016	0.006	0.051*
	1.030	1.270	1.100	(-2.64)	1.390	4.270	1.110	0.790	0.720	3.140
Average Years of Schooling for Household Heads	-0.020**	-0.008	-0.006**	-0.004	0.004	0.003	-0.008*	0.025*	0.010	0.023*
	(-3.27)	(-0.88)	(-5.90)	(-0.58)	0.460	0.620	(-2.51)	2.610	0.800	3.400
Urban*Average Years of Schooling for Household Heads	0.002	0.003	0.000	0.023	-0.007	-0.003	0.013	-0.010	0.010	-0.005
	0.200	0.270	-0.010	1.580	(-0.80)	(-0.32)	1.190	(-0.71)	0.740	(-0.47)
Proportion of Households Owning Agricultural Land	0.873	0.546**	0.652***	-0.132	0.293	0.355	-0.051	0.786	0.305	-0.038
	1.190	4.240	9.310	-1.190	1.310	1.410	(-1.08)	2.130	1.200	(-0.30)
Urban*Proportion of Households Owning Agricultural Land	-0.728	0.222*	-1.112*	0.400	-0.377	-0.275	0.147	-0.491	0.229	0.212
	(-0.88)	2.380	(-4.49)	1.660	(-1.16)	(-0.90)	-0.550	(-1.17)	0.720	0.890
Squared Proportion of Households Owning Agricultural Land	-0.353	-0.415*	-0.369**	0.093	-0.127	-0.233	0.044	-0.413	-0.076	0.077
	(-0.84)	(-3.07)	(-8.43)	0.850	(-0.89)	(-1.80)	1.020	(-1.53)	(-0.52)	0.920
Urban*Squared Proportion of Households Owning Agricultural Land	0.214	-0.071	0.931**	-0.185	0.908**	0.213	-0.346	0.577	-0.738	-0.237
	0.430	(-0.66)	4.690	(-0.85)	4.050	0.960	(-1.18)	1.380	(-1.79)	(-0.88)
Proportion of Households Owning Livestock	-0.407	0.009	0.306	0.104	0.685*	0.344*	0.819*	0.336	0.255	0.579*
	(-1.49)	0.130	1.290	0.970	2.510	2.760	2.850	1.020	1.140	3.140
Urban*Proportion of Households Owning Livestock	0.901*	0.032	-0.186	-0.177	-0.813	-0.065	-0.277	-0.231	-0.131	-1.317**
	2.290	0.200	(-0.40)	(-1.08)	(-1.64)	(-0.27)	(-0.87)	(-0.76)	(-0.47)	(-3.66)
Squared Proportion of Households Owning Livestock	0.196	-0.017	-0.205	-0.014	-0.637*	-0.296**	-0.506*	-0.283	-0.220	-0.412**
	1.280	(-0.21)	(-1.23)	(-0.18)	(-2.39)	(-3.52)	(-3.04)	(-1.17)	(-1.41)	(-4.02)
Urban*Squared Proportion of Households Owning Livestock	-0.579*	-0.186	0.181	0.210	2.704*	-0.131	0.297	0.700	0.310	1.318*
	(-2.18)	(-1.45)	0.410	0.930	2.760	(-0.56)	0.920	1.920	0.680	2.900
Proportion of Households With Electricity	-0.069	-0.037	-0.055	1.040*	-0.072	0.044*	0.107*	0.032	-0.151	-0.216*
	(-0.62)	(-1.59)	-0.450	2.880	(-0.82)	2.420	2.400	0.560	(-1.38)	(-3.23)
Urban*Proportion of Households With Electricity	0.154	0.005	-0.106	-0.719*	-0.223	0.051	0.276	-0.084	0.445*	0.351**
	1.230	0.070	(-0.90)	(-2.26)	(-1.55)	1.370	1.700	(-0.78)	2.660	3.800
R-Squared	0.848	0.918	0.936	0.858	0.943	0.921	0.946	0.932	0.923	0.939
Number of Enumeration Are	573	750	579	536	384	578	596	411	300	398

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. ** indicates significance at the 10 percent level.

