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ALTERNATIVE COOKING FUELS IN KENYA: HOW CAN HOUSEHOLD DECISION MAKING BE INFLUENCED?

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Abstract

The economic theory states that as income rises, households tend to substitute traditional solid biomass cooking fuels with transitional and modern clean cooking fuels.

However, in the case of Kenya, one of the few lucky African countries enjoying high growth rates whit a positive impact on the income level of its citizens, the switch to modern fuels is not always observed. In facts, Kenyan cooking practices are characterized by a strong dependence on solid biomass, with 82% of the households still using firewood or charcoal every day, and with a negative impact on the environment and severe health issues that need to be addressed.

This paper informs on the current situation of households cooking fuels consumption and maps out the country's cooking fuels market. By focusing on the analysis of the data collected through two independent field surveys, it then identifies the key factors affecting the fuel choices. In particular, the paper finds that affordability and access to credit are the variables with most explanatory power in predicting consumers¿ choices. The paper finally suggests specific actions to undertake in order to impact the households decisions.

Keywords: Cooking; Fuels; Energy; Renewables; Africa; Biofuels; Ethanol.

Classification JEL: Q420

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ALTERNATIVE COOKING FUELS IN KENYA: HOW CAN HOUSEHOLD DECISION MAKING BE INFLUENCED?

Executive Summary

This paper reports on the current consumption of household cooking fuel in Kenya. It contributes to the existing literature by mapping out the cooking fuel market in the country as well as by determining the key factors affecting households' choice of fuel for cooking.

Kenyan cooking practices are characterized by a strong dependence on solid biomass: 82% of households use firewood or charcoal. Poor infrastructure and an inefficient transport system pose distribution challenges that negatively affect the availability of clean alternative cooking fuels. A lack of public awareness at the local and national levels about the health and environmental consequences associated with certain cooking fuels reinforces damaging traditional cooking practices.

Cooking patterns in Kenya result in negative externalities for people's health and the environment that need to be addressed. The World Health Organization estimates that 1.5 million premature deaths per year are attributable to indoor air pollution stemming from traditional cooking fuel practices. Furthermore, the excessive use of solid biomass pollutes the air, releases carbon dioxide (CO_2) and particulate matter, depletes forests and degrades the land.

Based on data gathered from two independent surveys, this research uses a model that forecasts household fuel consumption decisions based on a combination of explanatory variables. The model finds that the variables "daily income," "convenience" and "affordability" can provide strong explanations when it comes to predicting consumers' behavior.

Finally, by recognizing the important role of government and policy-makers in overcoming barriers to modern cooking fuels, correcting market failures, and changing household behavior patterns in cooking fuel consumption, this paper provides policy recommendations in the following areas: clean cooking initiatives, financial instruments, public outreach, and education.

1. Introduction

In Kenya, 82% of households use traditional cooking fuels such as firewood or charcoal every day. In addition to the negative environmental impact, such as the creation of greenhouse gases, particulates, deforestation and land degradation, these cooking practices lead to numerous public health-related issues, mostly of a respiratory nature. The fact that firewood is exempt from the 16% VAT charge imposed on other fuels, such as ethanol, provides a strong incentive to use firewood.

On the one hand, "some sources estimate that cooking with traditional biomass fuels contributes about 18% of current global GHG [greenhouse gas] emissions when forest degradation and deforestation is included in the equation (SEI, 2008)."[1] On the other hand, according to the World Health Organization:

- "Around 3 billion people cook and heat their homes using open fires and simple stoves burning biomass (wood, animal dung and crop waste) and coal.
- Over 4 million people die prematurely from illness attributable to the household air pollution from cooking with solid fuels.
- More than 50% of premature deaths due to pneumonia among children under 5 are caused by the particulate matter (soot) inhaled from household air pollution.
- 3.8 million premature deaths annually from non-communicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer are attributed to exposure to household air pollution."[2]

Since sub-Saharan African countries such as Kenya consume high levels of solid biomass for cooking purposes, substituting cleaner cooking fuels for even a small proportion of the firewood or other solid biomass that would be consumed results in significant improvements in the Human Development Index. Indeed, there is a dimension related to cooking fuel ("household uses 'dirty' cooking fuel") in the Multidimensional Poverty Index (MPI), which in turn has a significant impact on the Human Development Index. Moreover, child mortality is another dimension of the health indicator that is factored into the MPI.[3] Consequently, modern energy services significantly increase people's quality of life. However, efforts to encourage households to invest in cleaner, more efficient energy have had little effect.

Kenya is one of the few African countries lucky enough to enjoy high growth rates, which has a positive impact on the income level of its people. According to empirical research[4] on cooking fuels, a rise in household income correlates with households switching to better sources of cooking fuels. Indeed, the energy ladder theory claims that households substitute an inferior cooking fuel by a superior cooking fuel when the household income increases. However, in Kenya,

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[1] AFREA, *Wood-Based Biomass Energy Development for Sub-Saharan Africa* (Washington, D.C.: International Bank for Reconstruction and Development and World Bank Group, September 2011), Executive Summary, p. ix.

[2] World Health Organization, "Household Air Pollution and Health," Fact Sheet No. 292, February 2016, http://www.who.int/mediacentre/factsheets/fs292/en/, accessed November 17, 2016.

[3] United Nations Development Programme, Technical Notes – Human Development Report 2015: Work for Human Development (New York: 2015), http://hdr.undp.org/sites/default/files/hdr2015_technical_notes.pdf, p. 9, accessed November 17, 2016.

[4] Smith, KR. 1987. The biofuel transition. Pacific and Asian Journal of Energy, pp. 13-32; Barnes, D. and W. M. Floor. 1996. "Rural Energy in Developing Countries: A Challenge for Economic Development, Annual Review of Energy and Environment vol. 21, pp. 497-530.

data show that, whereas the first extreme of the argument (income rises) happens, the second term (fuel substitution) does not hold[5].

Alongside the increases in income, the country undergoes general development through investment in various infrastructure projects. This, in turn, allows for more efficient transportation of commodities and improves access to alternative cooking fuels for Kenyan people. Sadly, practitioners have realized that improving connectivity is a necessary but insufficient condition to make an impact on households' cooking fuel purchasing habits.

Given the health and environmental benefits of using clean cooking fuels, the increase in household incomes, and the country's improved interconnectivity, we would expect modern cooking fuels to represent most of the fuel consumed in Kenya. Why then does solid biomass still represent 82% of total cooking fuel consumption in the country? The underlying question that this research asks is: What must occur for households to switch from traditional cooking fuels to alternative clean cooking fuels? In other words, what are the main variables that explain fuel switching from the low to the higher stages of the fuel ladder? By answering these questions, we will ultimately be in a better position to determine how household decision making can be influenced.

To come up with answers, we need to analyze in detail the cooking fuel market in Kenya, as well as household decision making and Kenya's cooking culture. We will go from analyzing the barriers to fuel switching to proposing specific actions to be taken to remove those barriers and let the desired fuel switching take place, which in turn will reduce the number of people (especially children) suffering from respiratory diseases and the number of fatalities. This switching will also reduce the current burden of land degradation, deforestation, CO2 emissions and particulate matter.

This paper is structured as follows. Following the broad introduction to the topic in section 1 (this section), section 2 provides the context and describes the types of cooking fuel used in Kenyan households. Section 3 shows household profiles produced from two independent field surveys we have conducted in Kenya. Section 4 sets out the research question, the working hypothesis, and the methodology for testing our model against the data we have collected from the field surveys. Section 5 summarizes the findings and section 6 concludes the paper and gives policy recommendations.

2. The Kenyan Fuel Market's Current Alternatives

Using a particular type of cooking fuel has usually been seen as a proxy for socioeconomic status, according to the energy ladder theory. This model assumes that households mimic the behavior of a utility-maximizing consumer. As their income increases, they move up the energy ladder to cleaner, more efficient, and more expensive fuels, switching gradually from traditional biomass to electricity. However, the empirical data show that, as income increases, households do not simply substitute one fuel for another but instead start to diversify, adding more types of fuels in a process of fuel stacking. More specifically, the research thus far has shown that modern fuel technology is used most commonly for services such as radio and television (electricity) or to heat small amounts of beverages such as tea and coffee (liquefied petroleum gas – LPG), while

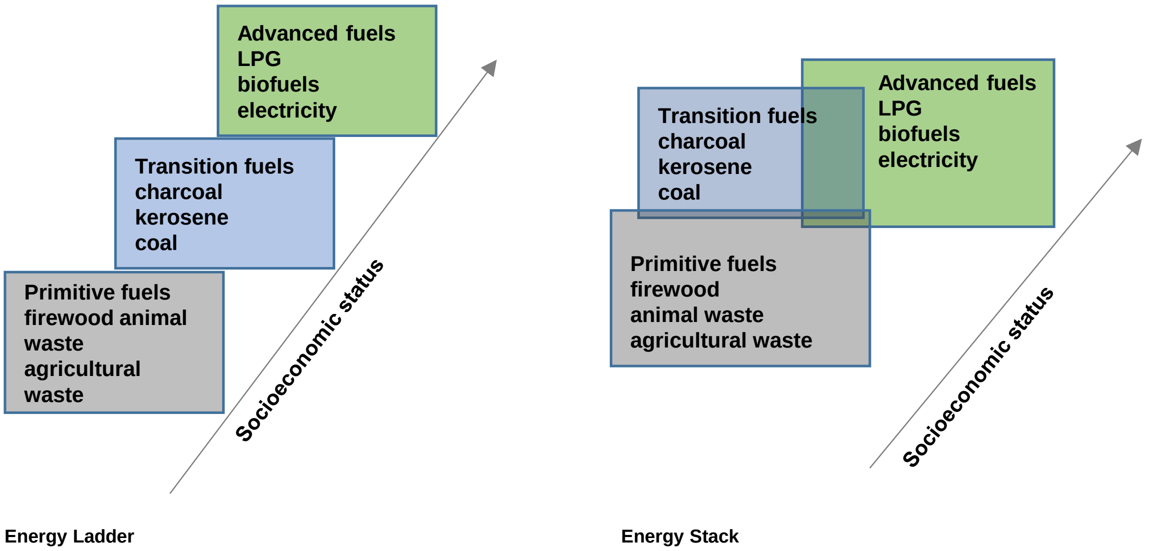
[5] AFREA, Wood-Based Biomass Energy Development for Sub-Saharan Africa (Washington, D.C.: International Bank for Reconstruction and Development and World Bank Group, September 2011), Executive Summary, p. ix.

traditional fuels are still used for the main and most energy-consuming activities, such as cooking and heating the house[6].

