

Working Paper in Economics No. 724

Decision-making within the Household: The Role of Autonomy and Differences in Preferences

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Department of Economics, March 2018

ISSN 1403-2473 (Print)
ISSN 1403-2465 (Online)



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Decision-making within the Household: The Role of Autonomy and Differences in Preferences *

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February 27, 2018

Abstract

We use a field experiment to identify how differences in preferences and autonomy in decision-making result in sub-optimal adoption of technologies that can maximize the welfare of all members of the household. We create income-earning opportunities and elicit willingness-to-pay (WTP) for energy-efficient cookstoves through a real stove purchase experiment with randomly chosen wives, husbands and couples. Experimental results suggest that women, who often are responsible for cooking and for collecting fuelwood, reveal a higher preference than men for the improved stoves. Using an instrumental variables tobit estimator, we show that women who have higher decision-making autonomy reveal higher WTP than those who have lower decision-making autonomy. A follow-up survey conducted 15 months after the stove purchase show that autonomy does not affect stove use. Our findings highlight the importance of considering division of labor, different preferences, and bargaining power differences within the household when promoting adoption of new household technologies.

JEL Classification: C93, D13, O12 Q56.

Keywords: Preference Difference, Decision-making Autonomy, Willingness-to-pay.

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1 Introduction

Household-level decisions made by spouses - who often have different preferences and bargaining power - have significant implications for the welfare of all members of the household, including children. There is consistent evidence on the differences in spending patterns - driven by differences in preference - between men and women in both developed and developing countries, which draws on observational data. For example, [Browning et al. \(1994\)](#) and [Phipps and Burton \(1998\)](#) in Canada and [Bourguignon et al. \(1993\)](#) in France document that women have different spending patterns than men. Women in developing countries spend a larger proportion of their income on children's and household goods ([Hoddinott and Haddad, 1995](#)), and children's health ([Thomas, 1990](#)), and micro-finance credits have a larger impact on household outcomes when women are the clients ([Pitt and Khandker, 1998](#)). In South Africa, pension income received by women has been shown to have a larger impact on the health status of children than pension income received by men ([Duflo, 2003](#)). In this paper, we use a novel field experiment to investigate to what extent differences in preferences, mainly driven by division of labor within the household, and differences in intra-household decision-making power lead to sub-optimal household decisions.

We created income-earning job opportunities for randomly selected wives, husbands and couples in the Tigray region of Ethiopia and conducted a real improved stove purchase experiment. The improved stove we offer, known as the "mirte stove", reduces fuelwood consumption by 50%, protects the cook from flames, and reduces smoke and indoor air pollution significantly.¹ Consequently, it enhances the welfare of women, who are the default cooks of the household and are responsible for fuelwood collection, more than for men.² We use the Becker-DeGroot-Marschak (BDM) method ([Becker et al., 1964](#)) to elicit willingness to pay (WTP) by our subjects. BDM is an incentive-compatible method of eliciting WTP because subjects make real trade-offs when they make decisions ([Alem and Dugoua, 2017](#); [Hoffman, 2009](#); [Lusk et al., 2001](#)). We refer to the joint WTP (revealed by the couple) as the "household-level preference" and the individual WTP revealed by wives and husbands as "wives' preference" and "husbands' preference" respectively. Preferences revealed in this way show to what extent the "household-level" preference resembles the wives' or the husbands' preference. However, individual/joint preferences may still be confounded by decision-making autonomy (power) within the household. For example, a wife who has low decision-making autonomy (power) may reveal a low WTP in the individual decision, not because she does not want the improved stove, but because she knows that her husband, who is the default head of the household, will not approve such a purchase. Thus, a low-power wife will very likely reveal the preference that her husband would normally reveal. In view of this, ignoring the

¹See "<http://stoves.bioenergylists.org/stovesdoc/Bess/Mirte.htm>" for a description of the "mirte" stove.

²In many developing countries, children also benefit from reduced fuelwood collection time and reduced indoor air pollution ([WorldBank, 2011](#)).

intra-household power relations in a patriarchal society may lead to an incorrect conclusion about household WTP for the new technology.

Observed bargaining power within the household, which we use as the key variable to explain WTP, is however likely to be endogenous. Drawing on sociological and anthropological literature (Dyson and Moore, 1983), and considering the cultural context of the study area, we use two valid instrumental variables (death of male siblings of the spouses and the spouses' birth order) to identify the impact of low intra-household bargaining power by women on their investment decisions. In patriarchal societies such as rural Ethiopia, a wife with a large number of adult male siblings is more likely to be protected and respected in her household and community. An exogenous shock to this variable is highly likely to affect the intra-household bargaining power of the wife within the household and the community. Moreover, in the context of the study area, a wife who is the first-born female in her family is likely to receive more assets from her family during her wedding and, thus, will very likely have more assets under her control. Neither the death of the wife's male siblings nor the wife's birth order affects stove purchase decisions directly except through decision-making power. These instruments are therefore relevant and exogenous, satisfying the key requirements of a valid instrument.

Experimental results suggest that wives, who by default are the household cooks and are responsible for fuelwood collection, are willing to pay 60% more than husbands for the improved stove, and wives who make the decision individually are willing to pay 40% more than those who make the decision together with their husbands. However, there is no statistically significant difference between husbands who make the decision individually and those who make the decision jointly with their wives. Instrumental variables tobit regressions show that wives who have high autonomy in decisions regarding the purchase of own material items are willing to pay 200% more than are husbands who are autocratic (i.e., those who do not allow wives to make such decisions). The results are robust to alternative specifications and definitions of decision-making power. A household survey conducted 15 months after the stoves were offered shows that decision-making power does not have any effect on how quickly the stove was put in use. Our results highlight that differences in preferences, driven by division of labor within the household, and differences in bargaining power among women and men have significant impacts on the speed of adoption of modern technologies that improve the welfare of all members of the household.

This paper contributes to a body of research in economics on intra-household decision-making. Previous studies in developed countries (Browning et al., 1994; Chiappori, 1992; Mazzocco, 2007) reject the collective model of the household, which assumes that household members achieve Pareto-efficient outcomes even if they have different preferences and bargain over possible outcomes.³ In a

³Other studies conducted in developed countries (Bourguignon et al., 1993; Browning and Chiappori, 1998; Chiappori et al., 2002), however, document evidence consistent with efficiency.

developing country context, [Udry \(1996\)](#), in Burkina Faso, rejects Pareto efficiency at the household level by showing that plots managed by women are cultivated much less intensively than similar plots within the household managed by men, while [Robinson \(2012\)](#), in Kenya, finds risk-sharing in the household to be Pareto-inefficient. Adding solid evidence to this, more recently, [Schaner \(2015\)](#) documents that poorly matched spouses in urban Kenya forgo a significant amount of income due to differences in time preferences, and [Almås et al. \(2015\)](#) show that women in urban Macedonia are willing to sacrifice household income to gain control over resources. Using both experimental and instrumental variables estimation strategies, we add solid evidence to this literature by isolating the impact of preference differences from the impact of bargaining power on household decisions and efficiency.

The paper also speaks to the literature on technology adoption in developing countries. Modern technologies, such as improved seed, fertilizer, insecticide-treated bed nets, water purifiers, improved cookstoves, and solar powered lighting devices significantly improve productivity and welfare of poor communities, but their adoption and diffusion rates have been sub-optimally low. Some of the key reasons include uninsured risk ([Alem et al., 2010](#); [Dercon and Christiaensen, 2011](#); [Lamb, 2003](#)), liquidity constraints ([Alem et al., 2017](#); [Cohen and Dupas, 2010](#); [Dupas, 2014](#); [Giné et al., 2008](#); [Grimm et al., 2017](#); [Tarozzi et al., 2014](#)), behavioral biases ([Duflo et al., 2011](#)), and limited experimentation ([Conley and Udry, 2010](#); [Foster and Rosenzweig, 1995](#)). The paper most closely related to ours, [Miller and Mobarak \(2013\)](#), points out a new reason - gender differences in preferences within households - to explain the low adoption of improved cookstoves. These authors offer either a “health-improving” or a “budget-saving” stove at randomly assigned prices to both women and men in rural Bangladesh. They document that women appear to show a stronger preference for any improved stove when offered for free, but, when a small price is charged for either stove, women become less likely than men to adopt, implying their lack of authority to make a purchase. Our identification strategies allow us to clearly show the impact of preference differences and the magnitude of the impact of decision-making power within the household on WTP, which is a continuous measure of adoption. Moreover, our outcome variable of interest - average WTP by households - is of key importance to policymakers and other stakeholders, who need to estimate the amount of resources required to speed up adoption in cases where revealed WTP is less than the cost of production, which appears to be true in our case.

