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Analysis

Improved cooking stoves and firewood consumption: Quasi-experimental evidence from the Northern Peruvian Andes

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ABSTRACT

Over the past few decades, improved firewood cooking stoves have been massively distributed around the world, mainly with the purpose of decreasing fuelwood consumption among rural households. Surprisingly, rigorous "on the field" evidence on the causal impact of these devices is very limited. This paper estimates the impact of an improved stove design distributed in the Northern Peruvian Andes on firewood consumption. To identify the causal effect of improved stoves, it exploits a quasi-experiment related to the improved stove intervention. The evidence indicates that a proportion of households that adopted the new device experienced iron frame failures. These failures were not systematically caused by inadequate usage, installation or maintenance, but by faulty iron frame construction. Moreover, faulty iron frames were randomly distributed, and whether an iron frame was faulty or not, was not ex-ante observable to the beneficiaries. Therefore, an iron frame failure indicator is used as an instrumental variable to identify the causal effect of improved stoves. Improved stove usage appears to reduce firewood consumption by approximately 46% in the study area.

1. Introduction

According to the Food and Agriculture Organization (FAO), approximately three billion people around the world rely on non-sustainable biomass-based energy sources to meet their cooking and heating needs.[1] In the Peruvian villages of the Andes Region, high dependence on biomass fuels is prevalent (Córdoba-Aguilar, 1992; Ektvedt, 2011). In the case of the Chalaco District of the Northern Peruvian Andes, where this study is based, more than 90% of households use fuelwood as the main source of cooking and heating energy.[2] Furthermore, firewood collection in preparation for the wet season in the Chalaco District villages (as in other villages throughout the Andes) is strongly related to cutting down trees. This extraction activity severely impacts cloud forest areas in the District,[3] as documented by Córdoba-Aguilar (1992) and Sánchez and Grados (2007). Cloud forests provide important environmental services: they capture and supply water for agriculture and human consumption, play a central role in carbon capture, and prevent erosion and soil degradation (Sánchez and Grados, 2007). In this sense, policy interventions aimed at reducing household firewood needs have a crucial role in preserving cloud forests and their associated benefits throughout the Andes Region.

Over the last few decades, the distribution of improved ("more efficient") firewood cookstoves has been one of the most widely implemented strategies to reduce fuelwood consumption[4] and alleviate deforestation and forest degradation in rural areas of developing countries (Boy et al., 2000; Chen et al., 2006; Barrueta et al., 2008; Hanna et al., 2012). In Perú, several improved stove interventions have been implemented over the last decade, particularly in the rural Andes areas.[5]

Although improved cookstoves usually perform more efficiently than open fire ones in laboratory or controlled cooking tests, their performance in real field conditions may considerably depart from that observed in controlled trials. First of all, a more efficient technology may influence cooking behavior. For instance, adopters may

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[1] http://www.fao.org/bioenergy/67564/en/

[2] 2008 Chalaco Survey, carried out by myself in the Chalaco District Area during the summer 2008.

[3] It must be understood, however, that deforestation and forest degradation are complex processes, and that fuelwood extraction for energy needs is just one of the many factors affecting them (Angelsen and Kaimovitz (1999)).

[4] As these stoves are usually equipped with a chimney, special attention has been recently given to the effect that these devices may have on respiratory health due to reduced indoor air pollution Duflo et al. (2008).

[5] One of the most extensive ones was carried out by "Programa Sembrando", which between 2007 and 2009 distributed close to 50,000 improved stoves in rural Andes communities (http://www.sembrando.org.pe/).

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switch to more firewood intensive meals; or may use the new stove more intensively for heating, given the savings experienced at cooking tasks (especially at cold, high altitude, Andes areas). Secondly, due to different factors such as education, preferences, wealth, etc.; rural households may fail to use the improved stove exactly as it was used in controlled tests, or may not invest on its maintenance. “On the field” studies that compare users' and non users' real firewood consumption levels have also been implemented (Wallmo et al., 1998; Heltberg et al., 2000; Chen et al., 2006; Barrueta et al., 2008), among others. However, most of these studies are observational, and thus suffer from self-selection issues. Namely, in these studies users and non users are likely to differ in a variety of non-observable characteristics (ability, health, and preferences), and are therefore not comparable. Rigorous evidence that properly addresses for self-selection issues in stove usage is still incipient. This evidence mainly relies on Randomized Control Trials (RCTs), in which treatment and control groups are randomly determined; that is, both groups have the same ex-ante probability of receiving an improved stove and are consequently comparable (Bensch and Peters, 2012; Hanna et al., 2012).

This paper adds to the literature by rigorously identifying, “on the field”, the causal impact on firewood consumption of an improved stove design distributed in 2003 in the Chalaco District of the Northern Peruvian Andes. In order to overcome for self-selection issues in stove usage, we exploit a quasi-experiment related to this intervention. Monitoring visits reports, carried out 8 to 12 months after stove distribution, indicate that a proportion of adopters experienced early iron frame deformations and cracks, and that close to 50% of these households stopped making use of their improved stoves. Importantly, these failures were not systematically caused by improper installation, usage or maintenance, but by faulty iron frame construction.[6] The evidence indicates that faulty iron frames were randomly allocated, and that these deficiencies were ex-ante unknown to the beneficiaries. Hence, experiencing an iron frame failure was random and exogenous to households' characteristics. Therefore, an iron frame failure indicator can be used as an instrumental variable to predict households' current stove usage in order to identify the impact of improved stoves. Our results show that improved stove usage reduces firewood consumption by 46% during the wet season in the study area. To the best of our knowledge, this is the first paper that presents rigorous empirical evidence on the causal effect of improved stoves for the Andes Region.