Scholars and practitioners[7] have hypothesized that switching to one single energy source would undermine the security provided by multiple energy sources, exposing the consumer to the risk of delays in fuel delivery, unreliable service, and the volatility of fuel prices. At the same time, they suggest that the slow transition to alternative cooking fuels might have some correlation with the unwillingness to abandon the already familiar and traditional ways of cooking and with the common idea that innovation is an unnecessary and costly expense. Consequently, even the wealthiest households continue to use firewood or charcoal to prepare traditional meals.

Figure 1

The energy ladder and energy stack models[8]



Source: Prepared by the authors based on the energy ladder and energy stack theories.

Fuels are usually classified into three main categories: traditional, transitional and advanced. (See Figure 2.) For the purposes of our research, we will divide them between the categories of dirty cooking fuels – such as firewood, coal and charcoal – and cleaner alternatives, such as kerosene, LPG, electricity and biofuels. However, "progression up the fuel 'ladder' does not necessarily result in across the board reduction in emissions depending upon combustion device used. For example, certain wick type kerosene stoves have been shown to emit more hydrocarbons than wood or charcoal stoves. Nor does progression up the energy ladder have consistent environmental

[6] Nicolai Schlag and Fiona Zuzarte, *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature* (Stockholm: Stockholm Environment Institute), 2008.

[7] Davis, 1998; Soussan et al., 1990; Hosier and Kipyonda, 1993; Masera et al., 2000; Murphy, 2001.

[8] Nicolai Schlag and Fiona Zuzarte, *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature* (Stockholm: Stockholm Environment Institute), 2008.

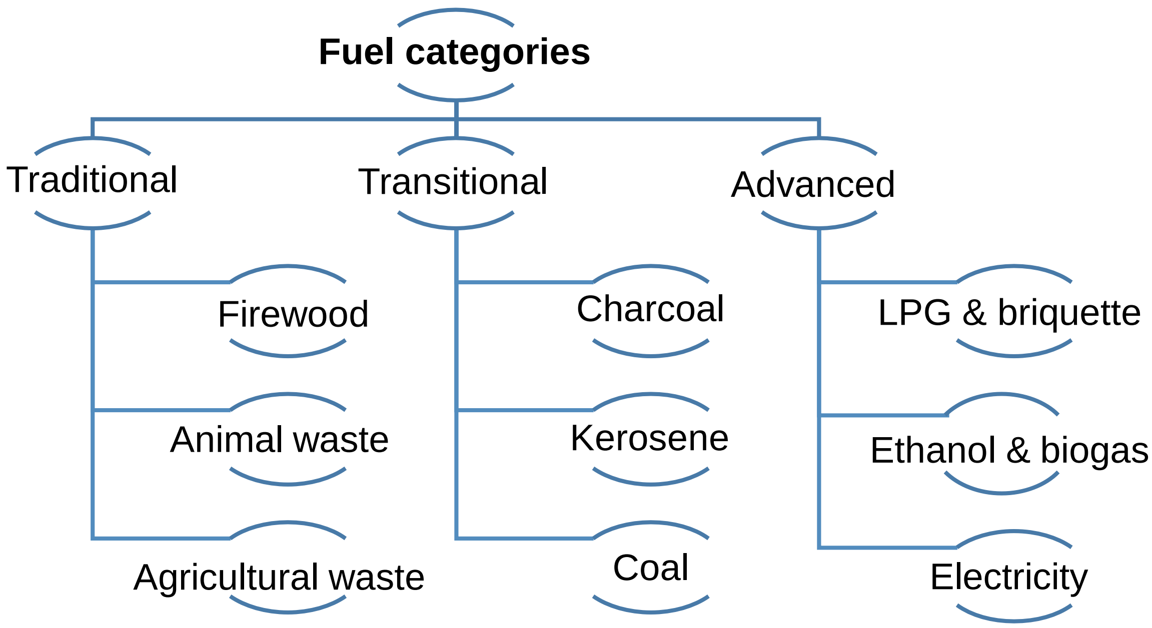
impacts. As mentioned previously, charcoal, a step above wood on the energy ladder, requires a great deal of wood in its production. It is thus overall less energy efficient than wood."[9]

Traditional fuels have many different harmful effects. Firewood, animal dung, coal, charcoal and other agricultural residues are known to produce high emissions of carbon monoxide and particulate matter: "that fraction of aerosol particles that is smaller than 2.5 μm and poses special risks to human subjects due to its access to the lower respiratory tract and alveolar structures of the lung, where gas exchange occurs."[10]

Women and children are traditionally the ones responsible for the preparation of meals, and therefore they are the ones who suffer the most from indoor air pollution and burns. Additionally, young children are particularly susceptible to diseases that result in premature deaths and lung problems. The severity of the illnesses depends on the source of pollution (types of fuel and stove), as well as on how the pollution is dispersed (housing and ventilation). The most severe effects occur when the heat from cooking using firewood or charcoal is also used to warm the house, resulting in the family sleeping and living in unventilated, smoky rooms.

Figure 2

Fuel categories



Source: Prepared by the authors based on the energy ladder theory.

Inefficient and unsustainable cooking practices also have serious implications from an environmental perspective, particularly in terms of land degradation and regional air pollution. Unsustainable wood harvesting contributes to deforestation, which in Kenya is a very serious threat, considering that the forest area represents only 7.8% of the total land, according to the

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[9] Donna M. Staton and Marcus H. Harding, "Health and Environmental Effects of Cooking Stove Use in Developing Countries," p. 30, http://lists.bioenergylists.org/stovesdoc/Environment/staton.pdf.

[10] William J. Martin II, John W. Hollingsworth, and Veerabhadran Ramanathan, "Household Air Pollution from Cookstoves: Impacts on Health and Climate," in *Global Climate Change and Public Health*, edited by Kent E. Pinkerton and William N. Rom (New York: Humana Press, 2014), p. 240.

data collected by the United Nations Development Program (UNDP) for the year 2015.[11] Furthermore, in areas where wood is scarce, agricultural residues and animal dung are used for cooking purposes, which limits their use as fertilizer, so leading to soil erosion.

In terms of air pollution, according to the Global Alliance for Clean Cookstoves, residential solid fuel burning accounts for 25% of global black carbon emissions, about 84% of which derives from households in developing countries. A 2013 report from the Stockholm Environment Institute[12] suggested that improving cookstoves could reduce global greenhouse gas emissions by 1 gigaton of carbon dioxide per year.

Sadly, for the majority of Kenyan households, this is not a feasible solution in the short term due to the income constraints implied in switching to alternative cooking fuels and in particular to the very expensive cooking stoves required by modern fuels (as shown in Table 1). A typical charcoal cookstove costs KSh500 to KSh1,000 (Kenyan shillings), while an LPG cookstove costs KSh3,500 to KSh7,000.[13]

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[11] United Nations Development Programme, Kenya, Human Development Indicators, Environmental Sustainability, "Forest Area (% of Total Land Area)," http://hdr.undp.org/en/countries/profiles/KEN, accessed November 18, 2016.

[12] Stockholm Environment Institute, Assessing the Climate Impacts of Cookstove Projects: Issues in Emissions Accounting (Stockholm, 2013).

[13] As of March 5, 2017, 100 Kenyan shillings (KSh100) were equivalent to $0.96, https://www.oanda.com/lang/es/currency/converter/, accessed March 5, 2017.