The rest of the paper is organized as follows. Section 2 describes the context, data and experimental design. Section 3 presents the conceptual framework, which motivates our empirical strategy. Section 4 describes the variables of interest and the empirical strategy. This section also presents a thorough motivation of our instrumental variables, which we use to address endogeneity of autonomy in decision-making. Section 5 presents descriptive results from our experiments, re-

gression results from an instrumental variables tobit estimator, and key robustness checks. Finally, Section 6 concludes the paper.

2 Context, Data and Experimental Design

2.1 *Context*

The survey and experiment were conducted in the Tigray region of Ethiopia. The Tigray region, in the North of the country, comprises the three main agro-ecological zones of the country, “Dega”, “Weynadega” and “Kola”. It is also a region where households have differing access to fuelwood, some with relatively high access, others with low access. Households in the areas with low access to fuelwood have to travel on average 30 km/day to collect fuelwood, while those in high-access areas travel only 6 km/day. Having such a variation in climate and forest conditions provides a favorable opportunity for the improved stove purchase experiment, because the demand for an improved stove may vary depending on weather and access to fuelwood.

Improved stoves have been introduced in Ethiopia in general and in the Tigray region in particular since the 1980s. Different government and non-government institutions have been involved in the development and dissemination of several types of biomass cookstove technologies ([Gebreegziabher et al., 2006](#)). However, the efforts made by these institutions to disseminate the various types of improved stoves have not been very successful, partly due to technical problems related to the stoves themselves (some of the stoves were not really improved or were poor quality) and partly due to negative perceptions by households ([Plan and Finance, 2011](#)). Unlike the old generation of improved stoves that were used in previous programs, the new stoves, known as “mirte” stoves, have quality control assurance during the manufacturing process, and use energy more efficiently with better combustion ([Gebreegziabher et al., 2006](#); [Plan and Finance, 2011](#)). Because of its superior technical design, the “mirte” stove reduces fuelwood consumption by 50%, protects the cook from flames, and reduces smoke and indoor air pollution significantly. However, even with such improvements in efficiency and quality, the adoption rate of the stove is disappointingly low. For example, in the Tigray regional state, take-up of the stove is less than 1% ([Plan and Finance, 2011](#)).

2.2 *Data collection*

Baseline and follow-up surveys were conducted in 12 randomly selected villages (kushets) in the region representing the major weather and forest conditions. For the baseline survey, a total of 600 sample households were randomly selected from these villages (i.e., 50 households from each village). A total of 300 households were used for the stove purchase experiment from six villages where the new generation of improved stove had not been introduced. The remaining 300 households were

selected from six other villages which also received the improved stove for free. These households will be used to assess the impact of the stoves in a different study.

We conducted the baseline survey two weeks before the stove purchase experiment and free distribution of the improved stoves. In these villages, after a short introduction about the study by village cadres and enumerators, both husbands and wives were asked if they were willing to be interviewed. If both agreed, the village cadre left and the interview began. Both spouses in all households were available and volunteered to be interviewed. We conducted the survey with one village at a time, i.e., all the 15 enumerators we hired interviewed all 50 subjects in most villages, except in two of the free distribution villages, where 48 and 49 households were interviewed. In the survey, households were asked about fuelwood collection and use, cooking practices, awareness about the adverse consequences of cooking with traditional stoves, awareness about improved cookstoves, household decision-making power, and other socioeconomic variables. About 15 months after the baseline survey, we conducted a follow-up survey of all households that participated in the baseline survey. In addition to most of the information collected during the baseline, we collected detailed information on stove use and experience in the follow-up.

2.3 Experimental Procedure

In the villages where the stove purchase experiment was conducted, 10 representative husbands, 10 representative wives and 30 joint couples from each village were randomly recruited to participate in the experiment. We informed the subjects that they were randomly selected to come to the farmers training center on a specified date for two to four hours of compensated physical work (weeding) and for two more hours to participate in a study. In order to avoid information spread, pre-experiment spousal influence and self-selection in attending the experiment, no information was provided about the stove purchase experiment prior to arriving at the farmers training center. All those randomly selected were willing to come and participate in the physical work and the experiment. The physical work was introduced to ensure that subjects would buy the improved stove using income earned from this work. Conducting an experiment with real labor income offers the advantage of observing the extent to which households can commit to purchase decisions using income obtained in exchange for labor. This is important because almost all households in the study area depend on earned income (mainly agricultural income). Our aim was to make the experiment as realistic as possible and reduce the risk that subjects might treat windfall income and earned income differently in the decision to buy the stove. This is in line with the theory of mental accounting, which stipulates that consumers tend to arrange expenditures into separate mental accounts and how the money is spent depends on how it is acquired (Clingingsmith, 2015; Hoffman, 2009; Thaler, 1990). These studies document that subjects are likely to share less from

an earned dollar than from a windfall dollar. [Christiaensen and Pan \(2012\)](#) found that farmers in China and Tanzania tend to spend earned and unearned income differently, the former on necessity goods/services and the latter on alcohol and other luxury items. Our subjects made their purchase decisions using earned income.

In cooperation with the administrators of the farmers training centers, as well as village leaders and village cadres who were involved in the baseline survey, we organized farmers to arrive at the place of the experiment at different time schedules. Representative husbands/wives who were invited to come alone arrived at 8:00 a.m. and representative couples arrived at 10:00 a.m. We had 100% show up on time because, two weeks before the experiment, village leaders and village cadres reminded the subjects that, if they arrived late, they would be excluded from the list of those who would participate in the compensated work. Upon arrival, the representative husbands/wives were told to weed for four hours per person in the center plots and stay for two more hours for the study, while the representative couples were required to weed for two hours per person and stay for two more hours for the study. It was required that both partners work for these hours.⁴ They were also informed that, at the end of the study, remuneration would be paid in proportion to the time invested. A representative husband/wife who worked alone for four hours would earn ETB 150 (USD 7.5)⁵ and a couple who worked together for two hours would also get ETB 150. Subjects were also informed that it was not possible to choose only one of the two activities (either weeding or participating in the experiment). No payment would be given if they did not participate in both activities. All subjects agreed to these terms and participated in both activities.

After completing the weeding task, we gathered all the subjects (50 subjects per village) in one place and gave them a demonstration of the attributes of the new improved stove. In the demonstration, the experimenter explained the fuel saving, smoke reduction, time saving, life span and other attributes of the stove. The same demonstrator was used in all villages to avoid the effect of the demonstrator. Once the demonstration was done, we divided the subjects into five groups and placed them in separate places that were far apart. The groups were: a group of representative wives who were invited alone and would make the stove purchase decision alone using the income they had earned individually; a group of representative husbands who were invited alone and would make the stove purchase decision alone using the income they had earned individually; a group of wives who were invited with their husbands and would make the stove purchase decision alone using the income the couple had earned; a group of husbands who were invited with their wives and would make the stove purchase decision alone using the income the couple had earned; and a group of couples who would make the stove purchase decision jointly using the income the couple had earned.

⁴Lunch and other refreshments were provided to all subjects and the survey team between the manual work and the experimental sessions.

⁵At the time of the experiment, 1 ETB = 0.05 USD.

Figure 1 presents a summary of the groups and number of subjects in each group. In the groups, we therefore had subjects who made decisions individually using individually earned income, while others decided individually using jointly earned income. We introduce this design to investigate to what extent husbands and wives treat individually earned income and “household” or “joint” income differently in the purchase decisions. With this approach, we can test the hypothesis in the intra-household literature that women in developing countries have limited access to household income to make material purchases for themselves and their children (Kishor and Subaiya, 2008; Miller and Mobarak, 2013; Orfei, 2012).

Figure 1 about here

In each of these five groups, we asked the subjects to make the purchase decision based on the Becker-DeGroot-Marschak (BDM) random price mechanism. This method has been used in other contexts, for example to elicit WTP for mosquito bed nets (Hoffman, 2009), for tender beef steak (Lusk et al., 2001), and for solar lanterns (Alem and Dugoua, 2017). The mechanism works as follows: participants were asked to bid a price for an improved stove by stating their maximum willingness to pay. Subjects were given a color copy of currency notes representing actual currency and an envelope in which to place the maximum amount they were willing to pay for the stove. At the end, all five groups were gathered in one place and a random price was selected from a bucket containing the following prices: 30, 45, 60, 75, 90, 105, 120, 135 and 150. The prices were unknown to the participants. Those who bid at or above the randomly drawn price would purchase the item at the price drawn, and those who bid below the price would not be allowed to purchase the stove. Under this procedure, it would be in the best interest of the participants to bid according to their actual valuation of the improved stove. In order to make the information flow consistent, one experimenter explained the mechanism of the BDM for all groups in all villages. Before the actual bidding for the improved stove, we conducted several practice sessions using pencils until all subjects understood the game. To make the bids for the stove as confidential as possible, subjects were placed as far apart as possible; we instructed subjects to keep their bids confidential. If they had questions, we asked them to raise their hands and the experimenter would give answers privately. They were told that, at the end, all groups would be gathered in one place and each subject would pick a random price from a bucket containing the prices set between 30 - 150 ETB.

