

COMBINING REVEALED AND STATED PREFERENCE DATA TO ESTIMATE URBAN DEMAND FOR IMPROVED COOK STOVES AND MODERN FUELS IN MOZAMBIQUE

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Overview

Most of the projected increase in the world's energy consumption in the coming years will occur in cities in the developing world (IEA, 2008). This increase in energy demand is driven by the rapid urbanization witnessed in most developing countries (Sadorsky, 2013). In 2010, the share of the African urban population was about 36 percent and this is projected to increase to over 60 percent by 2050 (ibid). Charcoal is still the major source of household energy for a majority of Africans residing in urban areas (Neufeldt et al., 2015). However, the use of charcoal in rapidly expanding urban areas causes serious environmental and health problems. At the same time, urbanization is seen as one of the most promising opportunities to resolve biomass issues. A shift from biomass to modern fuels has long been expected to occur in tandem with urban growth (Hiemstra-van der Horst and Hovorka, 2008). Despite Africa's rapid urbanization, the energy transition is proceeding slower than anticipated. Recent attention has therefore focused on encouraging the use of improved cook stoves. Such stoves could serve as an intermediate step on the energy ladder. Alongside improved cookstove developments, modern fuels are becoming increasingly competitive with biomass fuels (Arthur et al., 2010) and could finally open up the transition pathway to modern fuels.

So far, few studies have systematically assessed the role of underlying preferences for different fuels and technologies in relation to urban energy transitions. The main objective of the study presented here is therefore twofold: first to assess actual fuel switching behavior based on current urban household fuel profiles, and secondly to assess potential demand for alternative fuel sources in combination with improved cook stoves. By analyzing how household choices are influenced by current fuel profiles we gain knowledge on demand-side features for developing energy products and segmenting markets. Novel is the combination of both revealed (RP) and stated preference (SP) data to assess household preferences. Existing studies use only one of the two data types and never combined the two.

Methods

The study is based on revealed preference (RP) and stated preference (SP) data collected through a household survey in Matola, Mozambique. The research location has rapidly urbanized since 2000 and is known for its mixture of original rural population, well-off and poor newcomers. The survey was carried out in August 2013 among a total of 300 households. The RP data are based on in-depth questions covering urban households' current fuel use and cooking practices, while the SP data are based on a discrete choice experiment (DCE). The DCE design consists of three distinct fuel-stove combinations as labeled choice alternatives. These labeled alternatives comprise the 3 main urban energy transition pathways: 1) improved charcoal stove; 2) LPG stove and 3) ethanol stove. The fuel-stove combinations are characterized by the following five attributes, stove cost, weekly fuel costs, cooking time reduction, smoke level and environmental improvements. Alternatives for the three fuel-stove combinations were created by combining the 5 attributes based on their different attribute levels applying a main effects D-efficient fractional factorial design. The final design consisted of 10 versions of six choice sets each. Every respondent was randomly offered one of these ten choice versions.

Choice behavior based on the SP data was modeled using a random parameters logit model accounting for preference heterogeneity amongst the respondents. A multinomial logit model (MNL) is used to model the RP data. MNL allows for the systematic analysis of household switching behavior between different types of fuels.

Results

Charcoal was the most important household fuel for cooking used by over 90 percent of the households. On average, households were found to use about 2 fuels, spending on average US\$ 8.23 per week on cooking fuels¹. As income increases the use of firewood rapidly decreases, while that of LPG shows a steep upward trend. This pattern confirms both the inferior status of firewood as well as the upmarket status of LPG. Charcoal use remains relatively constant throughout each income quartile, indicating its importance to all household categories for cooking. A total of 19 different fuel portfolios were identified. We zoom in on the 4 most prominent profiles: firewood and charcoal (18%), charcoal (25%), LPG and biomass (22%) and electricity and biomass (24%). Household income and wealth-related

¹ Monetary values presented here have been converted from MZN to US dollars. In August 2013, 1 MZN equaled US\$ 0.0336.

factors seem to be the main factors explaining the transition towards more advanced fuel portfolios. Wealth indicators that were found to positively influence fuel switching behavior are house ownership, the number of rooms in the house and the availability of separate indoor cooking facilities.

Examining the households' socio-demographic characteristics, only a respondent's age and his or her family size turn out to play a significant role. The age of the household head has a significant negative impact on household switching behavior. This finding is in line with the assumption that older household heads may be more conservative in fuel choices, refraining them to move away from current practices. A significant negative effect of family size is found for a switch from firewood-charcoal to the LPG-biomass portfolio. This may be related to the associated type and volumes of food that are cooked for larger families. Further, the number of years a household has resided in the area has a significant negative effect on the use of a portfolio with modern fuels (LPG, electricity). Newcomers are therefore more likely to use LPG or electricity than households that have been residents for a longer period of time. Putting this in the perspective of the urbanization dynamics in the study area, newcomers, often from the congested bairros of the city of Maputo, are more likely to use modern cooking technologies, while the original rural population seems less likely to make this transition.

Choice behavior was modelled by two models. Model I only includes the choice attributes, Model II also includes the current fuel portfolios used by the respondent. The results indicate that respondents prefer the presented fuel-stove combinations instead of no change from their current situation. The LPG stove is preferred over the charcoal and ethanol alternatives. The significant positive value of the charcoal stove shows the continued interest in the use of charcoal as a cooking fuel. The respondents show a strong preference for a reduction in smoke levels and the implied positive health effects. A low environmental impact is valued positively as well. For both the weekly fuel usage cost and the stove cost no significant difference between the alternative specific estimates is found. This suggests that the type of cook stove and fuel type do not influence the households' price sensitivity. The results from model II show that the current fuel portfolio of the households significantly influences household choice behavior with respect to the charcoal and ethanol products. With a modern alternative available in their portfolio, LPG-biomass users will be less inclined to adopt any of the new technologies available despite the fact that biomass (mainly charcoal) still plays an important role in their cooking habits. Comparing the 2 biomass based profiles, we see that households who use a combination of firewood and charcoal have a significantly higher preference for the improved charcoal stove.

Conclusions

The results from the choice experiment show a clear demand and positive WTP for the presented modern fuel-stove combinations. The LPG stove is preferred over the ethanol and charcoal alternatives. Nevertheless, the inclusion of modern alternatives in the choice mix has not eliminated the interest of households to cook with charcoal as it remains a product of interest and continued usage is to be expected. The positive interest in the improved charcoal stove allows for a cleaner and environmental friendlier use of charcoal for cooking. This was confirmed by the fact that households responded as expected to the attributes of the fuel-stove combinations, favoring low fuel costs and stove cost, reduced environmental impact and smoke emissions. The reduced smoke emissions and implied health effects appeared a strong driver for product choices. The inclusion of the fuel portfolios in the estimated choice model mainly showed that LPG-biomass users were less inclined to adopt an improved charcoal or ethanol stove despite the fact that charcoal still plays an important role in their cooking habits, and that households who use a combination of firewood and charcoal have a significantly higher preference for the improved charcoal stove than charcoal only users, indicating that charcoal only users prefer to extend their fuel portfolio with modern fuels rather than investing in improving their current charcoal use.

References

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