Table 1

Costs and characteristics of selected fuels in Kenya

	Fuel Type	Cook Stove Cost (Kshs)	Fuel Cost (Kshs)	Fuel Heat Value (MJ/unit)	Cook Stove Efficiency	POLLUTION	EXTERNALITIES
Traditional	**Wood fuel**	Three Stone fire: 0 Ksh	70 Ksh/ bundle	16 MJ/ kg	20%	HIGH	**IMPACT ON HEALTH:** Particulate Matter (cause lung & heart problems), Carbon Monoxide (inhibits the blood's ability to carry oxygen), Irritant compounds (cause inflammation & allergic reactions), Polycyclic Aromatic Hydrocarbons (cause cancer), Volatile Organic Compounds (cause cancer), Dioxins (highly carcinogenic). **IMPACT ON THE ENVIRONMENT:** Contributes about 18% of current global GHG emissions when forest degradation and deforestation is included in the equation (SEI, 2008). The average annual per capita consumption is approximately 741 kg and 691 kg for rural and urban households, respectively. ***NOTE:*** The type of cook stove and cook stove efficiency accounts for the difference in pollution/ Collection is time consuming. Firewood is exempted from 16% VAT tax.
		Firewood Jiko Kisasa: 250-500 Ksh			28%	HIGH-MODERATE	
		Rocket mud stove: 250-500 Ksh			20%-28%	HIGH-MODERATE	
Transitional	**Charcoal**	Three stone fire: 0 Ksh	40 Ksh/ Kg	29 MJ/ Kg	12%	HIGH	**IMPACT ON HEALTH:** Charcoal produces less smoke than firewood, thus causing fewer deaths from respiratory diseases. It is cleaner than firewood, still dirtier than transitional fuels.
		Kenya ceramic Jiko: 500-1,000 Ksh			20%-50%	HIGH-MODERATE	**IMPACT ON THE ENVIRONMENT:** The conversion of 1 kg of wood yields only 0.1 – 0.3 kg of charcoal (at 10 %-30 % kiln efficiency). In order to produce 1 kg of charcoal with a specific energy content of 30 MJ/kg, 3.3 to 10 kg of firewood are required. Usually the process of converting wood into charcoal is very inefficient and polluting: it releases 450-500g of CO_2 per kg of charcoal produced. Per capita consumption is 156 kg in urban areas and 152 kg in rural areas. ***NOTE:*** Consumption is higher in urban areas compared to rural areas.
	Kerosene	Kerosene wick: 350-1,000 Ksh	63-65 Ksh/ litre (1l=1kg)	46 MJ/ kg	35%	MODERATE	**IMPACT ON HEALTH:** Kerosene stoves can emit substantial quantities of fine particulate matters even during normal operation(...) Women and their children may spend longer in the kitchen when cooking with kerosene, possibly because kerosene emissions are less visibly smoky than biomass emissions (...) Kerosene cooking was a stronger risk factor for tuberculosis than biomass cooking. Well-documented kerosene hazards are poisonings, fires, and explosions. **IMPACT ON THE ENVIRONMENT:** Kerosene appliances as wick cook stoves emit substantial amounts of fine PM, as well as CO, NOx, and SO_2. Urban households use around 90 litres of kerosene per year, rural households use about 41 litres per year. ***NOTE:*** Commercially available/ use significantly higher in rural areas also used for lighting purposes. Kerosene is exempted from some taxes in comparison with other fuel products.

Advanced	**Briquettes**	Kenya Ceramic Jiko: 720Ksh-	900 Ksh per bag (standard vendor briquettes)	20-23 MJ/ kg	20%-50%	LOW	**IMPACT ON HEALTH:** Need to bear in mind when switching from charcoal dust made briquettes towards the use of feedstocks (agricultural waste, organic waste) that requires carbonisation, the impact on air pollution (e.g. smoke) which arises during the carbonisation process, which poses a danger to health. **IMPACT ON THE ENVIRONMENT:** Briquettes produced from alternative raw materials which would otherwise have no other use, such as bagasse, coffee and maize residues or saw dust provide a more sustainable alternative to firewood and charcoal. It reduces some pressure on forestry resources. ***NOTE:*** Commercially available.
	Ethanol	Ethanol stove: 2,000Ksh-	200 Ksh/litre (1l=1kg)	30 MJ/ kg	N/A	LOW	**IMPACT ON HEALTH:** None. **IMPACT ON THE ENVIRONMENT:** It contributes to the use of sugarcane waste disposal otherwise dumped in rivers. ***NOTE:*** Problematic availability due to lack of local ethanol plants Clean
	LPG	LPG stove: 3,500-7,000 Ksh	133-200 Ksh/kg	46 MJ/ kg	55%	LOW	**IMPACT ON HEALTH:** None. **IMPACT ON THE ENVIRONMENT:** LPG stoves emit 50 times less pollutants than biomass burning stoves. ***NOTE:*** Only 7.8% of the population (23% urban and 1.8% rural) use LPG. Average per capita consumption is only 3.6 kg and 9.7 kg for rural and urban areas respectively.
	Biogas	Basic biogas unit: 50,000-80,000 Ksh	0 Ksh	50 MJ/ kg	N/A	LOW	**IMPACT ON HEALTH:** None. **IMPACT ON THE ENVIRONMENT:** Farmers are encouraged to have: 2-4 cows in order to use the animal dung as biogas and sell the milk to repay the loan, and access to water on their property. ***NOTE:*** High upfront costs prohibitive for many/ Development agencies and banks offer loans to farmers to be able to afford biogas systems.
	Electricity	Electric stove: 3,500Ksh-	19.69 Ksh/ kWh	3.6 MJ/ kWh	80%	LOW	**IMPACT ON HEALTH:** None. **IMPACT ON THE ENVIRONMENT:** It depends on the electricity sources. ***NOTE:*** Electricity in Kenya is expensive for the majority of the households, and only 46% of urban and 3.8% of rural households have access to electricity. Nationally, this translates to only 15% households with access to electricity.

Source: Prepared by the authors based on information from GIZ, Multiple-Household Fuel Use – A Balanced Choice Between Firewood, Charcoal and LPG (Eschborn, Germany: GIZ, February 2014), p. 4.

Key concepts

Heat value = the amount of heat produced by the combustion of a unit quantity of fuel.

Efficiency = the heat absorbed by the food as a percentage of the heat supplied by the fire.

GDP per capita in Kenya is about $1,377 (about KSh140,300).[14] The price of advanced types of cookstoves can therefore represent a significant portion of a household's income. (For example, an LPG stove priced at KSh5,000 represents 42% of an average monthly income.). With no external financing opportunities and no credit access, the income constraint remains the most serious impediment to switching. The only alternatives would be the transformation of biomass into a less polluting form of fuel or the improvement of stoves and ventilation.

How can people be encouraged to invest in more efficient cook stoves and clean cooking fuels? In different countries and in different areas within a given country, the sources of cooking fuel vary. Ethanol has been gaining in popularity in sugar-producing countries due to its cleanliness and safety, while biogas has gained considerable approval in many rural communities. In Kenya, ethanol has not yet gained particular popularity, due to past high levels of taxation on alcohol. However, biogas is already commercially available in many rural and urban communities. The monetary cost of biogas fuel is zero, considerably lowering households' monthly expenses. LPG is already quite established in urban areas and it is significantly cleaner and safer than biogas and briquette cookstoves. The main barrier remains the prohibitively high cost of LPG cookstoves.

Given the impact that cooking fuels have on health and the environment, the U.N. Millennium Project – an advisory body proposing strategies to meet the United Nations' Millennium Development Goals – recommended a target of enabling the use of modern fuels for 50% of those who were still using traditional biomass for cooking by 2015.[15] Sadly, the goal still has not been reached. As of 2017, firewood still represents 65% of the total fuels used for cooking, charcoal represents 17%, and kerosene represents 11%. LPG represents only 5% and biogas less than 1%. (See Figure 3.) At the same time, the Ministry of Energy in Kenya is expected to play a facilitative role in energy supply by creating and enabling an environment for private sector-led growth through policy formulation, the development of an appropriate legal and regulatory framework, and oversight responsibility. However, the energy sector's inability to control market prices still pushes many consumers to use inefficient energy resources, whose continued use is expected to deplete forests, increase global warming and take the lives of many women and children.

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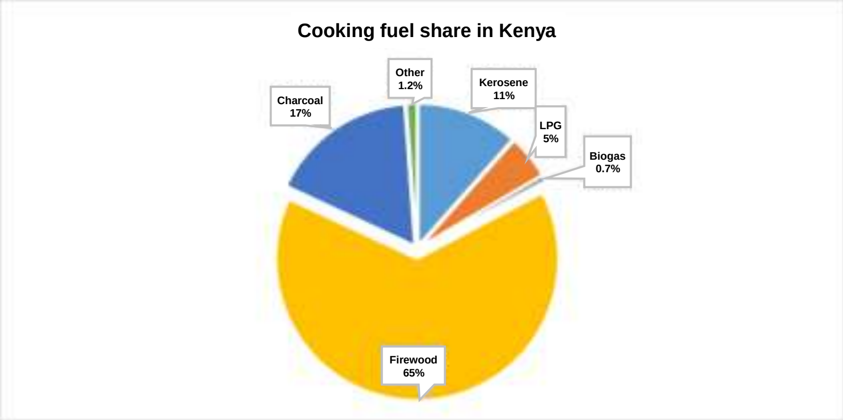
[14] "GDP Per Capita (Current US$)" in 2015, World Bank, http://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=KE, accessed November 28, 2016.

[15] Vijay Modi, Susan McDade, Dominique Lallement, and Jamal Saghir, *Energy Services for the Millennium Development Goals* (New York: Energy Sector Management Assistance Programme, United Nations Development Program, U.N. Millennium Project, and World Bank, 2005), p. 44.