3 Conceptual Framework

This section develops a framework to model willingness to pay for a household durable, taking into account differences in preferences and intra-household bargaining power between wives and husbands, and derives some testable predictions. We follow Anderson and Baland (2002) and

model a household comprising two members who are involved in decision-making (i.e., spouses), $i \in w, h$, a wife and a husband. Both members consume a private good c and a household durable S . There is a difference in preference and consequently in WTP for the household durable (S), the improved cookstove in this case. In the context of most developing countries and as supported by the descriptive statistics we present in the next section, improved cookstoves benefit women more than men because both cooking and fuelwood collection are women’s tasks.

For simplicity, consider a one-period utility maximization problem with two goods. The utility of the wife is given by

$$U^w = u(c) + \gamma S, \tag{1}$$

where c represents household consumption of private goods, $u(\cdot)$ is increasing and concave, and $S = 1$ when the household durable is purchased, and zero otherwise.⁶ The utility of the husband, on the other hand, is given by

$$U^h = u(c) + \eta S, \tag{2}$$

where $\eta < \gamma$, i.e., the husband gets a lower level of utility than the wife from the improved cookstove and, consequently, he is willing to pay less for it.

The purchase decision or WTP is therefore a utility maximization decision subject to budget constraints. The individual decides whether to pay the retail price (p) if

$$WTP \geq p. \tag{3}$$

Autonomy in decision-making may be confounded in the revealed WTP. Let WTP_w and WTP_h be observed willingness to pay of wives and husbands respectively, i.e., WTP revealed during the experiment. Let WTP_w^* and WTP_h^* represent the latent levels of willingness to pay that are free of direct spousal influence. Consider $(\alpha_w, \alpha_h) \in [0, 1]$ to be the wife’s and the husband’s decision-making power in the household. A value of 0 represents no power and 1 represents full power in decision making. Thus, $(\alpha_w + \alpha_h) = 1$.

A wife who purchases the stove in the absence of her husband might face a punishment D_w later if the husband does not want to have the stove.⁷ Suppose the probability of punishment is given by $1 - \alpha_w$. However, a husband who took part in the stove decision but who decided not to buy would also face a punishment D_h , given the stove would have benefited the wife. Assume the

⁶It is plausible to assume that the household durable S provides a flow of services for later periods as well (Besley et al., 1994). Relaxing the assumption in this way won’t change the predictions of the model.

⁷The punishments can be expressed in the form of arguments, nagging and yelling. See Ashraf (2009) for punishments couples exercise in a similar setting in rural Philippines.

probability of punishment by the wife is given by $1 - \alpha_h$. In the absence of spousal influence, wives and husbands will decide to buy the stove if the net benefits exceed 0, i.e.,

$$WTP_w^* - p \geq 0 \quad (4)$$

and

$$WTP_h^* - p \geq 0 \quad (5)$$

respectively. If the wife's and the husband's preferences match, neither of the spouses will face any punishment even if they have low decision-making power. The probability that the husband likes (approves) the purchase decision of the wife is given by

$$\phi^h(WTP_h^* - p \geq 0) = 1 - \Phi^h(p) \quad (6)$$

where Φ^h and ϕ^h are the cumulative and density probability functions of WTP_h^* respectively, i.e., the husband's latent WTP. Consequently, a wife taking part in the stove purchase experiment will purchase the stove if her expected payoff ≥ 0 , i.e.,

$$E[\text{payoff}]_w = [(1 - \Phi^h(p))(WTP_w^* - p) + \Phi^h(p)(\alpha_w(WTP_w^* - p) + (1 - \alpha_w)(WTP_w^* - p - D_w))] \geq 0 \quad (7)$$

$$= WTP_w^* - p - (1 - \alpha_w)\Phi^h(p)D_w \geq 0 \quad (8)$$

Using Equations 4 and 8, the revealed WTP of a wife who makes the stove purchase decision in the absence of her husband is given by

$$WTP_w = WTP_w^* - (1 - \alpha_w)\Phi^h(p)D_w \quad (9)$$

Equation 9 demonstrates that a wife's revealed and latent WTP will diverge if she has no autonomy in decision-making. In other words, she will reveal WTP that will very likely be accepted by her husband, i.e., his WTP.

The husband who makes the stove purchase decision in the absence of his wife may face punishment, depending on his decision-making power, if he decides not to buy the stove. In this case, the probability that the wife accepts her husband's decision not to buy the stove is given by

$$\phi^w(WTP_w^* - p \leq 0) = \Phi^w(p) \quad (10)$$

where Φ^w and ϕ^w are the cumulative and density probability functions of WTP_w^* respectively, i.e., the wife's latent WTP. The husband will therefore buy the stove if his expected payoff from the purchase is ≥ 0 .

$$E[\text{payoff}]_h = \Phi^w(p)[WTP_h^* - p] + (1 - \Phi^w(p))[\alpha_h(WTP_h^* - p) + (1 - \alpha_h)(WTP_h^* - p + D_h)] \geq 0 \quad (11)$$

$$= WTP_h^* - p + (1 - \alpha_h)(1 - \Phi^w(p))D_h \geq 0 \quad (12)$$

Using Equations 5 and 12, the husband's revealed WTP will therefore be given by

$$WTP_h = WTP_h^* + (1 - \alpha_h)(1 - \Phi^w(p))D_h. \quad (13)$$

Equation 13 shows that the revealed WTP of the husband is inversely related to his decision-making power in the household. If the wife has high decision-making power, the husband's revealed preference will converge to his wife's preference. For the spouses who make the stove purchase decision jointly, the revealed willingness to pay may therefore represent each spouse's latent WTP depending on their bargaining power.

4 Empirical Strategy

4.1 Variables

Alternative approaches have been used in the empirical literature to estimate the impact of decision-making power on various household outcomes. One approach is to use indirect measures of power from survey data, such as an individual member's asset ownership, income share, or education, and link this measure to observed household outcome. In this approach, a woman/man with a higher share of assets or income in the household is assumed to have greater decision-making power. The most frequent income and asset types used in the literature are unearned income such as transfers (Duflo, 2003; Schultz, 1990; Thomas, 1990), inherited assets (Quisumbing, 1994), assets brought into marriage and current assets (Quisumbing and de la Briere, 2000). The key limitation of this approach is that it does not directly show how individual preferences affect household decisions, because individual and household (joint) preferences are not separately observed, i.e., one cannot tell whether the observed choice of a member is taken at her/his own preference or at the behest of the other spouse. Moreover, these indirect proxy measures are subject to selection and omitted variables biases. Some authors, (e.g., Duflo, 2003), have used a quasi-randomized experiment to

eliminate this bias.

Another survey-based approach is to use a direct measure of power of members and link it with observed household outcomes. In this regard, couples are asked survey questions about whether they have the final say about specific or multidimensional household decisions (Allendorf, 2007; Becker et al., 2006; Chakraborty and De, 2011; Friedberg and Webb, 2006; Mabsout and van Staveren, 2010). In this approach, individual preferences are assumed to be reflected in the observed household choices where the individual has high decision-making power. This measure may also be subject to omitted variables biases, but it can be addressed using exogenous instruments, if available. For example, Chakraborty and De (2011) used distance to natal family as an exogenous instrument for decision-making power measured in this way. As discussed below, we use this approach in an instrumental variables framework to address endogeneity of reported decision-making power.

The final approach is to use lab-in-the-field experiments and directly estimate the influence of household members on joint decisions (Carlsson et al., 2012,1; De Palma et al., 2011; Yang and Carlsson, 2012). The advantage of this approach is that both individual members' preferences and their joint (household-level) decisions are observed. It is therefore possible to directly estimate the extent to which household (joint) decisions are influenced by individual spouse preferences (decisions). However, it is difficult to make causal claims on spousal influence captured in this way, because individual decisions can be confounded by the unobserved decision-making power of the subjects in the household. Despite this limitation, the approach provides useful insights because it reveals both individual and joint choices of the same household, which are difficult to elicit using observational data. Our approach also follows a similar experimental set-up to elicit individual and joint WTP and their difference. Most recently, Almås et al. (2015) use a novel strategy to identify decision-making power using a lab-in-the-field experiment, where they elicit WTP by women for gaining control over household income.

Outcome Variable

We conduct the stove purchase experiment on representative husbands, wives and joint couples recruited from different households to elicit WTP for the stove, our outcome variable of interest. As long as these representative husbands, wives and joint couples are selected randomly, we can consider their revealed WTP to represent the individual and joint preferences, respectively, of the same household. By comparing individual husband's and wife's preferences with the preferences of couples, we can infer the extent of spousal influence on joint decisions. However, revealed individual preferences may be confounded by decision-making autonomy (power) in the household. We control for a direct measure of decision-making power and instrument it with two valid instruments using an IV tobit estimator to identify its impact. Below, we motivate the instruments and discuss how the decision-making autonomy variable - our key explanatory variable of interest - has been

constructed.

