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Preferences for improved cook stoves: Evidence from rural villages in north India

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ABSTRACT

Because emissions from solid fuel burning in traditional stoves impact global climate change, the regional environment, and household health, there is today real interest in improved cook stoves (ICS). Nonetheless, surprisingly little is known about what households like about these energy products. We report on preferences for biomass-burning ICS attributes in a large sample of 2120 rural households in north India, a global hotspot for biomass fuel use and the damages that such use entails. Households have a strong baseline reliance and preference for traditional stoves, a preference that outweighs the $10 and $5 willingness to pay (WTP) for realistic (33%) reductions in smoke emissions and fuel needs on average, respectively. Preferences for stove attributes are also highly varied, and correlated with a number of household characteristics (e.g. expenditures, gender of household head, patience and risk preferences). These results suggest that households exhibit cautious interest in some aspects of ICS, but that widespread adoption is unlikely because many households appear to prefer traditional stoves over ICS with similar characteristics. The policy community must therefore support a reinvigorated supply chain with complementary infrastructure investments, foster experimentation with products, encourage continued applied research and knowledge generation, and provide appropriate incentives to consumers, if ICS distribution is to be scaled up.

1. Introduction

The use of solid biomass or coal fuels for basic household cooking and heating remains widespread throughout the world, and represents approximately 15% of global energy use (Legros et al., 2009). These fuels are often burned in cheap but highly polluting traditional stoves. Inefficient biomass fuel burning has been implicated in climate change, and also harms regional air quality, local forest environments, and household health (Bruce et al., 2006; Ezzati and Kammen, 2001; Martin et al., 2011; Ramanathan and Carmichael, 2008). These various ills have prompted great interest in, and a new push towards development and dissemination of more efficient and cleaner-burning improved cook stoves (ICS) (GACC, 2010; World Bank, 2013).[1]

Much of the recent push for widespread promotion of ICS in less developed countries stems from concerns over the role played by traditional cooking technologies in global climate change. Black carbon emissions from the use of traditional biomass cook stoves and diesel engines are considered to be the second largest contributor to global warming (Ramanathan and Carmichael, 2008). Research from villages in northern India located near our study sites has demonstrated that ambient black carbon concentrations increase during periods of

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[1] We use this term "improved cook stoves" (ICS) to refer to a broad set of more efficient technologies, which include stoves that rely on cleaner-burning fuels (e.g., gas or electricity), as well as more efficient biomass-burning options. When we wish to distinguish the biomass-burning class of ICS from technologies that rely on cleaner fuels, we use the term "biomass ICS".

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intensive traditional mud stove use (Praveen et al., 2012; Ramanathan and Balakrishnan, 2007). This research has also shown that mitigation of black carbon and other short lived climate pollutants (SLCPs) through various measures, including widespread replacement of traditional stoves with more efficient models, could reduce global warming and end-of-century sea level rise by as much as 20 percent (Hu et al., 2013). Well before the interest in how traditional stoves contribute to global climate change, much attention was paid to their contributions to forest degradation and deforestation (because of high fuel requirements) and to respiratory illness (Ezzati and Kammen, 2002; Jagger and Shively, 2014). Household air pollution is thought to kill more than 4 million people each year, and is today the leading cause of death in South Asia (Lim et al., 2013). In addition, ICS dissemination is increasingly viewed as a potential mechanism for reducing problems of energy access (i.e., energy poverty) in poor countries (Birol, 2007; Pachauri and Spreng, 2011).

Yet despite the very large health risks associated with traditional stoves and previous distribution efforts, adoption of cleaner burning biomass stoves has been slow, and new technologies have not reached scale (Barnes et al., 1994). Beyond well-known problems of high costs and a weak supply chain, researchers and practitioners have claimed, without systematic evidence from rigorous field studies, that ICS prototypes have not been sufficiently adapted to local cooking requirements and user preferences (GACC, 2011; Lewis and Pattanayak, 2012; Shell Foundation, 2013; Singh and Pathy, 2012; Whittington et al., 2012). Meanwhile, more widely accepted technologies such as liquefied petroleum gas (LPG) and electric stoves remain costly for many households, and lack a robust and strong supply chain in rural areas. Such technologies are therefore more typically subject to stacking (alongside traditional stoves) rather than switching (Heltberg, 2004; Masera et al., 2000).