	Share of Households Reporting Traditional Fuels as Primary Cooking Fuel										
	Lesotho	Madagascar	Mali	Malawi	Mozambique	Nigeria	Niger	Namibia	Sierra Leone	Uganda	Zimbabwe
Standardized Wealth Index	-0.500***	-0.488***	-0.029**	-0.122*	-0.561***	-0.451*	-0.034	-0.335***	-0.111	-0.459***	-0.263**
	(-13.99)	(-6.04)	(-5.49)	(-4.31)	(-5.54)	(-3.42)	(-1.75)	(-5.97)	(-1.22)	(-5.23)	(-3.74)
Urban*Standardized Wealth Index	-0.246*	-0.157	0.01	-0.225	-0.21	-0.037	-0.349*	-0.307**	-0.473	0.218	0.001
	(-2.36)	(-1.28)	(1.43)	(-1.37)	(-1.37)	(-0.32)	(-3.08)	(-3.65)	(-2.52)	(1.79)	(0.01)
Urban	-0.641**	-0.102	-0.386	-1.052*	-0.668*	-0.288*	-0.429	-0.665***	-0.693**	0.537	-0.357*
	(-4.57)	(-0.53)	(-2.39)	(-7.25)	(-3.00)	(-2.63)	(-2.08)	(-4.46)	(-6.39)	(2.19)	(-2.47)
Proportion of Households With Female Head	-0.005	0.006	0.004	0.006	0.053	-0.130*	-0.006	0.07	-0.011	-0.035	-0.027
	(-0.10)	(0.07)	(0.10)	(0.31)	(0.89)	(-3.83)	(-0.42)	(-1.22)	(-0.49)	(-0.67)	(-0.95)
Urban*Proportion of Households With Female Head	0.115	-0.064	0.12	-0.087	-0.07	0.205*	-0.062	-0.064	0.075	-0.082	0.144*
	(0.91)	(-0.56)	(0.50)	(-0.57)	(-0.70)	(2.91)	(-0.62)	(-1.30)	(0.71)	(-0.72)	(2.73)
Average Age of Household Heads	0.003	0.003	-0.001	0.001	-0.002	0.008*	0.001	0.004*	0.00	0.006**	0.00
	(1.47)	(1.69)	(-1.03)	(1.83)	(-1.17)	(2.75)	(1.02)	(2.35)	(-2.38)	(4.45)	(0.00)
Urban*Average Age of Household Heads	0.004	0.008*	0.01	0.011*	0.014**	-0.003	0.001	0.006*	0.011***	-0.004	0.005*
	(1.69)	(2.62)	(2.48)	(5.80)	(3.46)	(-1.33)	(0.49)	(2.75)	(24.98)	(-0.62)	(2.31)
Average Size of Households	0.009	0.001	-0.009	-0.001	0.00	0.012*	-0.002	-0.009	0.003	0.02	-0.016*
	(1.34)	(0.16)	(-2.07)	(-0.10)	(0.06)	(3.70)	(-1.10)	(-1.48)	(0.67)	(2.26)	(-2.32)
Urban*Average Size of Households	0.029	-0.045**	0.027*	0.023	-0.032*	0.048**	0.029*	0.053***	0.001	0.034*	0.040**
	(2.09)	(-2.90)	(3.12)	(1.27)	(-2.50)	(5.84)	(3.17)	(6.38)	(0.06)	(2.44)	(3.36)
Average Years of Schooling for Household Heads	-0.002	0.013	0.001	-0.007	0.00	0.007	-0.007	-0.011	0.005	0.007	-0.004
	(-0.34)	(1.96)	(0.18)	(-1.37)	(-0.10)	(2.04)	(-1.22)	(-1.82)	(0.90)	(1.13)	(-1.01)
Urban*Average Years of Schooling for Household Heads	0.047***	0.009	-0.006	0.046	0.009	-0.005	0.016	0.022*	0.008	-0.008	0.013
	(6.51)	(0.84)	(-0.58)	(3.76)	(1.26)	(-1.64)	(1.22)	(2.41)	(0.87)	(-0.43)	(2.20)
Proportion of Households Owning Agricultural Land	0.560**	0.307	0.73	0.201	0.027	0.433	0.027	-0.165	0.334	1.645**	-0.057
	(3.34)	(1.68)	(2.28)	(1.55)	(0.09)	(1.52)	(0.29)	(-1.78)	(2.27)	(4.54)	(-0.37)
Urban*Proportion of Households Owning Agricultural Land	-0.414	-0.471	-0.772	-0.331	0.141	0.131	0.083	-0.362*	0.145	-1.773**	0.175
	(-2.05)	(-1.68)	(-2.21)	(-0.55)	(0.73)	(0.72)	(0.69)	(-2.31)	(0.76)	(-3.48)	(0.69)
Squared Proportion of Households Owning Agricultural Land	-0.346**	-0.065	-0.471	-0.093	0.049	-0.193	-0.039	0.186	-0.199	-0.944**	-0.049
	(-3.54)	(-0.51)	(-2.43)	(-1.15)	(0.25)	(-1.08)	(-0.67)	(-1.97)	(-1.70)	(-4.02)	(-0.47)
Urban*Squared Proportion of Households Owning Agricultural Land	0.233	0.532*	0.644	0.428	-0.157	0.059	-0.102	0.553*	-0.279	1.383*	-0.068
	(0.85)	(2.23)	(2.42)	(0.62)	(-1.44)	(0.44)	(-0.59)	(2.32)	(-1.39)	(3.23)	(-0.25)
Proportion of Households Owning Livestock	0.373	0.484	0.203	0.353*	0.414	0.526*	-0.14	0.451*	0.178	0.227	0.285
	(1.15)	(1.78)	(0.56)	(6.13)	(2.21)	(2.78)	(-1.58)	(2.87)	(1.10)	(0.99)	(1.02)
Urban*Proportion of Households Owning Livestock	-0.524	-0.175	0.56	0.588*	0.276	-0.259	0.917***	-0.269	-0.105	-0.915*	-0.547
	(-0.77)	(-0.61)	(1.51)	(5.69)	(0.78)	(-1.56)	(6.49)	(-1.56)	(-0.59)	(-2.44)	(-1.78)
Squared Proportion of Households Owning Livestock	-0.278	-0.295	-0.149	-0.256*	-0.382*	-0.500*	0.101	-0.262	-0.137	-0.044	-0.103
	(-1.15)	(-1.57)	(-0.58)	(-5.13)	(-2.29)	(-3.24)	(1.77)	(-2.12)	(-1.27)	(-0.27)	(-0.56)
Urban*Squared Proportion of Households Owning Livestock	0.785	0.122	-0.827	-0.488	-0.116	0.183	-0.781**	0.232	0.243	1.209*	0.506
	(0.95)	(0.52)	(-2.06)	(-3.51)	(-0.31)	(0.87)	(-4.09)	(1.21)	(1.09)	(2.98)	(1.68)
Proportion of Households With Electricity	-0.118	-0.216	0.106*	-0.318	0.033	0.037	0.002	-0.104*	-0.506	0.128	-0.294**
	(-1.69)	(-1.97)	(3.13)	(-3.11)	(0.24)	(1.06)	(0.14)	(-2.94)	(-2.94)	(0.76)	(-3.58)
Urban*Proportion of Households With Electricity	0.261**	0.290*	-0.232**	0.238	0.238	0.093*	0.043	0.109	0.663	-0.165	-0.449***
	(4.49)	(2.27)	(-4.89)	(1.45)	(1.56)	(3.36)	(0.52)	(1.65)	(2.14)	(-0.73)	(-4.88)
R-Squared	0.955	0.947	0.88	0.887	0.93	0.896	0.794	0.918	0.877	0.939	0.968
Number of Enumeration Are	400	594	413	849	610	1782	476	1050	788	404	804

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. ** indicates significance at the 10 percent level.