Explanatory Variable of Interest and Instruments

Taking the patriarchal nature of the society into account, we use the term “autocratic” if the husband makes the decision(s) on his own, “moderate” if he makes the decisions with his wife and “non-autocratic” if he lets his wife decide on her own. Conversely, a wife has “high autonomy” if she can make the decision on her own, “moderate autonomy” if she makes the decision with her husband and “low autonomy” if her husband makes the decision.

Our measure of autonomy (or autocracy) is a continuous variable based on the response of husbands and wives to survey questions about decisions regarding the wife’s personal expenditures (e.g., purchase of clothes and shoes). For robustness checks, we also ask questions on decisions regarding the purchase of household durables. For each of these two decision categories, we assign a value of 1 when the wife reports she has full autonomy to decide (i.e., the husband is non-autocrat), 2 when she reports both make the decision (the husband is moderately autocrat), and 3 when she reports her husband makes the decision (the husband is autocrat). These two decisions are important in this particular context for two reasons: the stove is generally a durable household item, but husbands and wives may treat it as a good that disproportionately benefits the wife.

Taking advantage of the circumstances and cultural norms in the study area, we use birth order of couples and death of male siblings as exogenous instruments for decision-making power of the couples. In the study area, land is one of the assets that couples bring to marriage. Couples get land from their parents and the amount of land brought to the marriage depends on their birth order. A wife/husband who is first in birth order is more likely to get married earlier and get more land from the parents than a wife/husband with a later birth order. Upon separation, the husband/wife does not have a claim on the land because legally it is registered in the name of the wife’s/husband’s parents. In addition, a wife who is first in birth order is likely to bring more assets into marriage, as elder siblings are more respected and parents are likely to receive more gifts from friends and relatives during the wedding. Therefore, a wife who is first in birth order is more likely to have more assets under her control and hence more decision-making power than a wife with the later birth order. This instrument is exogenous and is not directly related to stove purchase decisions, except through decision-making power.

The second instrument, death of male siblings of spouses, is related to the influence of natal kin on the position of women in the household and community. Drawing on sociological and anthropological literature (Dyson and Moore, 1983) and consistent with circumstances in the study area, a wife with more adult male siblings is more likely to be protected, respected and get more material support than a wife who has more female siblings. A shock to this variable is likely to directly affect the bargaining power of a wife and indirectly affects her stove purchase decision. A

test for validity of the instruments can be performed using versions of the Sargan or Basman test of overidentifying restrictions (Baum et al., 2016).

4.2 Instrumental Variables Tobit

In the BDM experiment, we ask subjects to bid for the improved cookstove using the money they earned from the manual work. Because the BDM design is incentive compatible, subjects are expected to reveal their true preferences through their maximum WTP for the cookstove. However, their WTP may be bounded by the amount of money they earn from the manual work, which was set at 150 ETB. Our key empirical model is therefore an instrumental variables tobit model, which considers the censored nature of the data and takes care of endogeneity of decision-making power using the two instruments we motivated in the preceding sub-section. The model is specified as follows:

$$WTP_i^* = \mathbf{d}_i\boldsymbol{\beta} + \mathbf{x}_i\boldsymbol{\gamma} + u_i \quad (14)$$

$$\mathbf{d}_i = \mathbf{x}_i\boldsymbol{\Pi}_1 + \mathbf{z}_i\boldsymbol{\Pi}_2 + \mathbf{v}_i \quad (15)$$

where $i = 1, \dots, N$; \mathbf{d}_i is a $1 \times p$ vector of endogenous variables (decision-making autonomy or autocracy in our case); \mathbf{x}_i is a $1 \times k_1$ vector of control variables; \mathbf{z}_i is a $1 \times k_2$ vector of additional instruments; and the equation for the endogenous variable (equation 15) is expressed in reduced form. $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are vectors of structural parameters, and $\boldsymbol{\Pi}_1$ and $\boldsymbol{\Pi}_2$ are matrices of reduced-form parameters. WTP_i^* is not observable to the researcher; instead the researcher observes

$$WTP_i = \begin{cases} a & WTP_i^* < a \\ WTP_i^* & a \leq WTP_i^* \leq b \\ b & WTP_i^* > b \end{cases} \quad (16)$$

For the structural parameters to be identified, $k_2 \geq p$. It is also assumed that (u_i, \mathbf{v}_i) is a multivariate normal with covariance matrix

$$Var(u_i, \mathbf{v}_i) = \boldsymbol{\Sigma} = \begin{bmatrix} \sigma_u^2 & \boldsymbol{\Sigma}'_{21} \\ \boldsymbol{\Sigma}_{21} & \boldsymbol{\Sigma}_{22} \end{bmatrix} \quad (17)$$

The structural parameters of the model can be estimated using either the maximum likelihood estimator or Newey's efficient two-step estimator (Wooldridge, 2010). The maximum likelihood estimator has been shown to have difficulty in converging, especially if the endogenous variables

are more than one. The Newey’s two-step estimator, on the other hand, converges easily. In this paper, we use Newey’s estimator, which is estimated in STATA using the *ivtobit* command with the “two-step” option.

5 Results

5.1 *Baseline Characteristics*

Table 1 presents summary statistics from the baseline survey both at the spouse level and the household levels. First, means and standard deviations are reported in Columns 1 (Wives) and 2 (Husbands). Column 3 presents statistical tests on mean differences between the two samples. From Panel A, wives on average are almost 3 years younger, and have less political participation (27%) and involvement in off-farm work (30%), while about 56% of husbands report political participation, and 68% are involved in off-farm work. Fuelwood collection seems to be predominantly the wives’ task, with about 82% of wives involving in collection, while only 27% of husbands are involved in fuelwood collection. From Panel B, we observe that, on average, households spend about 0.44 hours in collecting 1 kg of fuelwood, and spend a total of about 48.8 hours to collect fuelwood every month. Households in the study area on average collect about 234.4 kg of fuelwood per month. These descriptive statistics reveal the significant reliance of rural households on biomass fuelwood and the substantial burden that women in developing countries carry to meet the cooking needs of the household.

Table 1 about here

Table 2 shows descriptive statistics on decision-making autonomy of wives in purchase of their own material items. We can see that about 47% of wives perceived themselves as having a low level of autonomy to make decisions regarding purchases of their own material items. On the other hand, around 45.5% of husbands consistently perceived their dominance (autocracy) in purchase decisions of their wife’s material items, i.e., they make the final decision on purchase of their wife’s material items. Table A.1 in the appendix presents descriptive statistics on autonomy in decision-making regarding purchase of household durables. These descriptive statistics imply that women in the study area lack autonomy in decision-making and support the hypothesis that the men are usually the default heads of households who control the households’ cash accounts. Overall, the gender-specific summary statistics presented are in line with existing evidence in developing countries on gender differences (e.g., [Anderson and Baland, 2002](#); [Hoddinott and Haddad, 1995](#); [Miller and Mobarak, 2013](#); [Pitt and Khandker, 1998](#)). Women work more at home and less for wage income, have low political participation, and lack autonomy regarding major household decisions.

Table 2 about here

5.2 *Experimental Results*

Mean WTP by wives, husbands and couples during purchase decisions conducted individually and jointly are reported in Table 3. Results show that wives who make the purchase decision individually are generally willing to pay ETB 35.67 (60%) more than husbands who make the decision individually. This difference is statistically strong, being significant at the one percent level in a two-sample comparison t-test. Wives who make the stove purchase decision individually are also willing to pay ETB 27.33 (40%) more than wives who make the decision with their husbands. Husbands who make the purchase decision jointly with their wives are willing to pay ETB 8.33 (14%) more than husbands who made the decision individually. However, this difference is not statistically significant at conventional levels. These results highlight both the strong preference difference between wives and husbands for the improved cookstove and the degree of spousal influence in household-level decision.

Table 3 about here

We further explore the difference in WTP between wives and husbands by taking into account the difference in intra-household decision making power of wives. Table 4 presents mean comparison tests between the sample of wives and husbands depending on wives' decision-making power on purchase of their material items. Results in Panel A suggest that wives who have high autonomy and make the stove purchase decision individually are willing to pay ETB 141.43, while those with low autonomy and make the stove purchase decision individually are willing to pay only ETB 61.44. This translates into about 130% more WTP by autonomous wives. WTP for the stove declines by only 14% when autonomous wives make the stove purchase decision jointly with their husbands. However, for wives with with low level of autonomy, WTP declines by about 35% when they make the stove purchase decision jointly with their husbands.

Panel B of Table 4 presents WTP of husbands based on their level of autocracy. Results reveal that there is no statistically significant difference in WTP between husbands who make the stove purchase decision individually and those who make the decision jointly. On average, husbands who are autocratic regarding the purchase of their wife's material items are willing to pay ETB 45.89, only around one-third of the full cost of the improved stove (ETB 150) when making the stove purchase decision individually, while non-autocratic husbands are willing to pay on average ETB 106.67, which translates into 132% more than autocratic husbands. Taken together, the results provide suggestive evidence on the possible role of women's decision-making autonomy in adoption decision of improved household technologies, such as improved cookstoves.