Figure 3

Use of cooking fuels by fuel type in Kenya

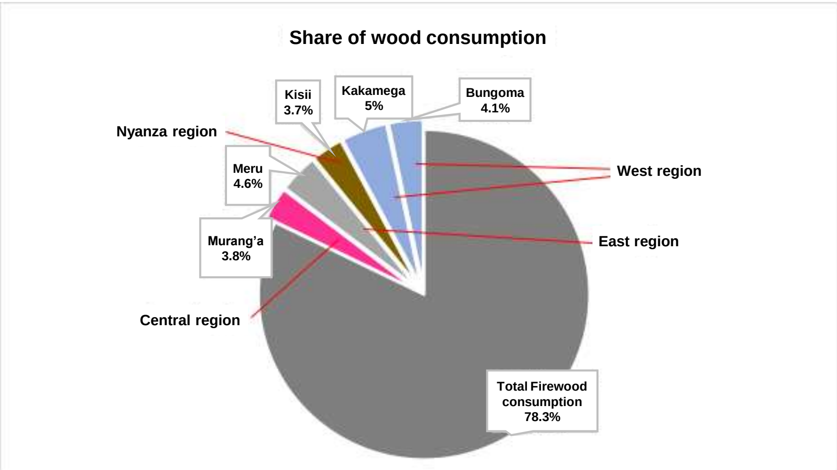


Source: Kenya National Bureau of Statistics, 2017.

The mix of cooking fuels that households use is very much affected by geography: there is a regional impact, as we can observe in Table 2. Advanced fuel use as a proportion of the total in Nairobi County is 56 times greater than in Mandera County. Transitional fuel use in Mombasa County is 40 times greater than in Wajir County while the use of primitive fuels in Wajir County is 47.5 times greater than in Nairobi County.[16]

Figure 4

Counties with the highest consumption of firewood in Kenya



Source: Kenya National Bureau of Statistics, 2017.

The counties of Bungoma and Kakamega together make up more than 9% of total firewood consumption in Kenya. Figure 4 shows the five counties with the largest share of firewood consumption. A switch to modern cooking fuels in those five counties alone would mean a reduction in firewood consumption of more than 20%

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[16] Society for International Development, "Cooking Fuel," http://inequalities.sidint.net/kenya/abridged/cooking-fuel/.

Table 2

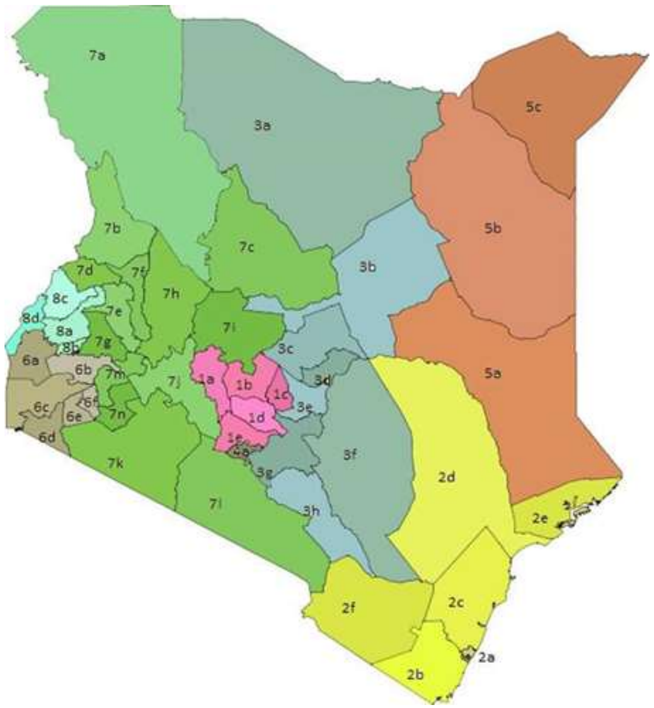
Regional distribution of cooking fuel consumption by fuel type

Map color	Kenyan Region	Main Fuels used	Counties
	Region 1 Central		
	This region is characterized by fertile terrain with coffee cultivation, and by mountains and forested highlands. Space heating is required only during the winter in the highlands.	Wood/ Agriresidues, Charcoal	1a-Nyandarua, 1b-Nyeri, 1c-Kirinyaga, 1d-Murang'a, 1e-Kiambu
	Region 2 Coast		
	This region lies on the Indian Ocean. The main urban centre is Mombasa, the second Kenyan city. While firewood and charcoal are prevalent in rural areas, kerosene is widely used in the cities.	Wood/ Agriresidues, Charcoal	2a-Mombasa (city), 2b-Kwale, 2c-Kilifi, 2d-Tana River, 2e-Lamu, 2f-Taita-Taveta
	Region 3 & 5 East/North Eastern		
	These regions are arid, hot lands populated mainly by Somali peoples.	Wood/ Agriresidues, Charcoal	3a-Marsabit, 3b-Isiolo, 3c-Meru, 3d-Tharaka-Nithi, 3e-Embu, 3f-Kitui, 3g-Machakos, 3h-Makueni
	Wood is the cooking fuel for almost 90% of people.		5a-Garissa, 5b-Wajir, 5c-Mandera
	Region 4 Nairobi		
	In Nairobi firewood is used only by 1.8% of population and charcoal by 10.5%, while kerosene (63%) and (LPG 20%) are the main fuels. There are wide differences between moderately-poor people and extremely poor people in terms of fuel use.	Wood/ Agriresidues, Charcoal	4a-Nairobi City
	Region 6 & 8 Nyanza and West		
	This area is centered around Lake Victoria. Malaria is a big issue and smoke is used to keep mosquitoes away.	Wood/ Agriresidues, Charcoal, LPG	6a-Siaya, 6b-Kisumu, 6c-Homa Bay, 6d-Migori, 6e-Kisii, 6f-Nyamira
	Clean fuels, especially LPG, are subsidised in Kisumu, the third city of Kenya, kerosene is used by less than 3% of households.		8a-Kakamega, 8b-Vihiga, 8c-Bungoma, 8d-Busia
	Region 7 Rift Valley		
	This region is characterized by the volcanoes and lakes of the Great Rift Valley. It is an important economical region of Kenya, with almost 7milion people. In the highlands, land is very fertile and tea is the main cultivated crop. Wood (70%) and charcoal (20%) are the main cooking fuels, while kerosene is used only by 7% of households, mostly in the urban areas.	Wood/ Agriresidues, Charcoal, LPG	7a-Turkana, 7b-West Pokot, 7c-Samburu, 7d-Trans Nzoia, 7e-Uasin Gishu, 7f-Elgeyo-Marakwet, 7g-Nandi, 7h-Baringo, 7i-Laikipia, 7j-Nakuru, 7k-Narok, 7l-Kajiado, 7m-Kericho, 7n-Bomet

Source: Prepared by the authors.

Figure 5

County map of Kenya



Source: Prepared by the authors.

To conclude, despite the numerous benefits of switching from traditional solid biomass fuels to modern energy-efficient and clean alternatives, there is still much resistance and demand remains low. More specifically, the literature[17] so far has identified a number of market barriers to fuel switching:

1. One of the major issues is cost: clean cooking fuels are prohibitively expensive for many households, and the high price of stoves further discourages their use.
2. Many consumers are hesitant to adopt the new technology, which reflects a lack of public awareness.
3. Due to underdeveloped infrastructure and an inefficient transportation system, availability is a third constraint.

The combination of these factors has largely stifled the transition to clean cooking fuels.

3. Field Research

The economic theory states that, as incomes rise, households tend to substitute traditional solid biomass cooking fuels with transitional and modern clean cooking fuels. However, in the case of Kenya, we do not always observe a correlation between income and fuel switching. According to the existing literature, to date, the combination of a few factors – namely, affordability, availability and awareness – has largely stifled the transition to clean cooking fuels. To gain a better understanding of the key drivers that encourage farmers to adopt modern cooking fuels, we conducted research through our field research team at Strathmore University.

3.1 Data Collection

We prepared a questionnaire and interviewed 204 Kenyan households, divided into two independent field survey samples:

- Sample 1 involved 106 field interviews in Nakuru County villages, in four specific locations: Hell's Gate, Lakeview, Viwandani and Olkaria.
- Sample 2 involved 98 interviews, carried out at five Kenyan universities and technical institutes.

The first field survey gives us an idea of what a typical resident of a rural area close to Naivasha takes into account when making purchasing decisions. The second survey uses a more general approach and has a more diverse selection of respondents, from different social classes and regions of the country. It is important to clarify that respondents in the second survey were students who, when reporting, were representing the head of their household.

3.2 Household Profile: Socioeconomic Status

To characterize the types of households in the two samples, the questionnaire included a set of questions aimed at revealing each household's socioeconomic status, including economic conditions, family size and educational level.

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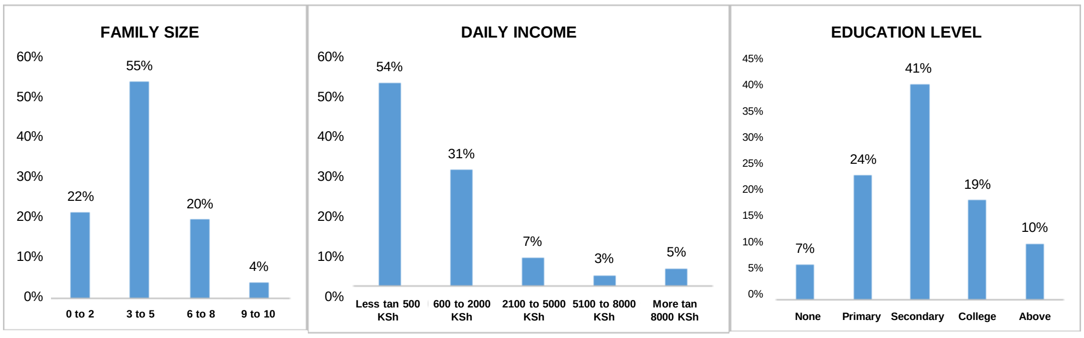
[17] AFREA, *Wood-Based Biomass Energy Development for Sub-Saharan Africa* (Washington, D.C.: International Bank for Reconstruction and Development and World Bank Group, September 2011), Executive Summary, p. ix.