In response to these observations, field-based empirical research has begun to raise important questions about diffusion and dissemination strategies for ICS, and particularly for higher-efficiency biomass stoves. While there is some evidence of limited demand for such stoves (Larson and Rosen, 2002), recent and notable studies from East and West Africa reveal successful promotion under some conditions, at least in the short-term (Bensch and Peters, 2015; Levine et al., 2013). In fact, the debate over demand for ICS parallels a discussion in the broader literature on adoption of environmental health improvements. First, while demand is often low, it is driven by consumers' diverse preferences, circumstances and constraints (Pattanayak and Pfaff, 2009). For example, households cannot be expected to adopt a stove that is inconvenient to use or that is insufficient for their specific cooking needs, even if it is highly efficient. Second, the heterogeneity in tastes and constraints across communities and individuals translates into substantial variation in the real costs and benefits of ICS (Whittington et al., 2012; Jeuland and Pattanayak, 2012). Third, household decisions about whether or not to adopt and continue to use ICS may not always follow from simple comparisons of economic costs and benefits. Lack of user awareness, peer influences, credit constraints, uncertainties over technological performance, risk aversion and impatience all influence decisions about whether or not to adopt an unknown technology (Beltramo et al., 2015; Tarozzi et al., 2014). This and the other two reasons described above can explain the low rates of adoption and continued ‘stacking’, instead of switching to ICS. Part of the solution has to lie in learning to engineer and adapt stoves and services to local cooking requirements and conditions. Perhaps nowhere is the scale of this challenge greater than in India, the largest potential market for such technologies and one of the world's hotspots for biomass burning in inefficient cook stoves (Smith, 2000). Progress in India has been particularly slow, even as global sales have sharply increased (GACC, 2012; Lewis et al., 2013).

This paper explores the demand for ICS using revealed and stated preference data collected from 2120 households located in two states – Uttar Pradesh and Uttarakhand. We analyze cross-sectional survey data that provides basic information on household socio-demographics and on perceptions, ownership and use of different stoves and fuels. This allows us to assess what types of households already use ICS, which in this sample are almost exclusively LPG stoves. We then use a discrete choice experiment (DCE) to consider how respondents value four different attributes of a hypothetical biomass-burning ICS: price, number of stove openings (i.e., burners), amount of smoke emissions, and amount of fuel required. All households selected their preferred stove options in a series of repeated discrete choice tasks; the analysis of these stated preference choices serves as the basis for assessing the heterogeneity in respondents' tastes for different ICS features (McFadden and Train, 2000). In particular, we consider whether and how various household characteristics, including ownership of LPG stoves, are correlated with variation in demand for these features of biomass ICS. Though we caution against ascribing a causal interpretation to the role of these observable characteristics in demand, and acknowledge that preferences for LPG versus biomass ICS may be systematically different, the comparison nonetheless allows us to assess the consistency of the patterns across the stated and revealed preference data.

Our paper makes several contributions. First, we add to the thin literature on preferences for household energy products by being the first to examine how much key players in the ICS scale-up conundrum – rural north Indian households – are willing to pay for changes in specific biomass ICS attributes such as reductions in emissions, inconvenience, and fuel requirements. Existing studies on the demand for ICS have largely ignored the heterogeneity of user preferences and focused on average demand for a single pre-selected technology with a specific set of features, or sought to isolate differences in demand by varying technologies across the arms of an experiment rather than allowing users to choose the technologies they prefer from a menu of options (Bensch and Peters, 2012; Mobarak et al., 2012). An advantage of discrete choice preference elicitation is thus to allow consumers to explicitly consider the tradeoffs between stoves with different levels of ICS features.

Second, by analyzing how choice patterns vary across different subgroups of our sample, we are able to test whether preferences are related to observable household characteristics and contextual factors (van der Kroon et al., 2014). Similarly, our revealed preference regressions allow us to examine whether similar variables are correlated with patterns of ICS (LPG) stove ownership in the data. Such patterns provide clues on the penetration of existing alternatives to traditional stoves, and can inform more effective targeting of ICS promotion interventions since not all households will adopt and use such technologies. Alternatively, they may indicate which types of households already have and use alternative technologies and therefore do not need to be targeted. In particular, our analyses reveal substantial heterogeneity in preferences, which suggests that future ICS interventions should consider developing promotion messages and strategies that allow beneficiaries to understand the features of different products. Also, the extremely low levels of penetration of cleaner-burning stoves other than LPG stoves in our sample point to major supply-side challenges that impede widespread dissemination and diffusion of ICS. Collectively, our results call for policies that foster technological experimentation, support investment in infrastructure to support the ICS supply chain, encourage continued research and learning, and stimulate demand. Such a multi-faceted strategy is particularly relevant for our study region, where the energy use behaviors of nearly a quarter billion people potentially alter a range of local health, regional environment and global climate outcomes (Bhojvaid et al., 2013).

2. Methods

2.1. Research site and household sampling

In this study, we surveyed 2120 households living in 66 Census-delineated villages in two states of India – Uttar Pradesh and