Table 4 about here

Does empowering women improve their decision-making power within the household? In order to shed light on this question, we let randomly selected wives, husbands and couples work for cash

to earn money and participate in the stove purchase experiment. We let both wives and husbands decide on the use of both individually and jointly earned income from the work. Experimental results for this set of the BDM game are presented in Table 5. Results indicate that wives who are fully entitled to earnings (they work and earn individually and make the stove purchase decision individually) are willing to pay 25% more than wives who use household (joint) income from the experiment. The difference is statistically significant at the one percent level. However, there is no significant difference in husbands' willingness to pay between individual and household (joint) earnings. Husbands do not seem to differentiate between these two income sources. The results of this part of the experiment have important implications on the role of empowering women in improving their decision-making power within the household.

Table 5 about here

5.3 *Econometric Results*

In this section, we investigate the causal relationship between decision-making power within the household and WTP by wives, husbands and couples using tobit estimators. We begin with the standard tobit estimator, which treats decision-making power of wives - our key variable of interest - as exogenous. Regression results are reported in Table 6. Column [1] reports WTP by the wives sample, Column [2] by the husbands sample, and Column [3] by the pooled sample, in which the gender of the participant is interacted with decision-making power and with whether the stove purchase decision was made individually or jointly. In all specifications, we control for individual characteristics, household characteristics and village fixed effects. Results in Column [1] suggest that wives' autonomy in decision-making on purchase of their material items has a strong positive impact on their willingness to pay for the improved stove. Consistent with the descriptive results presented in the preceding sub-section, compared to wives who make the stove purchase decision together with their husbands, wives who make the purchase decision individually are willing to pay about 20.08 ETB more. Both these effects are statistically significant at the one percent level. Results in Column [2] indicate how WTP declines with autocracy in household decision-making by husbands, an effect statistically significant at the one percent level. Results from the pooled sample, reported in Column [3], also confirm the findings in Columns [1] and [2] that husbands who are autocratic are willing to pay less (compared to non-autocrat husbands), and husbands who make the stove purchase decision individually are also willing to pay less (compared to those who make the decision together with their wives).

Table 6 about here

It is plausible to suspect that the point estimates of our key variable of interest - wives' decision-making power - obtained from the standard tobit are biased because of endogeneity. Omitted

variables bias due to measurement error and/or due to unobserved individual heterogeneity, such as spouses' ability to persuade each other, are likely to contribute to endogeneity of the power variable. In order to address this, we estimated instrumental variables tobit regressions using birth order of the spouses and death of male siblings as instruments. The first-stage relationships between the two instruments and the decision-making power reported in Table 7 are strongly negative: birth order and death of male siblings are both significantly related to decision-making power at the 99 percent confidence level, conforming their relevance. We further conduct a weak instruments test for such types of models following [Finlay and Magnusson \(2009\)](#) and reject the null hypothesis of weak instruments. This relationship is robust to the inclusion of controls and village fixed effects. Wives who were born first (earlier) are likely to be autonomous, while those who experienced death of male siblings after their marriage are likely to have less autonomy in decision-making. These results clearly indicate that the two instruments are relevant. We test exogeneity of the instruments using the versions of the Sargan or Basman test of overidentifying restrictions test, the Amemiya-Lee-Newey overidentification test, which tests for the null hypothesis that the excluded instruments are valid. A rejection of the null casts doubt on the validity of the instruments. The null hypothesis of exogeneity is not rejected in all regressions, implying that our instruments are exogenous.

Table 7 about here

The second-stage of the IV tobit equation estimates the impact of decision-making power on willingness to pay for the improved cookstoves. The results are presented in Table 8, Columns [1]- [3], for the wives, husbands and the pooled samples. Autonomy in decision making by wives strongly increases their WTP for the improved cookstoves and the effect is significant at the 99% confidence interval. The coefficient on the power variable for wives increased from 33.12 ETB in the standard tobit regression to 40.25 in the IV tobit. This is equivalent to about a 21.5% increase in the coefficient, providing strong evidence for the importance of addressing endogeneity of decision-making power. The coefficients of the variables indicating individual decision and decision using income earned individually by wives also increase after controlling for endogeneity of decision-making power, although the changes are not as large as coefficient on decision-making power. Results in Column [2], on the other hand, confirm that WTP by husbands declined further after controlling for endogeneity of decision-making power.

Table 8 about here

5.4 *Robustness Checks*

We investigate robustness of our results using alternative definitions of intra-household bargaining power and regressions. First, we re-construct the decision-making power (autonomy/autocracy) variable using the response to the question regarding decision making on purchase of household

durables. Following the definition of the power variable in decision-making on the wife’s material items, we construct the power variable in decision-making on household durables as a continuous variable, where 3 stands for complete autocracy by husbands and 1 for non-autocracy (i.e., the wife autonomously makes the decision). Table A.1 in the appendix shows that 49.5% of wives lack the autonomy to decide on household durables and only 26% feel that they have complete autonomy to make such decisions. These descriptive statistics are quite similar to the descriptive statistics on autonomy of wives in purchase of their own material items presented in Table 2.

We then investigate WTP for improved stoves based on the level of decision- making power on purchase of household durables. Mean WTP comparison results presented in Table A.2 (Panel A) in the appendix suggest that wives who have high autonomy and make the stove purchase decision individually are willing to pay more than twice what autocratic husbands who make the stove purchase decision individually (Panel B) are willing to pay. The results in the joint purchase decision of improved stoves are also similar to the ones we found using wives’ decision-making power on purchase of own material items. Wives who have more autonomy in decision-making for household durables are significantly willing to pay more than wives who lack autonomy.

Second, we re-estimate both the standard tobit and the instrumental variables tobit regressions using decision making autonomy for household durables. Tables A.3, A.4 and A.5 in the appendix present results from the standard tobit, IV tobit first-stage, and IV tobit main results respectively. The results are consistent with the ones we documented in the preceding section: wives who are autonomous in making decisions regarding purchase of household durables are willing to pay much more than husbands who are autocratic, and wives who make the stove purchase decision individually are willing to pay more than those who make the stove purchase decision together with their husbands.

Finally, we investigate whether decision-making power determines how quickly the improved stove is put in use. We conducted a follow-up survey on both groups of households, i.e., those who participated in the stove purchase experiment and those who received the cookstoves for free 15 months after the stoves were adopted. We collected detailed information on stove use, fuelwood collection, fuelwood consumption and time allocation. Table A.6 in the appendix reports instrumental variables linear (two-stage least square) regression results on the correlates of stove use measured by the number of months since the stove was in use. Results suggest that decision-making power does not have any impact on how quickly the stove is put to use once the household acquires the stove. This supports our hypothesis that decision-making power, rather than inability to understand the stove’s benefits, is the most important factor that hinders wives from purchasing the stove. Table A.6 also provides other useful insights on the correlates of the improved stove use. Column [3] shows that educated wives, those who participate in off-farm employment opportunities,

those who have more male adult household members, and children are very likely to use the stove for a longer period. Richer households, on the other hand, appear to use the stove for a shorter period of time.

6 Conclusions

This paper uses a field experiment to analyze the effects of differences in preferences and intra-household decision-making power on willingness to pay for a new household durable. The experiment was conducted using representative wives, husbands and couples from the Tigray region of Ethiopia. We invited randomly recruited subjects to participate in a public works project in order to earn income, which they were given the option to spend on the purchase of improved cookstoves. The stoves are a new generation of improved stoves called the “mirte stove” and have been proven to reduce fuel consumption by 50% and indoor air pollution by about 90%. Thus, they have a large potential for improving the wellbeing of all members of the household, but most importantly that of women and children. Motivated by the literature in sociology and anthropology, we use two exogenous instruments - birth order of the subjects and death of male siblings - to address endogeneity of decision-making power. A wife/husband who is first in birth order is more likely to get married earlier and get more land from parents than a wife/husband with a later birth order, which in turn improves their bargaining position in the household. Similarly, a wife with more adult male siblings is more likely to be protected, respected and get material support than a wife who has more female siblings (Dyson and Moore, 1983). A shock to this variable is likely to directly affect the power of a wife and indirectly affect a wife’s stove purchase decision. Neither of these instruments are expected to directly affect willingness to pay (WTP) for improved stove, satisfying the validity requirement of a credible instrument. Our experimental design and empirical strategy therefore allow us to tease out the role of both preference difference and decision-making power between women and men within the household, which is the key contribution of our paper.