	Share of Households Reporting Transitional Fuels as Primary Cooking Fuel									
	Burkina Faso	**Benin**	**Burundi**	**DRC**	**Congo**	**Cameroon**	**Ethiopia**	**Ghana**	**Guinea**	**Kenya**
Standardized Wealth Index	0.040	0.331**	0.326*	0.880**	0.346*	0.075*	0.241***	0.312	0.096	0.563***
	(1.45)	(3.35)	(3.28)	(3.37)	(2.36)	(2.26)	(5.13)	(1.96)	(2.06)	(5.87)
Urban*Standardized Wealth Index	0.045	-0.051	-0.238	-0.308	-1.033***	-0.138*	0.364*	-0.627*	0.731**	-0.218
	(0.56)	(-0.39)	(-1.26)	(-1.01)	(-6.77)	(-2.40)	(2.78)	(-2.86)	(4.91)	(-0.84)
Urban	0.201	-0.025	0.702**	0.229	0.026	0.054	0.717**	-0.040	0.422	1.093***
	(-0.98)	(-0.20)	(4.61)	(0.55)	(0.07)	(0.34)	(3.34)	(-0.10)	(1.39)	(5.62)
Proportion of Households With Female Head	-0.014	-0.043	0.037	0.123	0.019	-0.006	-0.004	-0.172	0.049	0.116
	(-0.64)	(-1.24)	(1.86)	(1.31)	(0.16)	(-0.35)	(-0.18)	(-1.58)	(0.79)	(2.26)
Urban*Proportion of Households With Female Head	-0.106	0.166	0.100	-0.081	0.265	0.005	-0.098	0.213	-0.042	0.146
	(-1.29)	(1.36)	(0.75)	(-0.33)	(1.21)	(0.06)	(-0.81)	(1.62)	(-0.34)	(1.33)
Average Age of Household Heads	0.000	-0.004*	-0.001	-0.002	-0.006	0.000	0.000	-0.003	0.001	-0.003
	(1.04)	(-3.08)	(-1.71)	(-1.06)	(-1.73)	(-0.69)	(-0.60)	(-1.08)	(0.49)	(-1.76)
Urban*Average Age of Household Heads	-0.004	0.002	-0.018**	-0.002	0.006	-0.002	-0.007	0.004	-0.002	-0.017***
	(-1.93)	(0.95)	(-4.75)	(-0.24)	(1.90)	(-0.78)	(-1.89)	(0.67)	(-0.99)	(-5.65)
Average Size of Households	-0.001	-0.005	-0.003	-0.044	0.004	-0.001	-0.008	0.002	-0.002	0.010
	(-0.36)	(-0.77)	(-1.55)	(-1.48)	(0.32)	(-0.50)	(-1.89)	(0.09)	(-0.55)	(0.80)
Urban*Average Size of Households	0.004	-0.011	-0.015	0.089*	-0.021	-0.019*	-0.032	-0.011	-0.005	-0.069
	(0.27)	(-1.09)	(-0.44)	(3.15)	(-1.57)	(-2.27)	(-1.20)	(-0.40)	(-0.60)	(-2.03)
Average Years of Schooling for Household Heads	0.001	0.006	0.006**	0.005	-0.001	0.000	0.006	-0.030*	-0.009	-0.021*
	(0.40)	(0.74)	(5.89)	(0.75)	(-0.05)	(0.15)	(1.96)	(-2.48)	(-0.74)	(-3.20)
Urban*Average Years of Schooling for Household Heads	-0.011	-0.016	0.003	-0.036	-0.020	-0.007	-0.021	-0.006	-0.022	-0.042*
	(-1.01)	(-1.49)	(0.24)	(-1.99)	(-1.82)	(-1.13)	(-1.62)	(-0.40)	(-1.14)	(-2.47)
Proportion of Households Owning Agricultural Land	-0.715	-0.526**	-0.652***	0.125	-0.237	-0.434	0.051	-0.635	-0.294	0.036
	(-1.20)	(-4.34)	(-9.05)	(1.18)	(-1.50)	(-1.77)	(0.94)	(-1.52)	(-1.18)	(0.29)
Urban*Proportion of Households Owning Agricultural Land	0.686	-0.319*	1.114*	-0.706	0.481	0.499	-0.172	0.225	-0.220	-0.428
	(1.27)	(-2.52)	(4.54)	(-1.75)	(1.25)	(1.83)	(-0.65)	(0.47)	(-0.67)	(-1.29)
Squared Proportion of Households Owning Agricultural Land	0.310	0.386*	0.369**	-0.088	0.074	0.275	-0.052	0.296	0.071	-0.076
	(0.94)	(3.07)	(8.20)	(-0.85)	(0.70)	(1.97)	(-1.07)	(0.96)	(0.50)	(-0.99)
Urban*Squared Proportion of Households Owning Agricultural Land	-0.334	0.064	-0.926*	0.384	-1.302***	-0.428*	0.334	-0.457	0.679	0.543
	(-1.22)	(0.49)	(-4.55)	(1.24)	(-5.27)	(-2.43)	(1.07)	(-0.93)	(1.35)	(1.19)
