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The impact of the household decision environment on fuel choice behavior

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Consumer preferences for fuels and alternative cookstove technologies in Kenya are examined, focusing on household internal and external determinants driving choice behavior in a choice experiment. The potential for a transition towards cleaner and more efficient fuels and technologies is assessed by zooming in on three fuel-stove combinations. We find substantial demand and positive willingness to pay for the fuel-stove combinations in three locations representing different decision environments. Demand is significantly higher in the peri-urban and the resource abundant rural location than in the resource scarce rural location. The presence of better developed consumer markets for fuels in these locations functions as an important driver for cookstove adoption. Although charcoal and ethanol stoves are preferred over improved firewood stoves, continued firewood usage is expected. Energy switching behavior cannot be substantiated. Instead, energy stacking is more likely, where charcoal and ethanol add to and extend a household's energy portfolio.

1. Introduction

Around 90 percent of the energy consumed by households in developing countries is used for cooking, making it the most energy intensive household activity (Murphy, 2001; WEC, 1999). In Sub-Saharan Africa (SSA) wood based fuels (firewood and charcoal) are the dominant source for domestic energy, used by some 80 percent of the households (World Bank, 2011). Whereas in other developing countries the use of wood as an energy source has already peaked or is expected to do so in the near future, in SSA it is predicted to remain at current levels and may even continue to grow (World Bank, 2011).

In this study, we examine cooking energy switching behavior and determinants of household decisions focusing on rural and peri-urban areas in Kenya. Whereas previous studies mainly addressed socio-economic household characteristics in describing fuel switching behavior (e.g. Heltberg, 2004; Hiemstra-van der Horst and Hovorka, 2008), we focus specifically on the relationship between product choice and decision environment, including household internal factors such as current traditional practices and income constraints, and external factors such as market access and resource availability. The main objective of this study is therefore to test the impact of contextual factors on fuel switching behavior and improved cookstove adoption. To this end, we develop and apply a choice experiment focusing on three fuel-stove combinations that represent different stages on the energy ladder. We target both men and women to account for possible gender effects. Existing studies on cooking fuels and cookstoves are primarily oriented towards female household members. Traditional gender relations in SSA show that the household's domestic tasks such as food preparation are indeed considered women's responsibilities, but men are often the decision-makers regarding the household's financial issues. By focusing on rural and peri-urban areas this study moreover contributes to the small body of empirical literature on energy transitions in such locations where little is known about household behavior.

The remainder of this paper is organized as follows. Section 2 introduces the background on which this study is built. Section 3 discusses the choice experiment design and section 4 describes the econometric model used. In section 5 the survey implementation is presented. Section 6 discusses the results and conclusions are drawn in Section 7.

2. Background

Biomass fuels are typically burned in open fires and traditional stoves that are known to do little to control combustion or optimize heat transfer and are thus highly inefficient in their use of fuel. This

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inefficiency is accompanied by a range of social and environmental challenges, including public health problems due to incomplete combustion (Grieshop et al., 2011), local degradation of forests and woodlands, large scale changes in land cover and greenhouse gas emissions (Bailis et al., 2012). To overcome these negative effects, a transition towards cleaner and more efficient fuels is needed. Switching from traditional biomass to modern fuels, such as liquified petroleum gas (LPG), biogas and ethanol is generally considered desireable as these fuels are expected to bring about the largest improvements, especially in use efficiency and public health conditions (Schlag and Zuzarte, 2008). In Africa's rural areas, little activity is recorded with regards to fuel switching by households (e.g. Barnes et al., 1994; Mirza and Kemp, 2009). In many rural communities, access to modern alternatives is limited as a result of low levels of availability and affordability, and biomass remains the most practical fuel for the foreseeable future (Arnold and Persson, 2003; Barnes et al., 1994; Masera et al., 2005). Here, improved cookstoves could serve as an intermediate step on the energy ladder (Arnold and Persson, 2003).

Despite numerous stove dissemination projects, the number of people that have adopted improved cookstoves remains relatively low (Jan et al., 2012; Karekezi et al., 2004; Legros et al., 2009). While their uptake in urban areas in SSA has been more widespread, rural households do not seem to have adopted improved stoves on a significant scale (Vermeulen, 2001). Abundantly available biomass, collected free of monetary costs, pose a serious barrier for successful diffusion of improved cookstoves. Rural households do not seem to feel a sense of urgency or experience a need to alter their behaviour and switch to more costly, but also more efficient fuels and technologies (Heltberg, 2004). The recently observed increase of commercial firewood transactions suggests growth potential of rural markets for improved cookstoves (Arnold et al., 2006). In order to assess this potential, it is of paramount importance to understand the behavioural drivers underlying household decision-making processes with regards to fuel use (Goldemberg et al., 2004; Schlag and Zuzarte, 2008).