We find strong evidence that difference in both preferences and intra-household bargaining power drive WTP for the improved cookstove. Wives who make the stove purchase decision individually in general are willing to pay 60% more for the improved stove than husbands. Wives who make the decision individually are willing to pay 40% more than those who make the decision together with their husbands. We don’t find a statistically significant difference between husbands who make the decision individually and jointly. Wives who have high autonomy in decisions regarding the purchase of their own material items are willing to pay more than twice that of husbands who are autocratic (one who does not allow his wife to decide on purchase of her own material items). A follow-up survey conducted 15 months after the stoves were offered shows that decision-making

power does not have any impact on how quickly the improved stove is put to use. This supports our hypothesis that, if wives do not purchase the stove, it is because of lack of autonomy rather than lack of interest in the stove. Our results remain robust to alternative definitions of decision-making power and alternative specifications.

The results here suggest that preference differences, mainly driven by division of labor in the household and women's lack of decision-making power have significant impacts on investment decisions on household durables that benefit all members of the household. Our results are consistent with previous studies ([Anderson and Baland, 2002](#); [Miller and Mobarak, 2013](#); [Schaner, 2015](#)) conducted in different set-ups and show that preference differences by couples lead to sub-optimal household decisions. Our results have policy implications that extend to many other technologies that can provide benefit to the entire household and improve welfare in poor communities. Very often, policymakers and other stakeholders, such as NGOs, face constraints on how to optimally distribute modern technologies. Our findings indicate that adoption can be increased significantly if the existing differences in division of labor and decision-making power within the household are taken into consideration. While empowering women is a long-term and relatively complex development outcome, the results suggest that simple and easy-to-design job opportunities, which entitle women to their own earnings, improve their decision-making power and benefit other household members, such as children.

References

- Alem, Y., Bezabih, M., Kassie, M., and Zikhali, P. (2010). Does fertilizer use respond to rainfall variability? Panel data evidence from Ethiopia. *Agricultural Economics*, 41(2):165–175.
- Alem, Y. and Dugoua, E. (2017). Passive learning and incentivized communication: A randomized controlled trial in india. Working Paper.
- Alem, Y., Ruhinduka, R., and Berck, P. (2017). Liquidity constraint, LPG stoves and charcoal consumption: A randomized controlled trial in tanzania. Working Paper.
- Allendorf, K. (2007). Do women’s land rights promote empowerment and child health in nepal? *World Development*, 35(11):1975–1988.
- Almås, I., Armand, A., Attanasio, O., and Carneiro, P. (2015). Measuring and changing control: Women’s empowerment and targeted transfers. NBER Working paper no. 21717.
- Anderson, S. and Baland, J.-M. (2002). The economics of roscas and intrahousehold resource allocation. *Quarterly Journal of Economics*, pages 963–995.
- Ashraf, N. (2009). Spousal control and intra-household decision making: An experimental study in the philippines. *American Economic Review*, 99(4):1245–1277.
- Baum, C. F., Wiggins, V., Stillman, S., and Schaffer, M. E. (2016). Overid v2.0. 8, 18 may 2016. Versions of a Sargan or Basman test of overidentifying restrictions. Available at: <http://fmwww.bc.edu/repec/bocode/o/overid.hlp>.
- Becker, G. M., DeGroot, M. H., and Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science*, 9(3):226–232.
- Becker, S., Fonseca-Becker, F., and Schenck-Yglesias, C. (2006). Husbands’ and wives’ reports of women’s decision-making power in western guatemala and their effects on preventive health behaviors. *Social Science and Medicine*, 62(9):2313 – 2326.
- Besley, T., Coate, S., and Loury, G. (1994). Rotating savings and credit associations, credit markets and efficiency. *Review of Economic Studies*, 61(4):701–719.
- Bourguignon, F., Browning, M., Chiappori, P.-A., and Lechene, V. (1993). Intra household allocation of consumption: a model and some evidence from french data. *Annales D’Economie Et De Statistique*, 29:137–156.
- Browning, M., Bourguignon, F., Chiappori, P.-A., and Lechene, V. (1994). Income and outcomes: A structural model of intrahousehold allocation. *Journal of Political Economy*, 102(6):1067–1096.
- Browning, M. and Chiappori, A. (1998). Efficient intra-household allocations: A general characterization and empirical tests. *Econometrica*, 66(6):1241–1278.
- Carlsson, F., He, H., Martinsson, P., Qin, P., and Sutter, M. (2012). Household decision making in rural china: Using experiments to estimate the influences of spouses. *Journal of Economic*

Behavior and Organization, 84(2):525 – 536.

- Carlsson, F., Martinsson, P., Qin, P., and Sutter, M. (2013). The influence of spouses on household decision making under risk: an experiment in rural china. *Experimental Economics*, 16(3):383–401.
- Chakraborty, T. and De, P. K. (2011). Mother’s autonomy and child welfare: A new measure and some new evidence. *IZA Discussion Paper Series*, (5438).
- Chiappori, P., Fortin, B., and Lacroix, G. (2002). Marriage market, divorce legislation, and household labor supply. *Journal of Political Economy*, 110(1):37–72.
- Chiappori, P.-A. (1992). Collective labor supply and welfare. *Journal of Political Economy*, 100(3):437–67.
- Christiaensen, L. and Pan, L. (2012). On the fungibility of spending and earnings evidence from rural china and tanzania. *World Bank Policy Research Working Paper*, (6298).
- Clingingsmith, D. (2015). Mental accounts and the mutability of altruism: An experiment with online workers. *Case Western Reserve University Working Paper*.
- Cohen, J. and Dupas, P. (2010). Free distribution or cost-sharing? evidence from a randomized malaria prevention experiment. *Quarterly Journal of Economics*, CXXV(1):1–45.
- Conley, T. G. and Udry, C. (2010). Learning about a new technology: Pineapple in ghana. *American Economic Review*, 100(1):35–69.
- De Palma, A., Picard, N., and Ziegelmeyer, A. (2011). Individual and couple decision behavior under risk: evidence on the dynamics of power balance. *Theory and Decision*, 70(1):45–64.
- Dercon, S. and Christiaensen, L. (2011). Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. *Journal of Development Economics*, 96:159–173.
- Duflo, E. (2003). Grandmothers and granddaughters: Old-age pensions and intrahousehold allocation in south africa. *The World bank Economic Review*, 17(1):1–25.
- Duflo, E., Kremer, M., and Robinson, J. (2011). Nudging farmers to use fertilizer: Theory and experimental evidence from kenya. *American Economic Review*, 101:2350–2390.
- Dupas, P. (2014). Short-run subsidies and long-run adoption of new health products: Evidence from a field experiment. *Econometrica*, 82(1):197–228.
- Dyson, T. and Moore, M. (1983). On kinship structure, female autonomy, and demographic behavior in india. *Population and Development Review*, 9(1):35–60.
- Finlay, K. and Magnusson, L. M. (2009). Implementing weak-instrument robust tests for a general class of instrumental-variables models. *The Stata Journal*, 9(3):398–421.
- Foster, A. and Rosenzweig, M. R. (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. *Journal of Political Economy*, 103(6):1176–1209.
- Friedberg, L. and Webb, A. (2006). Determinants and consequences of bargaining power in house-

- holds. *NBER Working Paper Series*, (12367):1–43.
- Gebreegiabher, Z., van Kooten, G. C., and van Soest, D. P. (2006). Land degradation in ethiopia: What do stoves have to do with it? *Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia*, pages 1–16.
- Giné, X., Townsend, R., and Vickery, J. (2008). Patterns of rainfall insurance participation in rural India. *World Bank Economic Review*, 22(3):539–566.
- Grimm, M., Munyehirwe, A., Peters, J., and Sievert, M. (2017). A first step up the energy ladder? low cost solar kits and household’s welfare in rural rwanda. *The World Bank Economic Review*, Forthcoming.
- Hoddinott, J. and Haddad, L. (1995). Does female income share influence household expenditures? evidence from cote d’ivoire. *Oxford Bulletin of Economics and Statistics*, 57(1):77–96.
- Hoffman, V. (2009). Intrahousehold allocation of free and purchased mosquito nets. *American Economic Review*, 99(2):236–241.
- Kishor, S. and Subaiya, L. (2008). Understanding women’s empowerment: A comparative analysis of demographic and health surveys (dhs) data. *DHS Comparative Reports*, (20).
- Lamb, R. (2003). Fertilizer use, risk and off-farm labour markets in the semi-arid tropics of india. *American Journal of Agricultural Economics*, 85(2):359–371.
- Lusk, J. L., Fox, J. A., Schroeder, T. C., Mintert, J., and Koohmaraie, M. (2001). In-store valuation of steak tenderness. *American Journal of Agricultural Economics*, 83(3):539–550.
- Mabsout, R. and van Staveren, I. (2010). Disentangling bargaining power from individual and household level to institutions: Evidence on women’s position in ethiopia. *World Development*, 38(5):783–796.
- Mazzocco, M. (2007). Household intertemporal behaviour: A collective characterization and a test of commitment. *Review of Economic Studies*, 74:857–895.
- Miller, G. and Mobarak, A. M. (2013). Gender difference in preference, intra-household externality and low demand for a new technology: Experimental evidence on improved cookstoves. *NBER Working Paper Series*, (18964):1–34.
- Orfei, A. E. (2012). *Essays on female empowerment and its health consequences in West Africa*. PhD thesis, University of Maryland.
- Phipps, S. A. and Burton, P. S. (1998). What’s mine is yours? the influence of male and female patterns of household expenditure. *Economica*, 65:599–613.
- Pitt, M. M. and Khandker, S. R. (1998). The impact of group-based credit programs on poor households in bangladesh: Does the gender of participants matter? *Journal of Political Economy*, 106(5):958–996.