Sample 1

As can be seen in Figure 6, the average family has three to five members (55%), with the rest of the households split almost equally between families with one or two members and families with six to eight members. The traditional large families of nine members or more appear to be less and less popular, with only 4% of observations falling in this group. The significant majority of households in our sample seem to have a daily income below KSh2,000, with 55% of the respondents making less than KSh500 per day. In our sample of 106 households, we seem to have been lucky in capturing the fuel choices of people with relatively high levels of education. Some 40% of household heads graduated from secondary school, while almost 30% of our respondents report having a college or graduate-level education. Only 24% of the interviewees have interrupted their education at primary level, and 7% do not have any schooling.

Figure 6

Households in sample 1 characterized by size, income and education level



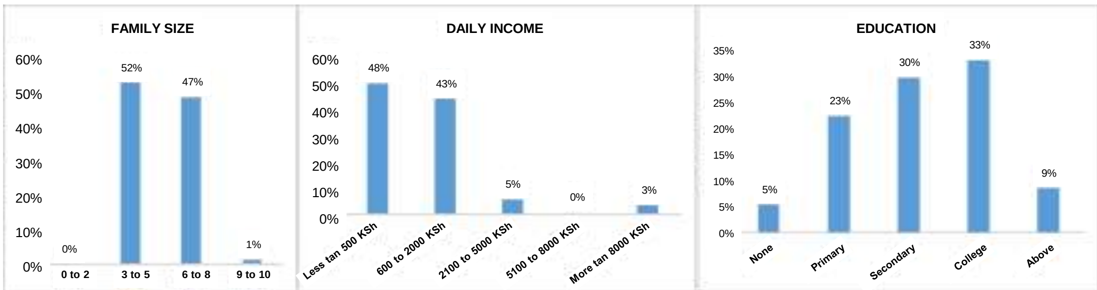
Source: Prepared by the authors.

Sample 2

As can be seen in Figure 7, our university students' sample is much less diverse when it comes to family size. Just over half of the students come from families with three to five members, while almost all the rest are from families with six to eight members. The income distribution in this sample is very similar to the one in the field study, with the majority of people (around 91%) making no more than KSh2,000 a day. The main difference between the two samples appears to be the level of education, with 33% of the respondents in sample 2 having a college education, compared with 19% in the rural area survey.

Figure 7

Households in sample 2 characterized by size, income and education level



Source: Prepared by the authors.

3.3 Methodology

We assume that both the demand and supply side factors affect a household's decision to switch to alternative cooking fuels. We therefore propose a set of variables, demand and supply-driven, that we think could be good predictors of the probability of households adopting modern cooking fuels. We test the predictive power of each variable by estimating a logistic regression model:[18]

$$(1)\ \log (\pi / 1-\pi) = \beta 0 + \beta_1\ DayInc + \beta_2\ Conv + \beta_3\ Afford + \beta_4\ Avail + \beta_5\ Trad + \beta_6\ Safety$$

where:

- *log (π / 1–π)* stands for the logic function, where *π* is the probability of switching to alternative cooking fuels (*AlterDum*) – that is, it provides a measure of the extent to which we can expect households to switch to alternative cooking fuels.
- *DayInc* stands for the explanatory variable "daily income" (scale: 1 to 5).[19] In line with the energy ladder hypothesis, we assume that the higher the daily income, the more inclined a household is to diversify fuel consumption.
- *Conv* stands for the explanatory variable "convenience" (scale: 1 to 5). It means access or proximity to the place where alternative cooking fuels are available: stores and other points of sale. Higher convenience values would imply a greater likelihood of switching to alternative fuels.
- *Afford* stands for the explanatory variable "affordability" (scale: 1 to 5). We assume that the greater the affordability, the greater the probability of switching to alternative cooking fuels.
- *Avail* stands for the explanatory variable "availability" (scale: 1 to 5),[20] meaning the ease of finding the fuel at the local store. We assume that the more available alternative cooking fuels are, the greater the probability of switching to them.
- *Trad* stands for the explanatory variable "tradition" (scale: 1 to 5). Given that traditional meals need to be cooked on an open fire, the higher the values given to the *tradition* variable, the lower the probability of switching to alternative cooking fuels.
- *Safety* stands for the explanatory variable "safety" (scale: 1 to 5). We assume that households that rank clean cooking fuels within higher safety values are more likely to switch from traditional cooking fuels to clean cooking fuels.

The coefficients of interest in equation 1 are $\beta 1$ to $\beta 6$. These estimates disclose the amount of increase in the predicted log odds of *AlterDum* = 1 that would be predicted by a one-unit increase in the predictor, all other predictors remaining constant. In the analysis below, we report both the estimated coefficients and the p-values of statistical tests (where each coefficient is significantly different from zero). In the analysis and summary of findings, we then comment on the type of effect (positive or negative) and the significance economic interpretation of the results.

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[18] The choice of using a logistic regression model is dictated by the fact that the dependent variable is a dummy (switching or not switching to alternative fuels).

[19] Data collected are ranked from 1 to 5 depending on the daily income range: 1 = less than KSh500; 2 = between KSh500 and KSh2,000; 3 = between more than KSh2,000 and KSh5,000; 4 = between more than KSh5,000 and KSh8,000; and 5 = more than KSh8,000.

[20] Data collected are ranked from 1 to 5 depending on whether this factor conditioned the decision to use alternative fuels: 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; and 5 = strongly agree.

3.4 Hypothesis Testing

Descriptive analysis

In Tables 3 and 4, we give descriptive statistics of the data collected for a number of variables in both samples. The descriptive analysis below suggests:

- 44% of households in sample 1 (mean of *AlterDum*: 0.44) use alternative cooking fuels compared with 24% of households in sample 2 (mean *AlterDum*: 0.24).
- Average daily income yields similar results for both samples: an average of 1.7, and a dispersion of 1 for sample 1 and 0.8 for sample 2. However, if we look at the number of people in the household (*NoHH*), we immediately notice that the average is significantly higher for sample 2, at 5.5, compared with 4.4 in sample 1. Thus, we can conclude that daily income per capita is lower in sample 2, which is, not surprisingly, the sample less inclined to switch.
- Households generally agree that alternative cooking fuels are available in their location. We observe an average of 4 (on a scale of 1 to 5) for sample 1, and an average of 3.2 for sample 2.
- Households seem to be fully aware of the alternatives available – as denoted by the high awareness score for both samples (4.6 for sample 1 and 3.9 for sample 2 on a scale of 1 to 5).
- Households report that tradition does not play an important role in their purchasing habits. (Sample 1 shows an average of 2.8 and sample 2 shows an average of 3.2.)
- Even if households in samples 1 and 2 show almost the same level of daily income, they show different affordability levels. (Sample 1 shows an average of 3.1 and sample 2 shows an average of 2.8.) This could be due to the fact that the data collected do not account for *discretionary daily income.*[21] In fact, there is a significant difference[22] between rural and urban areas in terms of discretionary income: households in rural areas enjoy a significantly higher discretionary income. With the same average daily income, households in rural areas do not pay rent or mortgage repayments or transportation, and the cost of food is significantly lower.
- Households already using alternative cooking fuels seem to remain neutral in relation to the impact of safety on their decision to use alternative cooking fuels, with an average of 3.3 in sample 1 and 2.9 in sample 2.

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[21] "Discretionary income is the amount of an individual's income that is left for spending, investing or saving after paying taxes and paying for personal necessities [...]. Discretionary income is what is left over from disposable income after the income-earner pays for rent/mortgage, transportation, food, utilities, insurance and other essential costs." (Investopedia, "Discretionary Income," http://www.investopedia.com/terms/d/discretionaryincome.asp#ixzz4R27TGCc8, accessed November 30, 2016).

[22] Professor África Ariño highlights the difference in disposable income between rural and urban areas in Kenya: "It is this suburban and rural reality that leaves more disposable income in the hands of consumers: living off a plot of land that feeds a family, and then some, makes for greater prosperity than meager city subsistence, a fact that is somewhat counterintuitive." (África Ariño, "Strategies That Go the Distance in Africa: Crossing the Divides," IESE Insight, first quarter 2015, p. 29).

Table 3

Descriptive analysis of sample 1

Variable	Obs	Mean	Std. dev.	Min	Max
AlterDum	106	0.4433962	0.499	0	1
DayInc	106	1.698113	0.997	1	5
NoHH	106	4.349057	1.872	2	9
Educ	106	3.028302	1.055	1	5
Avail	98	3.979592	0.885	1	5
Afford	103	3.087379	1.366	1	5
Trad	100	2.85	0.903	1	5
Safety	90	3.3	0.988	1	5
Convenience	89	4.146067	0.847	1	5
Awareness	101	4.594059	0.568	2	5

Table 4

Descriptive analysis of sample 2

Variable	Obs	Mean	Std. dev.	Min	Max
AlterDum	96	0.239	0.4290	0	1
DayInc	94	1.670	0.8473	1	5
NoHH	94	5.45	1.5426	4	9
Educ	94	3.180	1.0468	1	5
Avail	81	3.23	1.3534	1	5
Afford	88	2.840	1.5527	1	5
Trad	90	2.355	1.3095	1	5
Safety	66	2.909	1.2857	1	5
Convenience	68	3.117	1.333	1	5
Awareness	92	3.8695	0.9283	1	5
Credit	93	0.5913	0.4942	0	1

Logistic regression model

To test whether the identified variables are good predictors of a household's probability of switching to alternative cooking fuels, we estimated equation 1.