Proportion of Households Owning Livestock	0.183	-0.012	-0.307	-0.098	-0.609	-0.055	-0.747*	-0.165	-0.267	-0.791**
	(0.67)	(-0.18)	(-1.31)	(-0.92)	(-1.82)	(-0.65)	(-2.54)	(-0.37)	(-1.20)	(-4.07)
Urban*Proportion of Households Owning Livestock	-0.581	0.073	-0.029	0.251	0.911	0.025	0.216	0.118	0.077	2.078**
	(-1.38)	(-0.44)	(-0.06)	(1.19)	(1.50)	(0.27)	(0.60)	(0.23)	(0.27)	(4.32)
Squared Proportion of Households Owning Livestock	-0.092	0.027	0.204	0.012	0.531	0.050	0.459*	0.073	0.230	0.530**
	(-0.61)	(0.33)	(1.24)	(0.15)	(1.60)	(0.81)	(2.72)	(0.23)	(1.47)	(4.26)
Urban*Squared Proportion of Households Owning Livestock	0.325	0.028	0.068	-0.384	-3.690**	-0.076	-0.302	-0.912	-0.304	-2.005*
	(1.14)	(0.19)	(0.14)	(-1.37)	(-3.61)	(-0.74)	(-0.80)	(-1.86)	(-0.64)	(-2.86)
Proportion of Households With Electricity	-0.082	0.034	0.049	-1.054*	0.035	-0.023*	-0.122*	0.060	0.146	0.018
	(-1.73)	(1.36)	(0.41)	(-2.95)	(0.36)	(-2.34)	(-2.24)	(0.85)	(1.36)	(0.17)
Urban*Proportion of Households With Electricity	0.068	0.166	0.150	0.755	0.508**	0.090*	-0.183	0.205	-0.427*	-0.088
	(1.11)	(1.83)	(1.25)	(2.09)	(3.25)	(2.90)	(-1.03)	(1.35)	(-2.55)	(-0.75)
R-Squared	0.565	0.852	0.929	0.781	0.864	0.442	0.915	0.787	0.915	0.846
Number of Enumeration Areas	573	750	579	536	384	578	596	411	300	398

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. ** indicates significance at the 10 percent level.

	Share of Households Reporting Transitional Fuels as Primary Cooking Fuel										
	Lesotho	Madagascar	Mali	Malawi	Mozambique	Nigeria	Niger	Namibia	Sierra Leone	Uganda	Zimbabwe
Standardized Wealth Index	0.176***	0.487***	0.028**	0.101	0.543***	0.377*	0.022	0.022	0.109	-0.459***	-0.263**
	(5.85)	(5.92)	(5.74)	(3.72)	(4.97)	(2.98)	(1.20)	(1.04)	(1.19)	(-5.23)	(-3.74)
Urban*Standardized Wealth Index	-0.105	0.073	-0.017*	-0.123	0.112	-0.144	-0.045	-0.015	0.455	0.218	0.001
	(-1.09)	(0.47)	(-2.70)	(-0.54)	(0.68)	(-0.94)	(-2.30)	(-0.45)	(-2.34)	(1.79)	(0.01)
Urban	0.070	0.278	0.416	1.006*	1.176***	0.457*	0.423*	0.164*	0.701**	0.537	-0.357*
	(-0.28)	(1.32)	(2.42)	(5.48)	(6.08)	(3.64)	(3.24)	(2.57)	(6.56)	(2.19)	(-2.47)
Proportion of Households With Female Head	0.014	-0.023	0.002	-0.004	-0.067	0.143**	0.003	0.010	0.011	-0.035	-0.027
	(0.30)	(-0.24)	(0.06)	(-0.24)	(-1.04)	(4.50)	(0.37)	(0.81)	(0.52)	(-0.67)	(-0.95)
Urban*Proportion of Households With Female Head	-0.103	0.068	-0.158	0.211	0.128	-0.317*	0.003	0.005	-0.080	-0.082	0.144*
	(-0.41)	(0.50)	(-0.68)	(1.11)	(0.87)	(-3.61)	(0.04)	(0.14)	(-0.75)	(-0.72)	(2.73)
Average Age of Household Heads	0.001	-0.003	0.001	-0.001	0.003	-0.009*	0.000	0.000	0.000	0.006**	0.000
	(0.79)	(-1.70)	(1.04)	(-2.24)	(2.10)	(-3.00)	(-0.13)	(-0.73)	(2.52)	(4.45)	(0.00)
Urban*Average Age of Household Heads	0.005	-0.012**	-0.010	-0.012	-0.021**	0.002	0.000	-0.001	-0.011***	-0.004	0.005*
	(1.77)	(-3.52)	(-2.35)	(-2.82)	(-4.50)	(0.70)	(-0.17)	(-0.95)	(-33.76)	(-0.62)	(2.31)
Average Size of Households	-0.013*	-0.002	0.011	0.000	0.003	-0.006	0.000	-0.001	-0.003	0.020	-0.016*
	(-2.45)	(-0.17)	(2.44)	(0.06)	(0.29)	(-2.24)	(0.53)	(-0.50)	(-0.65)	(2.26)	(-2.32)