- Plan, T. R. B. and Finance (2011). Tigray regional state five years (2010/11-2014/15) growth and transformation plan. Regional Government Report.
- Quisumbing, A. R. (1994). Intergenerational transfers in philippine rice villages: Gender differences in traditional inheritance customs. *Journal of Development Economics*, 43(2):167 – 195.
- Quisumbing, A. R. and de la Briere, B. (2000). Women’s assets and intrahousehold allocation in rural bangladesh: testing measures of bargaining power. *FCND discussion paper*, (86).
- Robinson, J. (2012). Limited insurance within the household: Evidence from a field experiment in kenya. *American Economic Journal: Applied Economics*, 4(4):140–164.
- Schaner, S. (2015). Do opposites detract? intrahousehold preference heterogeneity and inefficient strategic savings. *American Economic Journal: Applied Economics*, 7(2):135–174.
- Schultz, T. P. (1990). Testing the neoclassical model of family labor supply and fertility. *The Journal of Human Resources*, 25(4):599–634.
- Tarozzi, A., Mahajan, A., Blackburn, B., Kopf, D., Krishnan, L., and Yoong, J. (2014). Micro-loans, insecticide-treated bednets, and malaria: Evidence from a randomized controlled trial in orissa, india. *American Economic Review*, 104(7):1909–1941.
- Thaler, R. H. (1990). Anomalies: Saving, fungibility, and mental accounts. *Journal of Economic Perspectives*, 4(1):193–205.
- Thomas, D. (1990). Intra-household resource allocation: An inferential approach. *The Journal of Human Resources*, 25(4):635–664.
- Udry, C. (1996). Gender, agricultural production, and the theory of the household. *Journal of Political Economy*, 104(5):1010–46.
- Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, Cambridge, MA, 2 edition.
- WorldBank (2011). *Household COokstoves, Environment, Health, and Climate Change: A New Look at an Old Problem*. International Bank for Reconstruction and Development, Washington D.C.
- Yang, X. and Carlsson, F. (2012). Intra-household decisions making on intertemporal choices: An experimental study in rural china. *Working Papers in Economics, University of Gothenburg*, (537).

Table 1: Descriptive Statistics at Baseline

	[Wives]		[Husbands]		[Mean Diff.]	
	Mean	SD	Mean	SD	Diff.	SE
<i>Panel A: Individual Characteristics</i>						
Age	45.16	12.96	48.14	13.41	-2.98**	1.39
Years of schooling	1.61	1.68	1.34	2.19	0.27	0.21
Member of the ruling party	0.27	0.45	0.56	0.50	-0.28***	0.05
Participates in fuelwood collection	0.82	0.38	0.27	0.45	0.55***	0.04
Time spent on fuelwood collection/month (in hours)	32.50	27.88	1.48	2.97	31.03***	2.09
Participates in off-farm income activities	0.30	0.46	0.68	0.47	-0.38***	0.05
Number of male siblings died	0.44	0.76	0.44	0.85	0.01	0.08
Birth order	2.64	1.61	2.18	1.43	0.46**	0.16
Participants in indiv. stove purchase decision	120		120			
Participants in joint stove purchase decision	60		60	60		
Participants in indiv. stove purchase decision - indiv. income.	60		60	60		
Participants in indiv. stove purchase decision - joint income	60		60	60		
Observations	180		180		360	
<i>Panel B: Household Characteristics</i>						
Mean hours spent in collecting 1 Kg of fuelwood (shadow price)	0.44	0.43				
Household monthly time spent in fuelwood collection (in hours)	48.81	41.73				
Household monthly fuelwood collection (in kg)	234.40	181.78				
Household livestock ownership (TLU)	4.93	4.12				
Household wealth in 1000 ETB	34.96	39.26				
Household land size (in Timad)	3.05	2.21				
Number of trees the household owns	12.04	33.47				
Number of adult males (age >15)	0.63	0.98				
Number of adult female (age >15)	0.64	0.97				
Number of male youth (age 7-15)	0.69	0.97				
Number of female youth (age 7-15)	0.94	1.10				
Number of children (age < 7)	0.86	0.99				
Household size	5.76	1.77				
Number of windows in the house	0.53	0.72				
Owns a separate kitchen (1=yes, 0=no)	0.51	0.50				
Observations	360					

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 2: Decision-making autonomy (autocracy)

<i>Panel A: Wives</i>		
	Freq.	Percent
Wives' autonomy in purchase of own material items		
Low level of autonomy	85	47.22
Moderate level of autonomy	45	25.00
High level of autonomy	50	27.78
Total	180	100.00
<i>Panel B: Husbands</i>		
Husbands' autocracy in purchase wives' material items		
High dominance (autocrat)	82	45.56
Moderate	62	34.44
Low dominance (non-autocrat)	36	20.00
Total	180	100.00

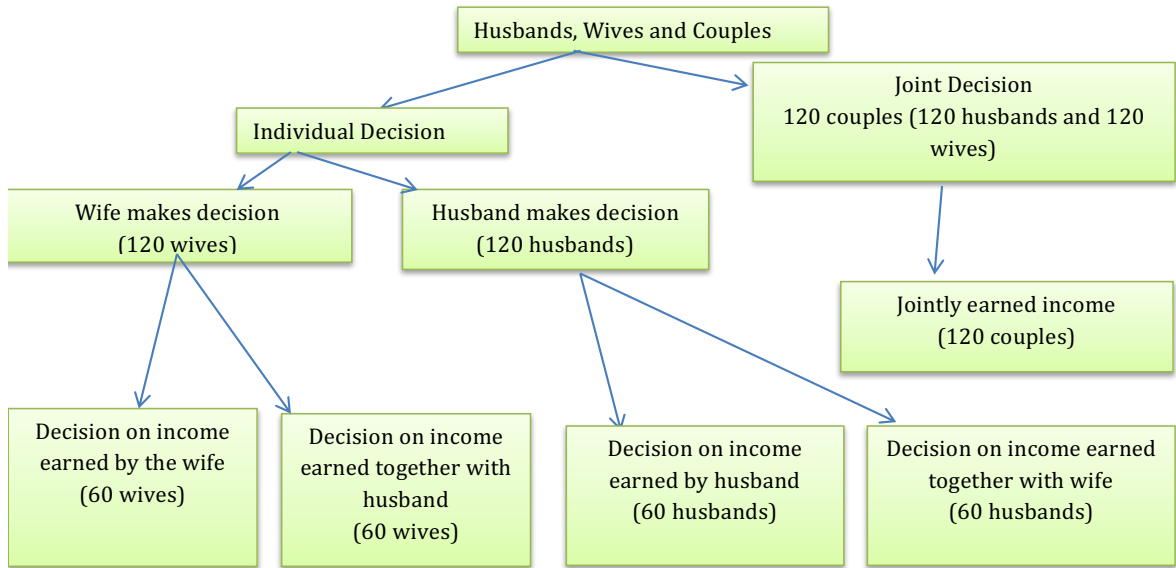


Fig 1: Diagram of Experimental Design

Table 3: WTP: wives, husbands, and couples in individual and joint decisions

Decision type	[1]		[2]		[3]	
	[Wives]		[Husbands]		[Mean Diff.]	
	Mean	SD(SE)	Mean	SD(SE)	Mean	(SE)
Individual decision	96.17	40.72	60.5	34.77	35.67***	(4.89)
Joint decision	68.83	43.66	68.83	43.66		
Mean difference	27.33***	(6.59)	-8.33	(6.00)		
Observations	180		180	360		

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Autonomy (autocracy) in decision-making and WTP by wives and husbands

	[1]		[2]		[3]	
	[Indiv.]		[Joint]		[Diff.]	
	Mean	SD(SE)	Mean	SD(SE)	Diff,	SD(SE)
<i>Panel A: Wives</i>						
Low level of autonomy	61.44	20.24	40.00	10.68	21.44***	(4.21)
Moderate level of autonomy	114.04	23.83	66.32	40.03	47.72***	(9.55)
High level of autonomy	141.43	15.56	122.00	34.48	19.43**	(7.02)
Mean diff: low and high autonomy	-79.99***	(3.98)	-82.00***	(7.25)		
Mean diff: low and moderate autonomy	-52.60***	(5.03)	-26.32**	(8.19)		
Mean diff: moderate and high autonomy	-27.39***	(5.04)	-55.68***	(13.02)		
Observations						
<i>Panel B: Husbands</i>						
Non-autocrat	106.67	23.73	122	34.48	-15.33	9.68
Moderate	56.98	32.39	66.32	40.03	-9.33	9.60
Autocrat	45.89	23.86	40.00	10.68	5.89	4.90
Mean diff: non-autocrat and autocrat	60.77***	(6.1)	82***	(7.25)		
Mean diff: non-autocrat and moderate	49.69***	(7.95)	55.68***	(13.02)		
Mean diff: moderate and autocrat	11.08*	(5.65)	26.32***	(8.19)		
Observations						