The model has been applied separately to the two samples to assess the consistency of the results and their external validity.

Table 5

Logit regression results for sample 1

	(1) Alter Dum	(2) Alter Dum	(3) Alter Dum	(4) Alter Dum	(5) Alter Dum	(6) Alter Dum
AlterDum						
DayInc	0.663***	0.651**	0.702***	0.728***	0.714***	0.708***
	(0.240)	(0.285)	(0.271)	(0.274)	(0.273)	(0.273)
Convenience		0.685**	0.573*	0.601*	0.600*	0.532
		(0.306)	(0.310)	(0.314)	(0.324)	(0.338)
Afford			0.593***	0.693***	0.752***	0.714**
			(0.215)	(0.256)	(0.275)	(0.283)
Avail				-0.267	-0.344	-0.354
				(0.363)	(0.373)	(0.374)
Trad					0.0586	0.121
					(0.304)	(0.319)
Safety						0.189
						(0.297)
_cons	-1.343***	-3.899***	-5.486***	-4.901***	-5.024***	-5.354***
	(0.442)	(1.375)	(1.584)	(1.764)	(1.844)	(1.938)
N	106	89	88	88	83	83

Table 6

Logit regression results for sample 2

	(1) Alter Dum	(2) Alter Dum	(3) Alter Dum	(4) Alter Dum	(5) Alter Dum	(6) Alter Dum
AlterDum						
DayInc	1.139***	0.918**	0.942**	0.926**	1.115***	1.168**
	(0.374)	(0.360)	(0.367)	(0.369)	(0.420)	(0.458)
Convenience		0.0892	-0.00739	0.00614	0.0301	-0.310
		(0.227)	(0.263)	(0.265)	(0.316)	(0.446)
Afford			0.170	0.243	0.181	0.327
			(0.231)	(0.293)	(0.349)	(0.404)
Avail				-0.139	0.117	-0.0133
				(0.330)	(0.366)	(0.478)
Trad					-1.177***	-1.177***
					(0.389)	(0.411)
Safety						0.396
						(0.494)
_cons	-3.200***	-2.830***	-3.102***	-2.877**	-1.753	-2.079
	(0.728)	(1.021)	(1.107)	(1.211)	(1.356)	(1.415)
N	93	67	67	67	65	63

3.5 Analysis

The sample size for different model specifications ranges from 83 to 106 for sample 1 and from 63 to 93 for sample 2.

The coefficients estimated with the regression allow us to make the following comments regarding the causal effect that the different variables have on the decision to switch to alternative cooking fuels:

1. *Explanatory variable "daily income."* The regression's results show that the coefficients of the explanatory variable *daily income* are positive and statistically significant, with p-values of < 0.01 and < 0.05 respectively. We can thus conclude *daily income* has a causal effect on *AlterDum* and state that daily income has a strong explanatory power in relation to fuel switching. In particular, by estimating the logit regression with the coefficients expressed as odds ratios (see Appendix 2), we notice that, for sample 1, for a one-unit increase (from one range of daily income to the next range, as defined previously), the

household's probability of switching to alternative fuel doubles. For sample 2, for a one-unit increase, the household's probability of switching to alternative fuel triples.

2. *Explanatory variable "convenience."* For both sample 1 and sample 2, the regressions show nonstatistically significant coefficients for the variable *convenience*.

3. *Explanatory variable "affordability."* The regression analysis for sample 1 shows a positive and significant ($p < 0.05$) coefficient, which prompts us to conclude that *affordability* has a strong causal effect on switching to alternative cooking fuels. Conversely, for sample 2, the coefficient of the variable *affordability* is positive but not statistically significant. Thus, we cannot conclude there is a causal effect.

4. *Explanatory variable "availability."* For both sample 1 and sample 2, the regressions show nonstatistically significant coefficients for the variable *convenience*. We cannot conclude that availability has a causal effect on switching to alternative fuels. However, based on the analysis of the data collected through the survey, most of the respondents agreed that the *availability* of alternative cooking fuels was a strong factor in switching from firewood and charcoal fuels.

   Looking at the descriptive statistics in Tables 3 and 4, we note a very high average availability of alternative cooking fuels, with very low variability (as the low values of the standard deviations show). Thus, most households agreed that alternative fuels are largely available to them. However, when they were asked about the frequency[23] of delivery of alternative fuels to their store, the answers consistently resulted in high percentages for monthly delivery. (Some 22% of the respondents reported fuel delivery took place monthly at their stores.) This leads us to think there might be a difference between how respondents understood "availability" when interviewed, and how available alternative fuels are in fact. The high homogeneity of the data collected could be the reason for the low explanatory power of availability in forecasting a household's probability of switching to alternative cooking fuels.

   Secondly, "availability" might not have captured the desired effect, since it is constrained by the fact that households have not been offered the possibility of purchasing the fuel on credit.

5. *Explanatory variable "tradition."* For sample 2, the regression results show a negative and statistically significant coefficient for sample 2, while the coefficient is not significant for sample 1.

6. *Explanatory variable "safety."* The regression results show positive coefficients for both sample 1 and sample 2, even though they are not statistically significant. Therefore, we cannot infer that safety has a causal effect on the decision to switch to alternative fuels.

   During the interviews, some of the respondents pointed out that safety was considered a luxury, which suggests that households do not pay much attention to it and might not fully realize all of the advantages that the use of alternative cooking fuels entails.

   Other respondents stated that they did not consider alternative cooking fuels to be safe and clean. Some households have argued that an open fire is much safer than other types

[23] It would be worth analyzing the correlation between the frequency of fuel delivery at local stores and households switching fuels.

of cookstoves, arguing, for example, that LPG stoves can cause explosions. Even though the coefficient of the explanatory variable "safety" is not significant, it is still positive, suggesting that it could become an important factor in the future. In fact, during the interviews, interviewees who had already switched to alternative cooking fuels reported that it was only once they had switched that they realized how positively the change had affected their lives in terms of safety.

To assess the importance of having access to credit, we have estimated a second logit regression for both sample 1 and sample 2, where we introduced the explanatory variable "credit" instead of *affordability* and *availability*:

(2) $log\ (\pi\ /\ 1-\pi) = \beta 0 + \beta_1\ DayInc + \beta_2\ Conv + \beta_3\ Trad + \beta_4\ Safety + \beta_5\ Credit$

where:

- *Credit* stands for the explanatory variable "credit access." It is equal to 1 if the household has access to credit and 0 if it does not have access to credit. We assume that having access to credit translates into a higher probability of switching to alternative cooking fuels, especially for the urban area sample (sample 2).

Table 7

Logit results for sample 1, accounting for credit

	(1) **AlterDum**	**(2)** **AlterDum**	**(3)** **AlterDum**	**(4)** **AlterDum**	**(5)** **AlterDum**
AlterDum					
DayInc	0.663***	0.651**	0.605**	0.601**	0.620**
	(0.240)	(0.285)	(0.279)	(0.276)	(0.280)
Convenience		0.685**	0.634**	0.453	0.475
		(0.306)	(0.312)	(0.321)	(0.324)
Trad			0.173	0.274	0.282
			(0.275)	(0.289)	(0.289)
Safety				0.434	0.431
				(0.276)	(0.276)
Credit					0.373
					(0.515)
_cons	-1.343***	-3.899***	-4.176***	-5.113***	-5.373***
	(0.442)	(1.375)	(1.469)	(1.631)	(1.696)
N	106	89	84	84	84

Standard errors in parentheses.

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

Table 8

Logit results for sample 2, accounting for credit

	(1) AlterDum	(2) AlterDum	(3) AlterDum	(4) AlterDum	(5) AlterDum
AlterDum					
DayInc	1.139***	0.918**	1.065***	1.069**	1.225**
	(0.374)	(0.360)	(0.412)	(0.422)	(0.512)
Convenience		0.0892	0.170	-0.144	-0.142
		(0.227)	(0.265)	(0.369)	(0.380)
Trad			-1.098***	-1.088***	-1.099***
			(0.365)	(0.374)	(0.378)
Safety				0.455	0.290
				(0.397)	(0.414)
Credit					1.771**
					(0.853)
_cons	-3.200***	-2.830***	-1.282	-1.740	-2.638*
	(0.728)	(1.021)	(1.154)	(1.212)	(1.484)
N	93	67	65	63	62

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

As predicted, for sample 1, the explanatory variable "credit" does not seem to be statistically significant (with a p-value higher than 0.1) but for sample 2 the coefficient of the variable credit is positive and statistically significant, with a p-value lower than 0.05.

This outcome is consistent with our intuition that, even though the level of household daily income for samples 1 and 2 is very similar, the level of affordability can differ due to the fact that the households in sample 1 (rural areas) have a higher discretionary daily income compared with households in sample 2 (urban areas). Access to credit therefore has a strong impact on the decision to switch to alternative cooking fuels in sample 2.

Furthermore, the fuel price differential between urban and rural areas acts in favor of our explanation since remote and rural areas account for higher fuel prices than urban areas.