Urban*Average Size of Households	-0.015	0.053**	-0.022	0.003	0.087**	-0.043**	-0.024*	-0.007	-0.001	0.034*	0.040**
	(-0.89)	(3.02)	(-1.97)	(0.13)	(4.09)	(-6.83)	(-2.67)	(-1.35)	(-0.04)	(2.44)	(3.36)
Average Years of Schooling for Household Heads	-0.001	-0.013	-0.002	0.008	-0.001	-0.005	0.008	0.001	-0.005	0.007	-0.004
	(-0.25)	(-1.99)	(-0.32)	(1.45)	(-0.19)	(-1.46)	(1.36)	(0.41)	(-0.85)	(1.13)	(-1.01)
Urban*Average Years of Schooling for Household Heads	-0.019	-0.023	0.008	-0.052	-0.065*	0.000	-0.011	0.000	-0.008	-0.008	0.013
	(-1.59)	(-1.93)	(0.81)	(-4.04)	(-3.05)	(-0.08)	(-1.26)	(-0.03)	(-0.89)	(-0.43)	(2.20)
Proportion of Households Owning Agricultural Land	-0.265*	-0.288	-0.740	-0.226	0.414	-0.347	-0.079	0.034	-0.331	1.645**	-0.057
	(-3.00)	(-1.57)	(-2.30)	(-1.71)	(1.87)	(-1.07)	(-0.83)	(1.02)	(-2.28)	(4.54)	(-0.37)
Urban*Proportion of Households Owning Agricultural Land	0.310	0.421	0.708	0.489	-0.604	-0.340	0.065	0.205	-0.149	-1.773**	0.175
	(1.08)	(1.42)	(2.09)	(0.69)	(-2.11)	(-1.33)	(-0.49)	(1.59)	(-0.78)	(-3.48)	(0.69)
Squared Proportion of Households Owning Agricultural Land	0.183**	0.046	0.471	0.108	-0.342	0.120	0.058	-0.048	0.197	-0.944**	-0.049
	(3.36)	(0.37)	(2.43)	(1.35)	(-2.15)	(0.59)	(0.89)	(-1.66)	(1.70)	(-4.02)	(-0.47)
Urban*Squared Proportion of Households Owning Agricultural Land	-0.427	-0.495	-0.558	-0.749	0.297	0.048	-0.107	-0.267	0.273	1.383*	-0.068
	(-1.07)	(-1.97)	(-2.13)	(-0.94)	(1.60)	(0.29)	(-0.67)	(-1.86)	(1.37)	(3.23)	(-0.25)
Proportion of Households Owning Livestock	-0.231	-0.394	-0.164	-0.382*	-0.388	-0.473	0.125	0.078	-0.175	0.227	0.285
	(-1.25)	(-1.23)	(-0.46)	(-7.21)	(-2.10)	(-2.25)	(1.50)	(1.65)	(-1.09)	(0.99)	(1.02)
Urban*Proportion of Households Owning Livestock	0.428	0.287	-0.521	-0.511*	-0.202	0.479	-0.963***	-0.222*	0.122	-0.915*	-0.547
	(1.27)	(0.92)	(-1.40)	(-5.03)	(-0.67)	(2.35)	(-5.93)	(-2.83)	(0.70)	(-2.44)	(-1.78)
Squared Proportion of Households Owning Livestock	0.168	0.238	0.124	0.273*	0.372*	0.453*	-0.084	-0.070	0.135	-0.044	-0.103
	(1.37)	(1.08)	(0.49)	(5.77)	(2.24)	(2.68)	(-1.60)	(-1.52)	(1.27)	(-0.27)	(-0.56)
Urban*Squared Proportion of Households Owning Livestock	-0.641	-0.263	0.750	0.339	-0.012	-0.505	0.762**	0.180	-0.260	1.209*	0.506
	(-1.54)	(-1.01)	(1.85)	(1.57)	(-0.04)	(-1.88)	(4.86)	(1.81)	(-1.17)	(2.98)	(1.68)
Proportion of Households With Electricity	-0.014	0.188	-0.099*	0.224	-0.030	-0.024	-0.009	-0.027	0.503	0.128	-0.294**
	(-0.40)	(1.63)	(-3.67)	(2.22)	(-0.22)	(-0.63)	(-0.61)	(-1.21)	(2.92)	(0.76)	(-3.58)
Urban*Proportion of Households With Electricity	-0.189	-0.129	0.281***	0.104	-0.178	0.014	0.148**	-0.094*	-0.650	-0.165	-0.449***
	(-1.32)	(-0.73)	(7.23)	(0.40)	(-0.96)	(0.36)	(3.98)	(-3.05)	(-2.05)	(-0.73)	(-4.88)
R-Squared	0.628	0.931	0.86	0.795	0.821	0.839	0.621	0.301	0.873	0.939	0.968
Number of Enumeration Areas	400	594	413	849	610	1782	476	1050	788	404	804

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. ** indicates significance at the 10 percent level.

