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Driving forces for households' adoption of improved cooking stoves in rural Tanzania

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ABSTRACT

With increasingly improved cooking stoves (ICS) that aim to reduce fuelwood consumption by forest-dependent households, more evidence of what drives households to adopt ICS is needed. Using data from a representative sample (N=271) of households in a rural part of eastern Tanzania, we estimated a mixed logit model to take into account the limitations of the standard multinomial logit model and relaxed the restrictive assumption of the conditional logit model. The experiment results show a strong correlation between payment mechanisms and adoption of ICS. We also found interesting results that households provided with just one type of ICS adopted it less (30%). On the other hand, households supplied with more than one type of ICS largely adopted it (48%). In addition, the ICS that uses both charcoal and firewood was purchased by most households (80%), which raised the total uptake of ICS to 48 %. These results also provide empirical evidence of a shift from consuming firewood for energy to charcoal in rural areas. The study suggests that any efforts to promote ICS should seriously consider offering rural households a choice of ICS as opposed to a single type, inducing suppliers of ICS to extend them on credit, and offering ICS for cash at harvest time, as their cash flow depends on seasonal income from agricultural activities.

1. Introduction

About 3 billion people of the world's population depend on biomass fuel or solid fuel for domestic energy consumption [1]. Most of them are forest-dependent households who cook and heat using fuelwood. In this study, fuelwood is a fuel source (firewood and charcoal) used by households for cooking and heating. The study by Mwampamba et al. [2] indicates that the forest cover in Tanzania is decreasing and is expected to keep on declining due to the increasing need for fuelwood and incomes, leading to deforestation. Approximately 87% of households in Tanzania depend on fuelwood, particularly in the form of firewood and charcoal for cooking and heating using traditional inefficient cooking stoves that do not burn the fuelwood well, leading to this resource being in great demand [3].

According to Adkins [4], improved cooking stove (ICS) use brings about a substantial reduction in households' consumption of fuelwood (somewhere in the region of 420–700 kg per year) compared with the traditional three-stone open fire stoves. The use of ICS has been acknowledged to reduce the demand for fuelwood by forest-dependent households [5].

Nevertheless, Troncoso et al. [6,7] indicate that the rate of adoption of ICS by forest-dependent households is low. For example, only about 25% of rural households in Tanzania use ICS [8]. Low adoption has been found even when ICS have been offered free of charge [9,10]. The study by Miguel and Adrianzén [10] confirmed the low adoption of ICS (45%) in 26 villages in Peru and Bangladesh where 69% of the households were offered ICS free of charge.[1] Therefore, the question remains, why is there low adoption even when ICS are distributed free of charge?

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[1] Low adoption means that the proportion of households accepting or using ICS is small or the uptake of ICS is low relative to the status quo. When the constraints are relaxed, such as cost and information about the ICS or when ICS are distributed free of charge, acceptance of ICS is expected to be 100% [56].

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Furthermore, offering and distributing ICS free of charge is arguably an uneconomical and risky way of promoting adoption [11]. Therefore, we learn little about household preferences regarding ICS versus the traditional cooking stove. It appears that those few households who adopted ICS probably accepted them because they were given free of charge, even if they did not like them despite their attributes. According to Mobaraka et al. (7), the low adoption rate of alternative cooking technology offered free of charge validates the need to find out what ICS attributes households find more attractive.

We agree with the literature that acknowledges that income is a factor that influences the choice of fuel type associated with ICS [12]. However, several studies indicate that age, household size, gender, occupation and education are known to influence ICS choice (e.g.13, 14). One of the shortcomings of these studies is that they mainly focus on socio-economic attributes [e.g. 12, 13], but systematically fail to address ICS distribution using different payment mechanisms, detailed in the subsequent sections, which is important for predicting ICS adoption. As opposed to most previous studies in the experimental setting, this study makes it possible to observe the preference of households, i.e. the choice of households, in the real market situation, where they were given the opportunity to buy ICS using cash. Several studies [e.g. 9,10, 11] have only shown households' stated preferences, i.e. hypothetical decisions [15], or they have shown that ICS are adopted when offered free of charge, but few studies if any have looked into the distribution of ICS being paid for on credit or in cash. Because experimental studies on ICS are limited, we add more information to the thin literature on ICS adoption through exploring new factors that drive individuals to adopt ICS and reporting on how the choice of ICS reflects adoption.