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Mean WTP of wives and husbands using individual or joint income

Income type	[1]		[2]		[3]	
	[Wives]		[Husbands]		[Mean Diff.]	
	Mean	SD(SE)	Mean	SD(SE)	Mean	SD
Individual earning	100.42**	38.38	59.25	35.62	41.17***	(6.76)
Joint earning	80.38	44.60	65.29	39.20	15.08**	(5.42)
Mean Difference	20.04**	(6.74)	6.04	(6.02)		
Observations	180		180			360

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: The impact of decision-making power on WTP: Tobit results

	[1]		[2]		[3]	
	[Wives]		[Husbands]		[Pooled]	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Power	33.120***	2.452	-28.244***	3.060	33.898***	2.432
Individual decision	20.083***	3.812	-4.376	4.550	19.814***	4.274
Earned individually	10.902***	4.016	-1.986	4.524	10.104**	4.423
Husband					-4.939	5.608
Power*Husband					-62.301***	3.625
Individual*Husband					-25.107***	5.985
Joint*Husband					-11.295*	6.086
Controls	Yes		Yes		Yes	
Village fixed effects	Yes		Yes		Yes	
Observations	180		180		360	

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7: The impact of decision-making power on WTP: IV Tobit results - First Stage Regressions

	[1]		[2]		[3]	
	[Wives]		[Husbands]		[Pooled]	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Birth order	-0.103***	0.032	-0.143***	0.034	-0.141***	0.026
Death of male siblings	-0.216***	0.070	-0.132**	0.058	-0.281***	0.049
Controls	Yes		Yes		Yes	
Village fixed effects	Yes		Yes		Yes	
Test of overidentifying restrictions (p-values)	0.79		0.13		0.34	
Observations	180		180		360	

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8: The impact of decision-making power on WTP: Instrumental Variables Tobit results

	[1]		[2]		[3]	
	[Wives]		[Husbands]		[Pooled]	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Power	40.250***	7.582	-36.059***	8.669	40.991***	8.155
Individual decision	21.016***	4.032	-3.672	4.673	20.352***	4.366
Earned individually	12.087***	4.298	-2.171	4.596	10.787**	4.539
Husband					-6.050	5.807
Power*Husband					-70.201***	9.407
Individual*Husband					-25.464***	6.072
Joint*Husband					-12.060*	6.218
Controls	Yes		Yes		Yes	
Village fixed effects	Yes		Yes		Yes	
Observations	180		180		360	

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.1: Decision-making autonomy (autocracy)

Panel A: Wives			
		Freq.	Percent
Wives' autonomy in purchase durables			
Low level of autonomy		89	49.45
Moderate level of autonomy		44	24.44
High level of autonomy		47	26.11
Total		180	100.00
Panel B: Husbands			
Husbands' autocracy in purchase of durables			
High dominance (autocrat)		91	50.56
Moderate		52	28.89
Low dominance (non-autocrat)		37	20.55
Total		180	100.00

Table A.2: Autonomy (autocracy) in decision-making and WTP by wives and husbands

	[1]		[2]		[3]	
	[Indiv.]		[Joint]		[Diff.]	
	Mean	SD(SE)	Mean	SD(SE)	Diff,	SD(SE)
Panel A: Wives						
Low level of autonomy	66.83	28.61	40.00	10.68	26.83***	(5.79)
Moderate level of autonomy	115.96	25.30	63.89	39.73	52.07***	(9.79)
High level of autonomy	139.19	17.08	121.25	33.44	17.94**	(7.33)
Mean diff: low and high autonomy	-72.37***	(5.58)	-81.25***	(7.04)		
Mean diff: low and moderate autonomy	-49.14***	(6.46)	-23.89***	(8.15)		
Mean diff: moderate and high autonomy	-23.23***	(5.64)	-57.36***	(12.68)		
Observations	120		60		180	
Panel B: Husbands						
Non-autocrat	107.87	24.83	121.25	33.44	-13.87	(9.57)
Moderate	53.09	29.49	63.88	39.73	10.80	(9.71)
Autocrat	49.23	26.97	40.00	10.68	9.23*	(5.47)
Mean diff: non-autocrat and autocrat	58.15***	(6.65)	81.25***	(7.04)		
Mean diff: non-autocrat and moderate	54.29***	(7.22)	57.36***	(12.68)		
Mean diff: moderate and autocrat	3.86	(5.9)	23.89**	(8.15)		
Observations	120		60		180	

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.3: The impact of decision-making power in purchase of durables on WTP: Tobit results

	[1]		[2]		[3]		[4]
	[Wives]		[Husbands]		[Pooled]		[Mar. Eff.]
	Coeff.	SE	Coeff.	SE	Coeff.	SE	
Power in purchase of durables	29.161***	2.567	-26.437***	2.834	25.641***	2.437	
Individual decision	20.865***	4.173	-1.703	4.566	20.461***	4.666	
Earned individually	11.058**	4.370	-2.797	4.517	9.852**	4.789	
Husbands					-2.691	6.112	
Power*Husbands					-52.067***	3.706	
Individual*Husbands					-29.178***	6.551	
Joint*Husbands					-9.809	6.608	
Controls	Yes		Yes		Yes		
Village fixed effects	Yes		Yes		Yes		
Observations	180		180		360		

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.4: The impact of decision-making power in purchase durables on WTP: IV Tobit results - First Stage Regressions

	[1]		[2]		[3]	
	[Wives]		[Husbands]		[Pooled]	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Birth order	-0.109***	0.033	-0.139***	0.037	-0.137***	0.027
Noumber of male siblings died	-0.192**	0.074	-0.165***	0.063	-0.268***	0.051
Controls	Yes		Yes		Yes	
Village fixed effects	Yes		Yes		Yes	
Observations	180		180		360	

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.5: The impact of decision-making power in purchase durables on WTP: IV Tobit results

	[1]		[2]		[3]	
	[Wives]		[Husbands]		[Pooled]	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Power in purchase of durables	40.844***	8.754	-32.816***	8.215	41.667***	9.627
Individual decision	22.931***	4.701	-0.425	4.832	22.525***	5.114
Earned individually	13.531***	4.993	-3.166	4.564	12.254**	5.285
Husband					-4.660	6.615
Power*Husband					-69.186***	10.666
Individual*Husband					-32.714***	7.280
Joint*Husband					-11.693	7.129
Controls	Yes		Yes		Yes	
Village fixed effects	Yes		Yes		Yes	
Observations	180		180		360	

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.6: Decision-making Power and Stove Use: 2SLS results

	[1]		[2]		[3]	
	[BDM Villages]		[Free Dist. Villages]		[All Villages]	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Autonomy in purchase of wife's material items	0.108	0.998	0.709	1.394	-0.665	0.866
Age	0.002	0.025	-0.004	0.018	-0.015	0.015
Proportion of time wife allocates for fuelwood collection	-1.004	0.799	2.786***	0.710	0.929*	0.533
Number of livestock in tropical livestock units	-0.012	0.060	-0.329***	0.059	-0.217***	0.042
Wife's years of schooling	0.822***	0.189	0.209**	0.092	0.480***	0.099
Wife participates in off-farm work (1=yes, 0=no)	0.612	0.726	2.353***	0.451	2.198***	0.417
Number of adulte males in teh household	0.424	0.314	1.340***	0.266	1.210***	0.207
Number of male youth in the household	0.163	0.332	0.035	0.230	0.038	0.212
Number of adult females in the household	-0.171	0.334	0.484**	0.217	0.176	0.211
Number of female youth in the household	-0.498	0.311	0.278	0.209	-0.063	0.194
Number of children in the household	0.965***	0.354	0.385*	0.218	0.739***	0.219
Number of windows	0.134	0.436	-0.662***	0.252	-0.750***	0.258
Separate kitchen	-0.050	0.578	-0.154	0.387	-0.315	0.368
Wealth (value/1000)	0.014*	0.007	-0.001	0.005	0.007	0.005
Household land size	-0.233	0.155	0.058	0.079	0.055	0.081
Number of trees	0.065	0.214	0.044	0.150	0.052	0.137
Intercept	3.385**	1.667	1.334	1.327	2.310**	1.148
Village fixed effects	Yes		Yes		Yes	
Observations	300		296		596	
R-squared	0.21		0.62		0.31	

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.