	Share of Households Reporting Modern Fuels as Primary Cooking Fuel									
	Burkina Faso	Benin	Burundi	DRC	Congo	Cameroon	Ethiopia	Ghana	Guinea	Kenya
Standardized Wealth Index	-0.003	0.029**	-0.004	0.001	0.138**	0.178***	0.004	0.347**	0.007	0.054
	(-0.11)	(-3.79)	(-2.28)	(-0.06)	(-4.14)	(-5.03)	(-0.34)	(-4.76)	(-1.57)	(-1.80)
Urban*Standardized Wealth Index	0.200*	0.190**	0.066	0.127	0.550***	0.534***	0.119**	0.319***	0.091	0.244**
	(2.66)	(3.39)	(2.64)	(1.40)	(7.71)	(7.80)	(3.40)	(4.88)	(1.19)	(3.62)
Urban	0.074	-0.001	-0.053	0.038	-0.229	0.253	-0.082	-0.088	-0.240	-0.779***
	(0.86)	(-0.02)	(-1.48)	(0.30)	(-1.86)	(2.15)	(-0.81)	(-0.52)	(-1.35)	(-7.40)
Proportion of Households With Female Head	0.010	-0.001	0.002	0.003	0.010	-0.052	0.005	0.119	0.002	0.006
	(0.53)	(-0.21)	(1.39)	(0.67)	(0.34)	(-1.50)	(0.90)	(2.20)	(0.56)	(0.36)
Urban*Proportion of Households With Female Head	-0.012	-0.040	-0.009	-0.082	-0.137	-0.010	-0.022	-0.096	0.101	-0.135
	(-0.12)	(-1.32)	(-0.55)	(-0.94)	(-1.57)	(-0.20)	(-0.58)	(-1.16)	(1.43)	(-1.95)
Average Age of Household Heads	0.000	0.000	0.000	0.000	0.000	-0.002**	0.000	0.001	0.000	-0.001
	(-0.84)	(-0.44)	(1.19)	(-0.75)	(0.20)	(-3.60)	(-1.56)	(-0.42)	(-1.55)	(-1.58)
Urban*Average Age of Household Heads	0.000	0.001	0.003**	-0.002	-0.002	-0.004*	0.001	-0.002	0.001	0.015***
	(-0.21)	(0.68)	(4.64)	(-0.44)	(-0.73)	(-2.55)	(0.37)	(-0.68)	(0.83)	(7.18)
Average Size of Households	-0.002	-0.001	0.000	0.001	-0.002	-0.003	-0.001	-0.006	0.001	0.004
	(-1.48)	(-0.46)	(-0.80)	(1.54)	(-0.49)	(-0.87)	(-1.02)	(-0.88)	(0.66)	(1.22)
Urban*Average Size of Households	-0.016	-0.001	-0.014	-0.018	0.000	-0.021***	0.005	-0.005	-0.001	0.018
	(-2.15)	(-0.23)	(-1.46)	(-1.79)	(-0.05)	(-6.22)	(1.10)	(-0.33)	(-0.29)	(0.88)
Average Years of Schooling for Household Heads	0.019*	0.001	0.000	-0.001	-0.004	-0.003	0.002*	0.005	-0.001	-0.002
	(2.99)	(1.19)	(-0.26)	(-1.56)	(-1.42)	(-0.94)	(2.51)	(1.34)	(-1.20)	(-1.35)
Urban*Average Years of Schooling for Household Heads	0.008	0.013**	-0.003	0.013	0.027***	0.011	0.007	0.016**	0.012	0.047**
	(1.18)	(3.78)	(-1.91)	(1.81)	(4.78)	(1.73)	(2.14)	(4.62)	(1.50)	(4.10)
Proportion of Households Owning Agricultural Land	-0.158	-0.021	0.000	0.007	-0.055	0.079	0.000	-0.151	-0.011	0.002
	(-0.42)	(-1.12)	(-0.10)	(0.74)	(-0.62)	(0.54)	(0.03)	(-1.21)	(-1.75)	(0.08)
Urban*Proportion of Households Owning Agricultural Land	0.043	0.097	-0.002	0.306	-0.104	-0.224	0.025	0.266	-0.008	0.216
	(0.09)	(1.04)	(-0.11)	(1.29)	(-0.47)	(-0.97)	(0.43)	(1.41)	(-0.11)	(1.10)
Squared Proportion of Households Owning Agricultural Land	0.043	0.028	0.000	-0.005	0.053	-0.043	0.009	0.117	0.005	0.000
	(0.19)	(1.61)	(0.15)	(-0.59)	(0.77)	(-0.47)	(0.82)	(1.41)	(0.95)	(-0.02)
Urban*Squared Proportion of Households Owning Agricultural Land	0.120	0.007	-0.005	-0.199	0.394	0.215	0.012	-0.120	0.058	-0.306
	(0.37)	(0.10)	(-0.38)	(-1.24)	(1.90)	(1.19)	(0.18)	(-0.60)	(0.32)	(-1.09)
Proportion of Households Owning Livestock	0.225	0.004	0.001	-0.006	-0.077	-0.289*	-0.071	-0.171	0.013	0.212
	(1.80)	(0.32)	(0.29)	(-0.55)	(-0.65)	(-2.79)	(-1.46)	(-0.88)	(1.62)	(2.05)
