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Decision-making within the household: The role of autonomy and differences in preferences

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

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

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Yonas Alem, Sied Hassen, and Gunnar Köhlin[1]

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

Abstract

We use a field experiment to identify how differences in preferences and autonomy in decision-making result in low willingness-to-pay (WTP) for technologies that can benefit all members of the household. We create income earning opportunities to empower households and elicit their WTP for fuel, time and indoor air pollution-reducing improved cookstoves through a real stove purchase experiment. The decision to buy the stove was randomly assigned to either wives, husbands or couples. Experimental results suggest that wives, who often are responsible for cooking and collecting fuelwood, are willing to pay 57% more than husbands, and 39% more than couples. Wives who earned their own income are willing to pay 67% more than husbands who earned their own income, and 45% more than couples. Results also show that women who have higher reported decision-making autonomy are willing to pay substantially more than those with lower decision-making autonomy. A follow up survey conducted 15 months after the stove purchase shows that neither the treatments nor decision-making autonomy have any effect on stove use. Our findings highlight the importance of considering division of labor, preference difference and decision-making autonomy within the household when promoting adoption of new household technologies, and that simple income earning opportunities enable poor women to make decisions that are in their best interest.

JEL-Code: C78, C93, D13, O12, Q56

Keywords: Preference; decision-making autonomy; willingness-to-pay

November 2020

1 Yonas Alem (Lead Author), University of Gothenburg and RWI Research Network; Sied Hassen, ECRC; Gunnar Köhlin, University of Gothenburg. *– We thank Randall Bluffstone, Fredrik Carlsson, Haileselassie Medhin, Alemu Mekonnen, Subhrendu Pattanayak, Dale Whittington, Thomas Sterner, Simon Schürz, Måns Söderbom, seminar participants at the Department of Economics, University of Gothenburg (Gothenburg, Sweden), participants in the Economic Sciences Association annual conference (Bergen, Norway), and participants at the Nordic Conference in Development Economics (Copenhagen, Denmark) for helpful comments. Financial support from the Swedish International Development Cooperation Agency (Sida) through the Environment for Development (EfD) is gratefully acknowledged.-* *All correspondence to: Yonas Alem, University of Gothenburg, Schweden, e-mail: yonas.alem@gu.se*

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 preferences - 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 within couples, mainly driven by division of labor within the household, and differences in intra-household decision-making power result in low willingness-to-pay for an important household durable.

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 by 90%.[1] Consequently, it benefits women, who are the default cooks of the household and are responsible for fuelwood collection, more than it benefits 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 (Hoffman, 2009; Alem and Dugoua, 2017; 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

[1] See "http://stoves.bioenergylists.org/stovesdoc/Bess/Mirte.htm" for a description of the "mirte" stove. At the time of the field work, the stove sold for 150 Ethiopian Birr, ETB (USD 7.5) at the regional markets. However households in the study area did not have previous knowledge about the stoves. See appendix A for a photo taken during the field demonstration.

[2] In the area where we conducted our study, 100% of cooking and 80% of fuelwood collection is done by women. In many developing countries, children also benefit from reduced fuelwood collection time and reduced indoor air pollution, because women look after children while cooking and firewood fetching, and children are also involved in firewood collection (WorldBank, 2011).

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 order to tease out to what extent spouses feel empowered to make the stove purchase decision using the household's income, we randomly assign wives and husbands to an additional treatment which involves making the stove purchase decision alone using the income the couple earned.

Experimental results suggest that wives, who by default are the household cooks and are responsible for fuelwood collection, are willing to pay 57% more than husbands and 39% more than couples (wives and husbands who make the stove purchase decision together). Wives who were randomly assigned to earn their own income alone and made the stove purchase decision alone are willing to pay 67% more than husbands who earned their income alone and made the stove purchase decision alone. We document that the average WTP by couples who earned income together and made the stove purchase decision together is closer to the average WTP by husbands who made the stove purchase decision alone. This clearly indicates the dominance of husbands in joint spousal decisions. Moreover, wives who report having the autonomy to decide on purchase of their own personal items reveal higher willingness-to-pay than those with low decision-making autonomy. A comprehensive follow-up household survey conducted 15 months after the stoves were offered shows that neither the treatments nor reported decision-making autonomy have any effect on how quickly the stove was put in use. This clearly indicates that women do not adopt these technologies not because they don't value them, but because they lack the financial resources and the autonomy to purchase them. Our findings offer important insights to policymakers, NGOs, and other stakeholders on how to empower women and design interventions that maximize uptake of modern technologies in poor communities.