4. Conclusions and Recommendations

In Kenya, the failure to attain the widespread use of alternative cooking fuels can be attributed to a number of barriers: high costs (including both the upfront cost of cookstoves and the cost of cooking fuel), underdeveloped infrastructure and a communication system that facilitates corruption and loss of cargo, resulting in financial losses, and lastly a lack of proper advertising, something that would increase public awareness significantly.

Our tested model suggests that to encourage households to switch to alternative cooking fuels, stakeholders willing to promote the consumption of alternative cooking fuels must ensure that alternative fuels are **affordable**. This goal could be pursued by:

1) *Allowing for the purchase of cookstoves and cooking fuel on credit.* This could be by microfinancing, by using a pay-as-you-go model, or by building a relationship with a customer on a regular basis, similar to the ones established by banks. A number of blossoming green businesses have anchored their business strategy and value proposition in the offering of new finance: pay-as-you-go and different sorts of installment buying are innovative ways to provide poorer households with access to credit.

2) *Attempting to make alternative fuels as competitive as possible with charcoal.* This could be done by producing ethanol locally or by building relationships with the oil industry in the area to provide sustainable solutions and avoid additional costs for imports.

3) *Using mobile phones to pay for fuel.* This has the aim of avoiding theft and allowing for the monitoring of household purchasing habits to improve product provision.

Even if alternative cooking fuel sources have been proven to be cleaner than wood and charcoal, health and safety are such abstract concepts for the average Kenyan household that alternative cooking fuels are still considered luxury goods, so those characteristics alone cannot offset the high costs associated with alternative cooking fuels. We encourage policy-makers and regulators to explore innovative mechanisms to levy effectively and collect taxes on firewood and charcoal to internalize the externalities caused by those fuel sources.

Raising **awareness** in local communities about the safety levels associated with alternative cooking fuels would help remove psychological barriers to the entry of alternative cooking fuels in the Kenyan market. This goal could be pursued by *running local and countrywide advertising campaigns.* This would promote increased awareness of the types of technology available and help people realize fully just how significantly alternative fuels would improve their quality of life with regard to safety, health and convenience.

Appendix 1

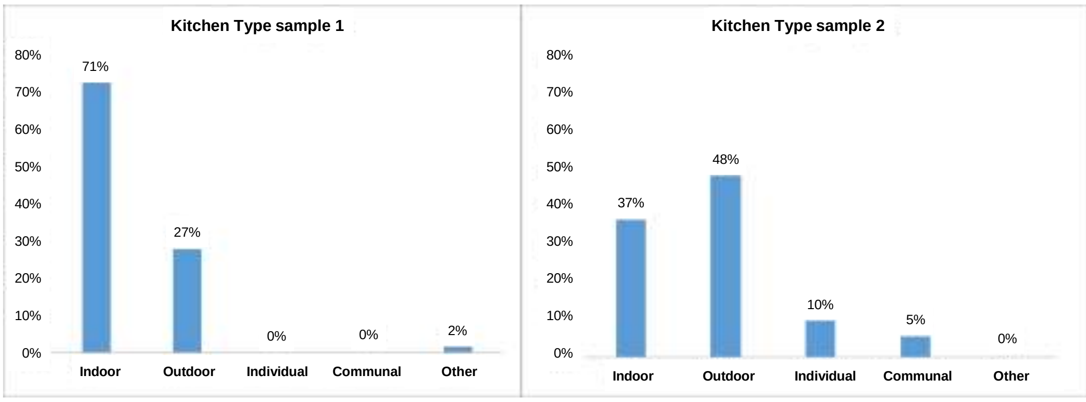
Analysis of Data Collected in the Field Surveys

Kitchen Type, Fuel Choice and Cookstove Type

When it comes to the type of kitchen in the house, surprisingly we note that 71% of the households in sample 1 have an indoor kitchen, while families that still cook outside represent only 27% of the sample. The 2% of the responses labeled “others” refer to households that use both types of kitchen. However, in sample 2, households that still cook outside are almost in the majority, with 48% of interviewees having an outdoor kitchen.

Figure 8

Kitchen type

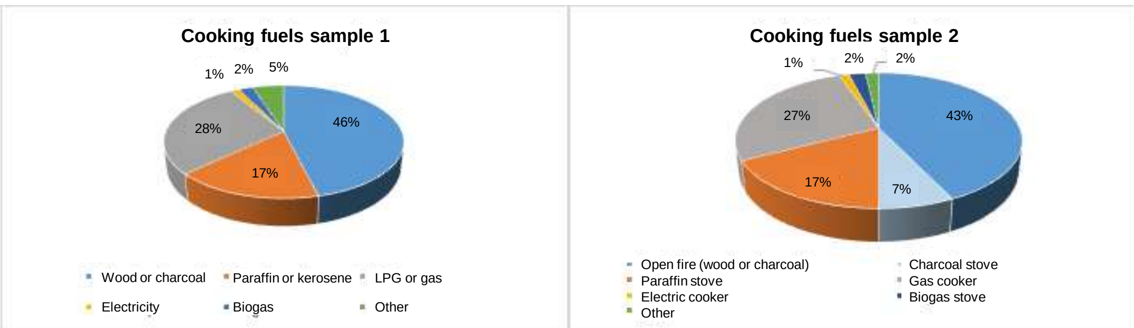


Source: Prepared by the authors.

We then asked the interviewees to indicate all the types of fuel and cookstove used by their household. Not surprisingly, wood and charcoal represent the most common responses in sample 1, with 46% of the total observations. In parallel, the most popular cookstove is the open fire (43%), where both wood and charcoal are usually burnt. Charcoal is used with charcoal stoves in 7% of the observations. With 28% of the observations, LPG is the next most popular fuel, with a corresponding 27% of LPG stoves used for cooking. Kerosene accounts for 17% of the answers, with a corresponding percentage of kerosene stoves. Electricity and biogas still represent a minority, with 2% of observations for each of them.

Figure 9

Cooking fuels and stoves used by households in sample 1



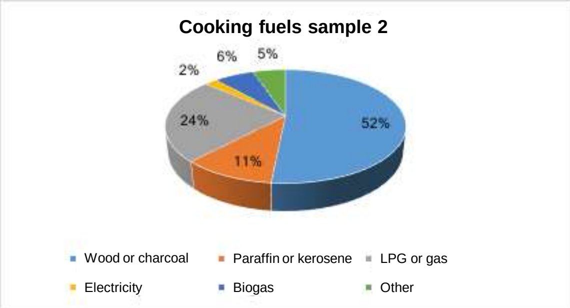
Source: Prepared by the authors.

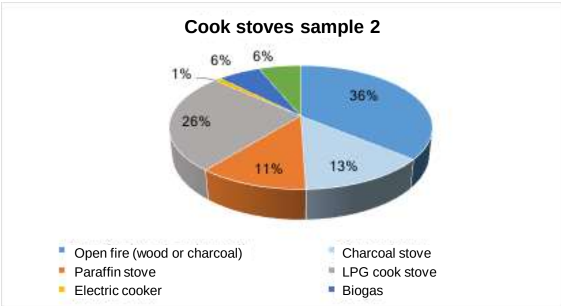
Appendix 1 (Continued)

In sample 2, wood and charcoal represent an even more common fuel, with 52% of the total observations. However, when it comes to the cookstove chosen, we note that an open fire accounts only for 36% of the observations, while 13% of the households choose a charcoal stove. With 24% of the observations, LPG is the next most popular fuel, with a corresponding 26% of LPG stoves used for cooking. Kerosene accounts for 11% of the answers, with a corresponding percentage of kerosene stoves. While electricity still represents a minor choice (2%), biogas seems to be a valid option for this sample, with 6% of respondents indicating biogas among their household fuel choices.

Figure 10

Cooking fuels and stoves used by households in sample 2





Source: Prepared by the authors.

Household Preferences

In the survey, we have been able to monitor the attitude of households toward purchasing/collecting practices depending on the cookstove used.

With regard to those households that use an open fire, as can be seen in Figure 4.1, families from both sample 1 and sample 2 are generally aware of the existence of other types of cooking fuels available in the market.

When it comes to choosing between purchasing or collecting/making firewood or charcoal, 80% of the households in sample 1 admitted they bought it. In the majority of cases they do not seem to produce their own charcoal or collect firewood on their own. Conversely, most respondents from sample 2 said they made their own charcoal and collected their own firewood. The proportion of households that buy firewood and charcoal is therefore much smaller than in sample 1.

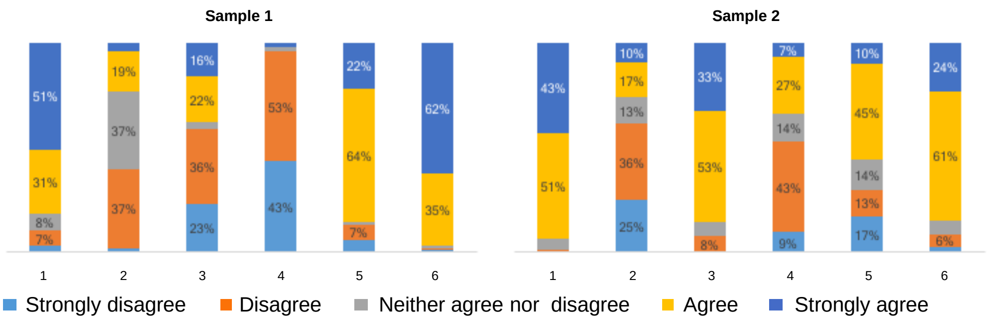
Additionally, as we have pointed out before, households do not say they cook with an open fire for traditional reasons. At the same time, they consistently report that they use firewood and charcoal since these are readily available.