Urban*Proportion of Households Owning Livestock	-0.320	-0.106	0.215*	-0.074	-0.098	0.041	0.061	0.113	0.054	-0.761*
	(-1.84)	(-2.19)	(3.38)	(-0.56)	(-0.42)	(0.22)	(0.59)	(0.36)	(0.66)	(-2.97)
Squared Proportion of Households Owning Livestock	-0.104	-0.010	0.001	0.002	0.106	0.246*	0.047	0.210	-0.010	-0.118
	(-1.47)	(-0.81)	(0.13)	(0.25)	(0.87)	(3.07)	(1.63)	(1.44)	(-1.48)	(-1.75)
Urban*Squared Proportion of Households Owning Livestock	0.254	0.158**	-0.250*	0.173	0.986	0.206	0.005	0.212	-0.006	0.688
	(2.04)	(3.28)	(-3.15)	(1.33)	(1.42)	(1.00)	(0.05)	(0.73)	(-0.05)	(2.09)
Proportion of Households With Electricity	0.150	0.003	0.005	0.014	0.037	-0.021	0.014	-0.092**	0.005	0.197**
	(1.50)	(0.57)	(1.67)	(0.71)	(0.67)	(-1.39)	(1.23)	(-3.99)	(1.55)	(4.07)
Urban*Proportion of Households With Electricity	-0.222	-0.170**	-0.044	-0.036	-0.286***	-0.142**	-0.093*	-0.121	-0.018	-0.263***
	(-1.80)	(-4.22)	(-1.82)	(-0.50)	(-4.56)	(-3.54)	(-2.64)	(-1.88)	(-0.64)	(-6.01)
R-Squared	0.80	0.74	0.27	0.54	0.87	0.92	0.48	0.87	0.38	0.87
Number of Enumeration Are	573	750	579	536	384	578	596	411	300	398

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. ** indicates significance at the 10 percent level.

Share of Households Reporting Modern Fuels as Primary Cooking Fuel											
	Lesotho	Madagascar	Mali	Malawi	Mozambique	Nigeria	Niger	Namibia	Sierra Leone	Uganda	Zimbabwe
Standardized Wealth Index	0.323***	0.000	0.002	0.020*	0.017	0.075***	0.011	0.313***	0.002	-0.459***	-0.263**
	(-8.80)	(-0.05)	(-1.64)	(-8.32)	(-0.53)	(-6.94)	(-0.99)	(-5.04)	(-1.31)	(-5.23)	(-3.74)
Urban*Standardized Wealth Index	0.351**	0.084	0.007*	0.348*	0.098	0.181	0.394**	0.323***	0.018	0.218	0.001
	(3.60)	(1.75)	(3.42)	(5.55)	(1.24)	(1.93)	(3.60)	(5.15)	(2.57)	(1.79)	(0.01)
Urban	0.570**	-0.176***	-0.030	0.046	-0.508*	-0.169*	0.006	0.500*	-0.008	0.537	-0.357*
	(3.44)	(-4.81)	(-1.54)	(0.54)	(-3.09)	(-2.70)	(0.05)	(2.79)	(-1.38)	(2.19)	(-2.47)
Proportion of Households With Female Head	-0.009	0.018	-0.006	-0.001	0.014	-0.013	0.003	-0.080	0.000	-0.035	-0.027
	(-0.23)	(1.02)	(-1.49)	(-1.45)	(1.43)	(-0.53)	(0.39)	(-1.45)	(-0.41)	(-0.67)	(-0.95)
Urban*Proportion of Households With Female Head	-0.011	-0.003	0.038	-0.124	-0.058	0.112*	0.058	0.059	0.005	-0.082	0.144*
	(-0.08)	(-0.11)	(2.26)	(-2.65)	(-0.81)	(2.74)	(1.45)	(1.08)	(1.94)	(-0.72)	(2.73)
Average Age of Household Heads	-0.004	0.000	0.000	0.000	-0.001	0.001	-0.001	-0.003*	0.000	0.006**	0.000
	(-1.83)	(1.08)	(-0.58)	(-1.47)	(-1.70)	(2.13)	(-1.93)	(-2.21)	(-0.61)	(4.45)	(0.00)
Urban*Average Age of Household Heads	-0.009*	0.004***	0.000	0.000	0.007**	0.001	-0.001	-0.005*	0.000	-0.004	0.005*
	(-2.80)	(4.98)	(0.91)	(0.13)	(4.22)	(1.26)	(-0.47)	(-2.33)	(0.56)	(-0.62)	(2.31)
Average Size of Households	0.004	0.000	-0.002*	0.000	-0.003	-0.006	0.002	0.010	0.000	0.020	-0.016*
	(0.71)	(0.12)	(-2.77)	(0.50)	(-0.87)	(-2.50)	(1.16)	(1.78)	(-0.22)	(2.26)	(-2.32)
Urban*Average Size of Households	-0.013	-0.008	-0.005	-0.026	-0.055**	-0.005	-0.005	-0.046**	0.000	0.034*	0.040**
	(-1.11)	(-1.56)	(-1.03)	(-2.76)	(-4.18)	(-1.39)	(-0.86)	(-4.23)	(-0.26)	(2.44)	(3.36)