We are aware of one previous study from Uganda by Levine et al. [16] using a randomized intervention, whereby households could buy ICS under different sales contracts. A week's trial was used and payment was made over the week. The main difference in this study is the use of different types of ICS, longer repayment periods and the treatment mechanism, whereby households choose the ICS they prefer. We assume that constraining the choice to just one stove, hence not accommodating households' preference, as well as the distribution mechanism, could suppress ICS adoption. We tested to see if this was the case. Moreover, we used a longer trial period, offering stoves on credit with a longer repayment period, since we believe that more time would be needed to gain enough experience and information concerning the stove and ease liquidity constraints.

In our study we offered ICS on credit to households with a repayment period of 3 months to one year. We believed that households need to use the product and become a source of information to other people about its benefits. Our assumption was that ICS is an experience variable (good or commodity), which few studies if any have taken into account, i.e. that households need to have time to use the product (ICS) so as to learn about its benefits. We also presumed that a choice between stoves accommodates the preferences of households than if just one type of ICS was offered for adoption [17]. We examined the outcomes of ICS distribution and adoption under different payment mechanisms and determined an effective ICS design aimed at promoting the significant adoption of ICS. Employing a discrete choice experiment (DCE), we show how different payment mechanisms, a longer trial period and the choice of stove affect the adoption of ICS in developing countries, a challenge that many studies overlooked when employing DCE, despite the fact that it is a serious component of ICS adoption. Lastly, we evaluated the immediate effect of liquidity constraints by offering ICS on payment of cash.

The study is grounded on the utility theory, particularly on the preference aspect, which assumes that households' preference for adopting ICS is associated with a comparison of alternatives. In other words, households' preference is a function of a combination of alternatives that vary according to ICS and socio-economic attributes [18].

We argue that households may have different preferences that constrain the intended outcome of fuel economy or efficiency, which could be acknowledged at policy level and by the academic community through the adoption of ICS. For example, on the one hand, households may be more interested in ICS that are versatile in terms of portability and in adopting them when there are incentives, like the market for fuelwood [19]. On the other hand, households might not adopt them because there is no serious constraint to the supply of fuelwood or because of financial constraints [20].

The aim of our study was to explore what drives households to adopt ICS, other than income and socio-economic attributes, by employing the DCE approach to find out whether the mechanism for paying for ICS and a longer trial period would influence households to adopt ICS, and whether having a choice of ICS would increase uptake. These are the questions that remain unanswered.

It was further assumed that some households adopt ICS because they do not have an alternative and others may prefer cooking stoves that are closely related to traditional cooking stoves. Therefore, the settings of this study contains two categories, A and B, as explained in the description of the experiment in section 3.2.

The rest of the paper is organized as follows. Section two gives the empirical overview and reviews the empirical evidence. Section three provides the methodology and description of the experiment. Sections four and five present the descriptive statistical analysis and econometric results, respectively. We discuss our main results in section 6 and draw the main conclusions in section 7.

2. Conceptual framework and review of empirical evidence

The conceptual framework of this study is grounded on the random utility theory to determine the attribute that influences households to opt for a particular alternative cooking stove (c). The theory assumes that a household's utility or preference is a function of drivers or attributes of a particular choice [21]. Using the utility theory in terms of linear utility, we assumed that the utility of household i to adopt ICS is driven by a particular choice offered (ICS_1, ICS_2 ICS_3 or ICS_4). Thus;

$$Adoption = f(u_{ic}) \quad and \quad u_{ic} = \psi_i(\alpha_1, P_{cn}, T_{cn}, \alpha_2, \beta, \chi_{ic}, Z_{ic}) + \mu_{ic}\ldots \tag{1}$$

where u_{ic} represents household i utility given an alternative cooking stove(c) in a set (n) of all other alternatives. ψ_i is the value of the utility function of household i and P_{cn} stands for the price of a cooking stove given other alternatives in the set. χ_{ic} is a control variable (characteristics of individual i), Z_{ic} stands for the characteristics of alternative ICS (Table 2) for an individual i and μ_{ic} is a stochastic zero-mean error term.

The random utility model (1) can correspond to different intervention choices using different assumptions about the distribution of the error term through which the model can be transformed [22]. Thus, ψ_i and μ_{ic} are very important in analysing the choice of alternatives as they are likely to correlate when the $E(\psi, \mu) = 0$ assumption is violated.

In this study, we had four ICS and one traditional alternative in the choice basket or set of alternatives (Table 1). However, we used the intervention (T) strategy because we assumed that household i has a traditional cooking stove attached to utility denoted as t.

The option of the household not to adopt ICS implies that it will