This paper contributes to a body of research in economics on intra-household decision-making and the role of empowering women. Previous studies in developed countries (Chiappori, 1992; Browning et al., 1994; 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 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. Contributing 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

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

in urban Macedonia are willing to sacrifice household income to gain control over resources. In order to improve the economic position of women and benefit children, most conditional cash transfers in developing countries make women the recipient of the transfer (Fiszbein et al., 2009). Women also engage in informal strategies such as saving in ROSCAs - Rotating Savings and Credit Associations (Anderson and Baland, 2002) to improve their economic position. Using carefully designed income-earning opportunities and a novel experimental design, we provide new evidence by isolating the role of preference differences (which are likely driven by division of labor within the household) from the role of decision-making autonomy in household decisions.

The paper also speaks to the literature on technology adoption in developing countries in general and adoption of improved cookstoves in particular. 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 (Lamb, 2003; Alem et al., 2010; Dercon and Christiaensen, 2011), liquidity constraints (Giné et al., 2008; Cohen and Dupas, 2010; Mobarak et al., 2012; Dupas, 2014; Tarozzi et al., 2014; Beltramo et al., 2015; Pattanayak et al., 2019; Alem and Ruhinduka, 2020; Grimm et al., 2017), behavioral biases (Duflo et al., 2011), and limited experimentation (Foster and Rosenzweig, 1995; Conley and Udry, 2010). In order to reduce the significant negative consequences of biomass fuel use for households and the environment, a number of recent studies (Smith-Sivertsen et al., 2009; Miller and Mobarak, 2014; Hanna et al., 2016; Beyene et al., 2015; Bensch and Peters, 2015) have used a randomized experimental set-up to examine the factors that promote adoption of improved cookstove technologies in developing countries.[4] These studies identify liquidity constraint, lack of learning through social networks, and poor technical designs that do not meet cooking needs of households as the key factors that explain the low adoption rate and use of improved biomass cookstoves.

A paper with a similar research question to ours, Miller and Mobarak (2013), points out a different 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

[4]Nearly 3 billion people in developing countries, and almost all rural households in Africa, use biomass fuel (such as firewood and charcoal) in order to meet their cooking needs. Biomass fuel use has been a key cause of deforestation and forest degradation (Campbell et al., 2007; Mercer et al., 2011), loss of of biodiversity and destruction of local ecosystems (Allen and Barnes, 1985; Geist and Lambin, 2002; Hofstad et al., 2009; Köhlin et al., 2011), indoor air pollution, which accounts for 3.3% of global burden of disease and 2 million premature deaths per year (WHO, 2009), and climate change, through emission of harmful greenhouse gases including black carbon and carbon dioxide (Sagar and Kartha, 2007; Kandlikar et al., 2009; Grieshop et al., 2011).

price is charged for either stove, women become less likely than men to adopt, implying their lack of authority to make a purchase. Our experimental design, combined with the income-generating activity we offer to participants, allows us to clearly identify the impact of preference differences on WTP for the improved cookstove and to tease out the role of decision-making autonomy within the household. Our outcome variable of interest - average WTP by subjects - is a continuous variable 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 presents the conceptual framework that guides the experimental design. Section 3 describes the context, sampling and experimental design. Section 4 presents descriptive statistics of baseline variables and covariate balance test results. Section 5 presents the results from our stove purchase experiment, key robustness checks and the mechanisms that explain the treatment effects. Section 6 concludes the paper.

2. Conceptual Framework

In this section, we build on a model of the household consisting of two members, a husband and a wife, who are engaged in an informal contract of division of labor, to motivate our experimental design and why we expect a difference in WTP between them. The microeconomic theory of consumer behaviour suggests that an economic agent's demand for a new product (technology) is equal to the agent's willingness to pay for the product. WTP is the monetary equivalent of the welfare impact of the technology, i.e., the difference in the utility with and without the new technology. Before making a purchase decision, the agent weighs the benefits and the costs of the product. Because of its technical efficiency, the improved stove reduces fuelwood consumption by half, protects the cook from harmful flames, and offers a large reduction in indoor air pollution. The fuelwood efficiency of the stove offers reduction in time spent collecting fuel and cooking as well. The agent therefore compares her demand for the new technology represented by her WTP with the retail price to decide to buy the product or not. In the context of the Becker-DeGroot-Marschak (BDM) method (Becker et al., 1964), which we describe later, the agent reveals a WTP value of WTP^* for the improved cookstove when her expected utility with the improved cookstove is greater than or equal to her utility without the improved cookstove.

