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Why do households forego high returns from technology adoption? Evidence from improved cooking stoves in Burkina Faso

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ABSTRACT

Around 3 billion people in developing countries rely on woodfuels for their daily cooking needs with profound negative implications for their workload, health, and budget as well as the environment. Improved cooking stove (ICS) technologies appear to be an obvious solution in many cases. Indeed we find that users of a very simple ICS in urban Burkina Faso need between 20 and 30 percent less firewood compared to traditional stoves, making the investment highly profitable. In spite of these high returns and great efforts made by the international community to disseminate ICSs, take-up rates are – similar to many other high-return innovations – strikingly low; in our case a mere 10 percent. When exploring adoption decisions of households, we find suggestive evidence that a major deterrent to adoption is the upfront investment costs. They seem to be much more important than access to information, taste preferences, or the woman's role in the household. These findings suggest that perhaps more direct promotion strategies such as subsidies would help households to overcome liquidity constraints, and would hence improve adoption rates.

1. Introduction

Firewood and charcoal are the primary cooking fuels for poor people in developing countries. A common feature of biomass users is that the technology they have access to – often not more than three stones to support the cooking pot – is characterized by low efficiency. Efficiency-enhancing improved cooking stoves (ICSs) have long been the obvious instrument of policy makers to counter the wasteful and unhealthy use of biomass resources in traditional cooking. Furthermore, biomass usage for cooking is responsible for a considerable proportion of climate-relevant emissions (Martin et al., 2011; Shindell et al., 2012). It is in this context that the United Nations set out the *Sustainable Energy for All* initiative with the ambitious

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goal of global universal adoption of clean cooking stoves and electricity by 2030. A multitude of ICS promotion projects have been implemented by various donor organizations and national governments. The dissemination strategy currently favoured is geared towards the establishment of sustainable markets by intervening on the demand side through awareness and marketing campaigns and on the supply side through training of small-scale producers (see Martin et al., 2011).

In spite of these efforts, ICSs have not yet made inroads into households in developing countries. In particular in Africa, take-up rates are generally very low and even market-based programmes have difficulty in achieving sustainable usage in their target areas. One obvious reason might be that ICSs simply do not always yield the benefits they promise. In fact, the literature shows an ambiguous picture with some promising evidence (Adrianzén, 2013; Bensch and Peters, 2013, 2015; Smith-Sivertsen et al., 2004, 2009; Smith et al., 2011), contrasting with very sobering examples which show that not all ICSs can be expected to decrease woodfuel consumption and the health burden (see Burwen and Levine, 2012; Hanna et al., 2012; Nepal et al., 2010). Little is known about other reasons that might discourage people from obtaining and using ICSs. Mobarak et al. (2012) and Miller and Mobarak (2015) examine ICS adoption in Bangladesh and also observe low take-up rates. They find that monetary reasons and liquidity constraints are much more important in driving the decision on which stove to use as compared to health considerations. As a way forward for both future research and ICS promotion policies they call for cheaper cooking stoves to be designed and for disseminating ICSs geared towards fuel savings in areas in which fuels are not easily or cheaply available.

The present paper steps into this research gap by, first, examining the profitability of a relatively simple ICS that is mainly designed to achieve fuel savings and not explicitly to reduce smoke emissions. Second, the paper explores the reasons why people adopt or do not adopt this ICS. The ICS under research is disseminated by the Government of Burkina Faso together with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in the two major cities of the country, Ouagadougou and Bobo-Dioulasso. The analysis is based on a representative survey conducted among 1473 households in these two cities in 2011 when the programme had been running for about 5 years. The ICS is a low-cost and maintenance-free portable metal stove. It is produced in a fairly standardized way by local whitesmiths in their workshops and is marketed at a retail price of between 4 and 7 US$.

According to lab tests, so-called controlled cooking tests (CCTs) conducted by the programme at the beginning of the dissemination activities, the ICS is expected to save, depending on the exact stove model used, between 29 and 43 percent on firewood consumption compared to the three-stone stove. As a first step of our analysis, we conduct a real-world usage evaluation of the woodfuel savings that ICS users actually achieve and compare this to the CCT results. The difference between savings rates obtained in CCTs and in our study reflects the behavioural component linked to technology adoption. Efficiency gains that are technically possible (which is what CCT measure) can rarely be expected to materialize in full in the field. In our specific case, stove users in the real world may do other things simultaneously while cooking, they may have incomplete knowledge on how to use the stove optimally, and they may not maintain the stove correctly or simply cook other meal types not tested in the CCTs. In addition, not all ICS adopters switch to an ICS from three-stone stoves, the most inefficient traditional stove that was used as the reference stove in the CCTs, but also from traditional metal stoves.

The methodological challenge we face is the heterogeneity in cooking behaviour (e.g. cooking duration, type of meals that are cooked) and the fact that different stove types exists, which all have different efficiency levels. In addition to the ICS and the traditionally used stove types, an imitation of ICS exists. These 'imitated ICSs' are stoves that are produced by non-trained producers and resemble the original ICS but tend to be of lower quality and less efficient. They have no quality label, but nonetheless can be expected to perform better than the traditional cooking stoves. It is another contribution of this paper to establish a rigorous way of dealing with these challenges. This happens on two levels: first, we use a unique data set that encompasses detailed information on the level of cooked dishes. Second, given the absence of adequate baseline data, we apply a propensity score weighted regression approach that combines propensity score matching and multivariate regression techniques in a two-step procedure. This enables us to identify consumption differences between three groups of cookstove types and, at the same time, to rule out biases that stem from the heterogeneity in cooking behaviour. Both would not be possible in an ordinary matching approach. Furthermore, we control for a rich set of household-level and dish-level variables and therefore can exclude a large number of potential sources of self-selection biases. Unobserved differences between the groups might still exist and could induce self-selection biases to the extent that they also correlate with the outcome, fuel consumption.

In the specific Burkinabè context, we identified three structurally different woodfuel stove user groups for which matching is applied to produce a balanced sample: *ICS owners*, *owners of imitated ICSs* and *other ICS non-owners*. Using our survey data, we find for firewood-using households real-world savings rates of ICSs between 20 and 28 percent as compared to traditional cooking stoves, which are less than the rates observed in the CCTs but still considerable. Even these lower real-world savings rates make investment in the ICS highly profitable. Nonetheless, the take-up rates in the two cities are surprisingly low at a mere 10 percent of all targeted households. In a second step, we therefore examine the drivers of and barriers to ICS adoption, taking into account the findings of Mobarak et al. (2012), but also factors that are usually put forward by development practitioners such as cultural traits and the role of women in the decision process on how to use the household budget.

Beyond the improved cooking stove sector, explaining low take-up rates in the presence of high returns is of general relevance in development economics, as there are many examples where investments with high returns are not realized (De Mel et al., 2008; Cohen and Dupas, 2010; Duflo et al., 2011; Grimm et al., 2011). Explanations for such behaviour include capital market imperfections and risk, as well as norms and traditions. We find suggestive evidence that in fact financial constraints are the most important barrier to adoption, followed by information asymmetries, i.e. people are either unaware of the