The transition away from biomass to modern fuels has been described in the literature primarily based on the so-called "energy ladder" (Leach, 1992). The model underlying the energy ladder assigns differences in energy-use patterns between households to variations in economic status (Barnes and Floor, 1996; Hosier and Dowd, 1987; Leach, 1992). Non-income factors are thought to have little effect on fuel selection. Furthermore, it is assumed that households, while climbing the ladder, displace one fuel by another. The fuels on the energy ladder are ordered according to households' preferences, which are in turn based on physical characteristics of the fuels, including cleanliness, ease of use, cooking speed, and efficiency (Hiemstra-van der Horst and Hovorka, 2008). A growing body of empirical literature on household energy use shows, however, that the energy transition does not occur as a series of simple, discrete steps as predicted by the energy ladder model. Instead, multiple fuel use is more common and is also referred to as fuel stacking (Arnold et al., 2006; Brouwer and Falcao, 2004; Campbell et al., 2003; Davis, 1998; Heltberg, 2004; Karekezi and Majoro, 2002; Leach, 1992; Martins, 2005; van der Kroon et al., 2013). With increasing income, households adopt new fuels and technologies that serve as partial, rather than perfect substitutes for more traditional ones.

Both the energy ladder and stacking model fail to fully explain the role of consumer choices in fuel and stove selection (Hiemstra-van der Horst and Hovorka, 2008; Takama et al., 2012). Numerous revealed preference studies made an attempt to provide a more comprehensive picture by analyzing fuel switching behavior and cookstove adoption focusing on socio-economic determinants in the form of household characteristics and factor endowment (Campbell et al., 2003; Farsi et al., 2007; Gupta and Kohlin, 2006; Heltberg, 2004; Hiemstra-van der Horst and Hovorka, 2008; Israel, 2002; Masera et al., 2000; Mekonnen and Kohlin, 2008; Sathaye and Tyler, 1991; Schlag and Zuzarte, 2008). These studies led to the identification of distinct profiles of households based on their fuel choice behavior. Takama et al. (2012) argue that studies based only on socio-economic factors do not provide sufficient information for the practical design of programs or policies to promote energy transitions in view of the fact that these factors are not easily changed. They advocate the inclusion of product-specific factors, such as the characteristics of cookstoves. Product-specific factors will vary, and can therefore be adjusted in the short term based on the market availability of new products and people's awareness and understanding of the available alternatives (Takama et al., 2012).

In this study, we argue that household choices are not made in a vacuum, but instead shaped by the environment in which people operate. We refer to such an environment as the 'household decision environment', representing a complex web of factors that influence behavior (van der Kroon et al., 2013). To structure and describe the household decision environment, the decision framework developed by Bruntrup and Heidhues (2002) has been modified in this study to account for household fuel choices. Within this household decision environment, a distinction is made between external and internal factors: (i) the decision context reflecting a household's external (natural, institutional, economic, political etc.) environment shaping the boundaries within which it has to function (e.g. natural resource availability, consumer and labor markets, government policies); and (ii) the household opportunity set representing a group of household internal factors based upon the characteristics and factor endowment of the household (e.g. education, family size). The interaction between factors across categories determines the decision environment, which is expected to be unique for each individual household.

The general structural cooking fuel demand model is summarized in Eq. (1) (modified from Bohi and Zimmerman, 1984):

$$Q_{nf} = \sum_{k=1}^{K} R_{nk} C_{nk} \tag{1}$$

where Q_{nf} represents household n's demand for fuel f, which is typically a combined function of the available cooking stoves C_{nk} in the household, and the utilization rate R_{nk}. Since for each fuel typically different stoves with specific characteristics are on the market, Eq. (1) accounts for the fact that different types of stoves can be used by the household.

Demand for the cooking stove technology C_{nk} in Eq. (2) by household n depends on and is a function of φ, the characteristics of the cooking stove technology A_k, the purchase price of the particular stove technology P_k, the price of fuel f P_f, the price of alternative fuel g P_g (for all $f \neq g$), household income Y_n, other household characteristics Z_n, such as household size, and external decision environment factors E_n such as the presence or absence of markets for cooking stoves and fuels.

$$C_{nk} = \phi\left(A_k, P_k, P_f, P_g, Y_n, Z_n, E_n\right) \tag{2}$$

The utilization rate R_{nk} is in turn a function ϑ of the price of the fuel P_f, household income Y_n, other household characteristics W_n such as traditional cooking practices, and external household characteristics such as the abundance or lack of fuel resources E_n. The price of alternative fuels g is not included in Eq. (3) under the assumption that each cooking stove technology is operated on a single fuel type.

$$R_{nk} = \vartheta\left(P_f, Y_n, W_n, E_n\right) \tag{3}$$

In this study, Eqs. (2) and (3) are combined into one single reduced form function, as presented in Eq. (4):

$$Q_{nf} = \varsigma\left(A_k, P_k, P_f, P_g, Y_n, I_n, E_n\right) \tag{4}$$

where the household internal decision environment characteristics for