Following earlier studies in developing countries (Anderson and Baland, 2002; Ashraf, 2009; Miller and Mobarak, 2013; Almås et al., 2015; Schaner, 2015), the framework also takes into account differences in preferences and intra-household bargaining power between wives and husbands. We consider a household comprising two members, $i \in w, h$, a wife and a husband who engage in an informal contract about division of labor within the household at the beginning of marriage. In the context of

many rural communities in general, and rural Ethiopia in particular, cultural norms dictate that wives are responsible for cooking, collection of fuelwood and looking after children, while husbands are responsible for working on the farm to provide for the household (Fernández, 2007; Duflo, 2012; Berniell and Sánchez-Páramo, 2011; Burda et al., 2013; Rubiano-Matulevich and Viollaz, 2019).[5] As is shown in Section 4, in the context of the study area, wives are more responsible than husbands for collecting fuelwood, and also undertake all cooking, tasks which they often perform while looking after children. The benefits of the improved cookstove therefore accrue mainly to wives rather than husbands, and this leads to a preference difference driven by division of labor within the household. Hence, we formulate Hypothesis 1 as follows:

Hypothesis 1 *Wives are willing to pay more for the improved cookstove than husbands and couples.*

The difference in division of labor within the household is also directly linked to autonomy in intra-household decision making. In many low-income societies, including in rural Ethiopia, men are the default heads of the household, with the autonomy to control household resources and make important household decisions (Bruce, 1989; Strauss and Beegle, 1996; Anderson and Baland, 2002; Duflo, 2012; Almås et al., 2015).[6] Women and girls are not only responsible for household work, such as cooking, water and fuel collection, but they also have lower political representation (Jayasuriya and Burke, 2013), and display lower bargaining power over many household decisions, such as wealth inheritance and the purchase of household durables (Deininger et al., 2013; Miller and Mobarak, 2013; Roy, 2015; Kandpal and Baylis, 2019). Household decisions conducted jointly by spouses are then very often a reflection of men's preferences (Carlsson et al., 2012, 2013). If this is the case, both individual and joint decisions may be confounded by decision-making autonomy. A wife with low decision-making autonomy may reveal a low WTP in an individual decision, not because she does not value the improved stove, but because *ex ante*, she knows that her husband, who is the default head of the household, may not approve such a purchase. These patterns of inequality in access to resources and decision-making autonomy in poor communities have been the main basis for most conditional cash transfer programs that target women as the recipients of the transfer (Fiszbein et al., 2009). Our second hypothesis is therefore:

[5]The difference in time allocation between women and men is not unique to developing countries. Using time use data from a wide range of 23 countries, Berniell and Sánchez-Páramo (2011) show that there is a clear pattern of difference in time allocation between men and women even in developed countries. The authors, for example, show that at all income levels, women allocate a larger proportion of their time to household work and family care and less time to formal work than men. Nevertheless, these patterns have been documented to be much more stronger in developing countries than in developed countries.

[6]Bruce (1989) and Strauss and Beegle (1996), two early review studies on gender inequalities within the household in developing countries, provide evidence that inequality in access to household resources is more prevalent in Africa than in other regions of the world.

Hypothesis 2 *Autonomous wives are willing to pay more for the improved stoves than non-autonomous wives.*

Given that women and men have different preferences and men have decision-making autonomy on household resource use, offering women the opportunity to earn their own income would likely give them the freedom to make decisions consistent with their preferences. Many development interventions that improve the living standards of poor households in general would lead to some improvement in the wellbeing of women as well (Duflo, 2012). However, interventions that directly target women are likely to have a larger impact on women's wellbeing. Women spend a larger proportion of their income than men on children's and household goods (Hoddinott and Haddad, 1995) and children's health (Thomas, 1990). The poverty reduction impact of access to micro credit and household income is larger when women are the recipients (Pitt and Khandker, 1998; Duflo, 2003), and microcredit opportunities improve women's intra-household decision making power (Angelucci et al., 2013). Experimental work in developing countries has confirmed that women sacrifice some portion of income in order to have access to household resources and make decisions consistent with their preferences. In line with this, Almås et al. (2015) show that women in Macedonia are willing to sacrifice substantial amount of household income to receive the money in their own private account than in a joint account with their spouses. Shurz (2020) documents that women in Tanzania sacrifice significant amount of resources to avoid bargaining with their spouses and, as a result, make an inefficient level of investment in child education. This leads to our third hypothesis:

Hypothesis 3 *Wives who earn their own income to make the stove purchase decision alone are willing to pay more than wives who don't earn their own income, husbands and couples.*