To conclude, household choices seem to be based on the convenience of cooking fuel provision and self-sustainability, in the case of families that are able to collect firewood or produce charcoal themselves. Furthermore, while households do not point to tradition as a strong factor in the use of an open fire, this factor still seems to remain an obstacle to fuel switching.

Appendix 1 (Continued)

Figure 11

Answers for sample 1 and sample 2 for households using an open fire



INDICATORS SAMPLE 1

1. I cook with fuel that is readily available such as wood or charcoal
2. I cook with wood and charcoal for traditional reasons
3. I gather my own wood for cooking fuel
4. I make my own charcoal for cooking fuel
5. I purchase wood/charcoal for cooking fuel
6. I am aware of others types of cooking fuel available

INDICATORS SAMPLE 2

1. My family cook with fuel that is readily available such as wood or charcoal
2. My family cook with wood and charcoal for traditional reasons
3. My family gather my own wood for cooking fuel
4. My family make my own charcoal for cooking fuel
5. My family purchase wood/charcoal for cooking fuel
6. My family am aware of others types of cooking fuel available

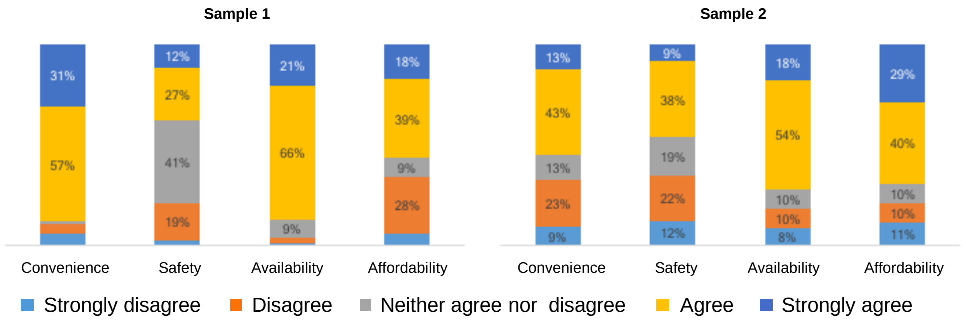
Total number of respondents: 92-98/105 for sample 1 and 72-79/95 for sample 2.

Source: Prepared by the authors.

With regard to households using other types of fuel (Figure 12), the interviewees generally agreed that alternative cooking fuels were easily available (70% to 80% of cases) and that they chose fuels due to their affordability – more than 50% of households in sample 1 and over 60% in sample 2. Convenience seems to be an important factor in fuel purchases for sample 1 (around 90% of households), while only 50% of the more educated and diverse sample 2 choose other cooking fuels because of their convenience. Lastly, it seems surprising that the households do not seem to choose alternative cooking fuels for the safety they provide. A substantial group of interviewees seems to be undecided when it comes to the safety level that alternative fuels offer.

Figure 12

Reasons for using alternative cooking fuels



Total number of respondents: 85-86/105 for sample 1 and 56-62/95 for sample 2.

Source: Prepared by the authors.

Appendix 1 (Continued)

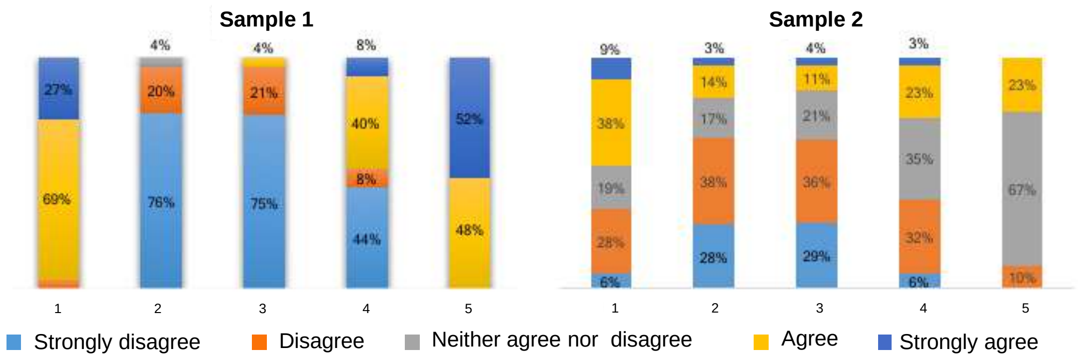
Household Financial Possibilities

Once we have learned what affects households' choices and what respondents' preferences are, we now check what financial possibilities households have and whether they can afford alternative cooking fuels.

Household responses in both samples consistently highlight the lack of opportunities to receive cookstoves at no cost or credit facilities to purchase alternative cookstoves. Moreover, respondents agree there is no installment buying option for cooking fuels. Interestingly, the slightly less educated group (sample 1) claims to be able to afford alternative cooking fuels more easily than sample 2. The question that remains is whether this result is related to the locality of that specific group of households, especially as the situation appears similar in the case of the availability of alternative cooking fuels.

Figure 13

Fuel purchasing options



INDICATORS SAMPLE 1

1. I can afford to purchase cooking fuels other than wood
2. I was offered credit to buy stoves that do not use firewood
3. I was offered the alternative cooking fuel at no cost
4. I can purchase the fuel on credit
5. The other fuels are available from my local store

INDICATORS SAMPLE 2

1. My family can afford to purchase cooking fuels other than wood
2. My family was offered credit to buy stoves that do not use firewood
3. My family was offered the alternative cooking fuel at no cost
4. My family can purchase the fuel on credit
5. The other fuels are available from my family's local store

Total number of respondents: 24-26/105 for sample 1 and 28-32/95 for sample 2.

Source: Prepared by the authors.

What our qualitative analysis tells us is that, for people who have already switched from traditional to transitional and modern cooking fuels, availability and affordability do have a strong explanatory power.

Appendix 2

Logit Regressions With Coefficients Reported as Odds Ratios

Results of the logit regression for sample 1. Coefficients are reported as odds ratios.

	(1) AlterDum	(2) AlterDum	(3) AlterDum	(4) AlterDum	(5) AlterDum	(6) AlterDum
AlterDum DayInc	1.941***	1.917**	2.019***	2.070***	2.042***	2.031***
	(0.466)	(0.546)	(0.547)	(0.567)	(0.558)	(0.555)
Convenience		1.983**	1.773*	1.824*	1.822*	1.702
		(0.607)	(0.550)	(0.573)	(0.591)	(0.576)
Afford			1.810***	1.999***	2.120***	2.041**
			(0.388)	(0.512)	(0.584)	(0.577)
Avail				0.765	0.709	0.702
				(0.278)	(0.264)	(0.262)
Trad					1.060	1.128
					(0.323)	(0.360)
Safety						1.208
						(0.358)
N	106	89	88	88	83	83

Exponentiated coefficients; standard errors in parentheses.

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

Results of the logit regression with credit for sample 1. Coefficients are reported as odds ratios.

	(1) AlterDum	(2) AlterDum	(3) AlterDum	(4) AlterDum	(5) AlterDum
AlterDum DayInc	1.941***	1.917**	1.831**	1.824**	1.858**
	(0.466)	(0.546)	(0.511)	(0.503)	(0.520)
Convenience		1.983**	1.886**	1.573	1.608
		(0.607)	(0.589)	(0.504)	(0.521)
Trad			1.189	1.316	1.326
			(0.327)	(0.380)	(0.383)
Safety				1.544	1.539
				(0.427)	(0.425)
Credit					1.452
					(0.747)
N	106	89	84	84	84

Exponentiated coefficients; standard errors in parentheses.

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

Appendix 2 (Continued)

Results of the logit regression for sample 2. Coefficients are reported as odds ratios.

	(1) AlterDum	(2) AlterDum	(3) AlterDum	(4) AlterDum	(5) AlterDum	(6) AlterDum
AlterDum						
DayInc	3.122***	2.503**	2.564**	2.525**	3.050***	3.216**
	(1.167)	(0.902)	(0.941)	(0.931)	(1.280)	(1.473)
Convenience		1.093	0.993	1.006	1.031	0.733
		(0.248)	(0.261)	(0.267)	(0.326)	(0.327)
Afford			1.185	1.275	1.199	1.387
			(0.273)	(0.373)	(0.419)	(0.561)
Avail				0.870	1.124	0.987
				(0.287)	(0.411)	(0.472)
Trad					0.308***	0.308***
					(0.120)	(0.127)
Safety						1.486
						(0.734)
N	93	67	67	67	65	63

Exponentiated coefficients; standard errors in parentheses.

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

Results of the logit regression with credit for sample 2. Coefficients are reported as odds ratios.

	(1) AlterDum	(2) AlterDum	(3) AlterDum	(4) AlterDum	(5) AlterDum
AlterDum					
DayInc	3.122***	2.503**	2.901***	2.912**	3.405**
	(1.167)	(0.902)	(1.194)	(1.230)	(1.743)
Convenience		1.093	1.185	0.866	0.867
		(0.248)	(0.314)	(0.319)	(0.329)
Trad			0.334***	0.337***	0.333***
			(0.122)	(0.126)	(0.126)
Safety				1.577	1.337
				(0.626)	(0.553)
Credit					5.879**
					(5.016)
N	93	67	65	63	62

Exponentiated coefficients; standard errors in parentheses.

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