The rest of the paper is structured as follows. Section 2 in this paper revises the related literature. The 2003 stove distribution program and the identification strategy are discussed in Section 3. Section 4 describes the data. Section 5 presents the empirical results. Section 6 concludes and discusses policy implications.

2. Related Literature

Initial studies of the effect of improved stoves on firewood consumption mainly rely on laboratory or “in situ” standardized tests. These studies provide mixed results. Some show that improved stoves perform better than “open fire” stoves at Controlled Cooking Tests, which carefully replicate traditional cooking tasks. Others show that improved stoves do not seem to outperform “open fire” stoves at standard Water Boiling Tests[7] (McCracken et al., 1998; Boy et al., 2000; Barrueta et al., 2008). Nonetheless, standardized tests are not likely to capture the complexity of daily cooking tasks (Johnson et al., 2010). Hence, efficiency gains in real conditions likely differ from those observed in controlled trials.[8] Moreover, cooking behavior may be affected by the new stove. Users may opt for consuming foods that are even more firewood intensive,[9] may fail to use the stove exactly as it was used during controlled trials, or may fail to invest in its maintenance (Hanna et al., 2012).

In order to estimate the effect of improved stoves in real usage conditions, some studies include “on the field” Kitchen Performance Tests, in which firewood consumption by rural households during normal daily cooking is monitored and measured (Wallmo et al., 1998; Boy et al., 2000; Barrueta et al., 2008). Nevertheless, these studies present serious identification issues. For example, Wallmo et al. (1998) fail to address for self-selection in the stove usage decision. Hence, their results are likely biased due to unobservable factors simultaneously correlated with firewood consumption and stove usage. In Boy et al. (2000), improved stove adopters in Guatemala were asked to cook for five days with their improved stove and then for five days with an open fire one. They found that the improved stove uses 39% less firewood. However, firewood was freely provided in any amount, and households were required not to change their cooking habits. As a result, no clear conclusion on the impact of improved stoves can be obtained. In Barrueta et al. (2008), a group of Mexican rural households were randomly selected and assigned an improved stove. In this study, firewood usage decreased by 67% after one year. Unfortunately, no control group was included to account for time variant factors potentially affecting firewood consumption. Improved stoves have also been added as a control variable in observational empirical studies whose main focus is some other factor related to rural household's firewood usage decisions (Amacher et al., 1996; Heltberg et al., 2000; Chen et al., 2006). However, these studies usually control for stove ownership, not usage, and little or no attention at all is given to self-selection issues.

Rigorous, “on the field”, evidence on the firewood consumption impact of improved stoves, that properly addresses for self-selection issues in stove usage is still incipient. This evidence mainly relies on RCTs, in which the treatment is randomly allocated. In RCTs, treatment and control groups have the same ex-ante probability of receiving an improved stove; therefore, the groups are perfectly comparable, and any difference in groups' outcomes can be identified as a causal impact of the intervention. Among the few RCTs studies evaluating firewood consumption in the field, we have the papers by Bensch and Peters (2012) and Hanna et al. (2012). The former, based in Senegal, finds significant firewood savings among treated households twelve months after stove distribution. The latter, based in rural Orissa, India, does not find any significant difference in firewood usage (neither in the short or the long term) among treated and control households. In our opinion, these mixed results call for more rigorous empirical evidence. Our paper significantly adds to this incipient experimental literature, as it exploits the random distribution of faulty iron frames to overcome for self-selection in stove usage. Moreover, it is also the first paper providing rigorous evidence on the long term impact of improved stoves for the Andes Region.

3. The Intervention: Identification Strategy

In the fall of 2003, improved cookstoves were freely distributed and installed in 37 of the 39 villages within the 5 watersheds of the Chalaco

[6] One of the most extensive ones was carried out by “Programa Sembrando”, which between 2007 and 2009 distributed close to 50,000 improved stoves in rural Andes communities (http://www.sembrando.org.pe/).

[7] The standard Water Boiling Test developed from Baldwin (1986) has three components: two high power tests, one conducted at cold starting conditions and the other at warm starting conditions, and a low power test designed to simulate slow cooking tasks (tasks requiring low heat).

[8] In addition to this, different qualitative studies (e.g. Gill, 1985) suggest that rural households do not only care about firewood savings; speeding up cooking, for example, can be more important to them. Also, they tend to modify and adapt the new stove to their specific needs, affecting in this way the performance of the device.

[9] If the stove is also used as a heating device, you may decide to keep the stove fired more hours a day, increasing in this way your firewood consumption. However, it can also be the case that the stove design is more efficient at performing cooking tasks but less efficient at heating the household unit.