Average Years of Schooling for Household Heads	0.004	0.001	0.001	-0.001	0.001	-0.002**	-0.001	0.010	0.000	0.007	-0.004
	(0.63)	(1.11)	(1.48)	(-0.97)	(0.50)	(-5.13)	(-1.55)	(1.75)	(-1.74)	(1.13)	(-1.01)
Urban*Average Years of Schooling for Household Heads	-0.028*	0.014***	-0.002*	0.006*	0.056**	0.006	-0.004	-0.022*	0.000	-0.008	0.013
	(-3.23)	(5.04)	(-2.90)	(8.67)	(3.60)	(1.24)	(-0.66)	(-2.54)	(-0.37)	(-0.43)	(2.20)
Proportion of Households Owning Agricultural Land	-0.295*	-0.019	0.010	0.025	-0.441	-0.086	0.052***	0.131	-0.003	1.645**	-0.057
	(-2.40)	(-0.39)	(0.59)	(3.63)	(-1.45)	(-1.91)	(5.47)	(1.42)	(-1.55)	(4.54)	(-0.37)
Urban*Proportion of Households Owning Agricultural Land	0.104	0.050	0.064*	-0.158	0.463	0.209	-0.148	0.157	0.004	-1.773**	0.175
	(0.48)	(1.01)	(3.49)	(-1.29)	(1.65)	(2.08)	(-1.21)	(1.66)	(0.30)	(-3.48)	(0.69)
Squared Proportion of Households Owning Agricultural Land	0.163	0.018	0.000	-0.015	0.292	0.073	-0.019	-0.138	0.002	-0.944**	-0.049
	(2.11)	(0.64)	(-0.02)	(-2.73)	(1.52)	(2.18)	(-1.51)	(-1.50)	(1.46)	(-4.02)	(-0.47)
Urban*Squared Proportion of Households Owning Agricultural Land	0.195	-0.037	-0.086*	0.321	-0.140	-0.107	0.209	-0.286	0.006	1.383*	-0.068
	(0.80)	(-0.99)	(-2.90)	(2.82)	(-0.86)	(-1.29)	(1.30)	(-1.96)	(0.82)	(3.23)	(-0.25)
Proportion of Households Owning Livestock	-0.142	-0.091	-0.038*	0.028*	-0.027	-0.053	0.015	-0.529**	-0.003	0.227	0.285
	(-0.40)	(-0.99)	(-2.67)	(5.02)	(-0.43)	(-1.42)	(0.71)	(-3.32)	(-1.19)	(0.99)	(1.02)
Urban*Proportion of Households Owning Livestock	0.096	-0.112*	-0.039	-0.077	-0.074	-0.220*	0.046	0.491**	-0.018*	-0.915*	-0.547
	(0.20)	(-2.09)	(-2.49)	(-1.74)	(-0.41)	(-3.49)	(0.27)	(3.54)	(-3.30)	(-2.44)	(-1.78)
Squared Proportion of Households Owning Livestock	0.110	0.057	0.025*	-0.016	0.010	0.047	-0.017	0.332*	0.002	-0.044	-0.103
	(0.41)	(0.93)	(2.85)	(-3.19)	(0.18)	(1.83)	(-0.88)	(2.75)	(1.30)	(-0.27)	(-0.56)
Urban*Squared Proportion of Households Owning Livestock	-0.143	0.141*	0.077	0.148	0.129	0.322*	0.019	-0.412**	0.018	1.209*	0.506
	(-0.23)	(2.66)	(2.45)	(1.82)	(0.66)	(2.94)	(0.09)	(-3.50)	(2.72)	(2.98)	(1.68)
Proportion of Households With Electricity	0.132	0.028	-0.007	0.095**	-0.003	-0.013	0.007	0.131**	0.002	0.128	-0.294**
	(1.69)	(1.97)	(-0.87)	(19.06)	(-0.16)	(-2.42)	(1.66)	(3.24)	(1.49)	(0.76)	(-3.58)
Urban*Proportion of Households With Electricity	-0.073	-0.161*	-0.049*	-0.342	-0.060	-0.106**	-0.191*	-0.015	-0.013	-0.165	-0.449***
	(-0.49)	(-2.35)	(-3.73)	(-3.31)	(-0.65)	(-4.58)	(-2.94)	(-0.26)	(-0.93)	(-0.73)	(-4.88)
R-Squared	0.94	0.62	0.48	0.81	0.78	0.45	0.82	0.92	0.12	0.94	0.97
Number of Enumeration Are	400	594	413	849	610	1782	476	1050	788	404	804

Note: All regressions ran at the level of the enumeration area. Includes country, region and phase fixed effects. All standard errors are clustered at the regional level and are robust to heteroskedasticity. T-statistics reported in parentheses. Asterisks indicate significance levels. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. ** indicates significance at the 10 percent level.

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