In order to clearly understand the effect of decision-making autonomy of spouses on outcome variables of interest and to make causal claims, one would need to understand how marriage contracts are formed. Becker (1973, 1981) emphasizes the gains from a marriage through specialization between spouses. Becker's theory demonstrates that differences in comparative advantage of spouses can result in division of labor, which then leads to significant welfare gains. Later studies (e.g., Kremer, 1997; Fernandez et al., 2004; Fernández et al., 2005) show that there is distinct sorting in marriages based on particular attributes and family interactions, and sorting has implications for labor market outcomes, inequality and economic growth. In the context of rural Ethiopia, Fafchamps and Quisumbing (2005) show that marriage is largely characterized by an assortative matching process, and that parents and relatives play important roles in arranging marriages. In view of this, reported decision-making autonomy of spouses is likely to be endogenous and one cannot separate it from sorting. The process and conditions under which marriage and division of labor

contracts between spouses emerge is outside the scope of this paper. Consequently, we refrain from asserting a causal relationship between WTP and decision-making autonomy. Our main focus is on the causal impact of the exogenously assigned treatment effects, which we describe in detail in the next section.[7]

3. Context, Sampling and Experimental Design

3.1. *Context*

The surveys and experiment were conducted in July 2013 in the Tigray region of Ethiopia, located in the North of the country. The region comprises the three main climatic zones of the Ethiopia, "Dega" (cool and humid), "Woynadega" (cool and sub-humid) and "Kola" (warm semiarid).[8] 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 in the areas where it has been tried. For example, in the areas of Tigrai regional state where the stoves were introduced, uptake is less than 1% (Plan and Finance, 2011). Liquidity constraint has been identified as the key reason for the low uptake of the new generation of improved stoves in the region and in the rest of the country (Beyene and Koch, 2013; Gebreegziabher et al., 2012).

[7] We thank an anonymous reviewer for encouraging us to discuss the issue of marriage formation in rural Ethiopia and for providing helpful sources.

[8] More information about the climatic or agro-ecological zones of Ethiopia is available at the Ministry of Agriculture's website: http://publication.eiar.gov.et.

3.2. *Sampling and Data Collection*

At the time of the baseline survey, Tigray region was was divided into six zones; Southern, South Eastern, Central, Eastern, North Western and Western zones. Our sample of villages (kushets) were selected from the Southern zone, because it was the only zone comprising villages with all the three major climatic conditions. The Southern zone constitutes eight woredas (districts), including five rural and three urban woredas. Since our study focuses on rural households, we excluded all urban woredas from our sampling list and stratified the five woredas (Endamokoni, Alaje, Ofla, Alamata, and Raya-Azebo) by climatic condition. Three woredas had Dega climate, one had Woynadega climate, and two had Kola climate.[9] We selected one woreda from each climatic condition: Endamokoni, representing both Dega and Woynadega climatic conditions, and Raya-Azebo, representing the Kola climate condition.

One of the sample woredas, Endamokoni, consists of eight villages. Six villages were randomly selected from the two climatic conditions, four of which were assigned to the stove purchase experiment. The remaining two were assigned to a free stove distribution intervention. The Raya-Azebo woreda has eight villages, all of which belong to the Kola climatic zone. In this woreda as well, we selected two villages for the stove purchase experiment, and four villages for the free stove distribution intervention. The total number of villages selected for the whole stove study is therefore 12, with equal representation of the three climatic zones. From each village, we recruited 50 households to participate in the study following the procedure described in the next paragraph. Thus, we used 300 households in six villages (Adiagam, Adidemishash, Adielmela, Adimoknney, Menkere, and Garasa1) for the stove purchase experiment. We used the remaining six villages (300 households) for a separate free stove distribution intervention. These villages were assigned to an improved stove intervention program we implemented after a baseline survey. Half of these households (N=150) received an improved stove, and the other half, the control group, (N=150) received a bag of wheat with comparable value to the stoves. Data from these 300 households will be used to conduct impact evaluation of the stoves on fuel consumption and labor allocation of women in a separate study. Consequently, we do not include these villages and households in the current paper.

Once the sample villages had been identified, we approached the cadres in each village who keep the list of all households living in their village to recruit the sample households. On average, a village consisted of around 200 households. First, we divided the number of households living in a village by 50 (the proposed number of households per village who will participate in the study) to determine the interval which we use to recruit a household from the list. For example, for a village with 200 households, the number is 4. We then picked every 4th household from the list

[9] One of the woredas, i.e., Endamokoni represented both Dega and Woynadega climatic conditions.

of households kept by the village cadres. If the selected household did not satisfy our selection criteria (i.e., living with a spouse), we chose the next household.[10]

Baseline and follow-up surveys were conducted in the 12 sample villages during July-October, 2013 and February, 2015 respectively. All households in the 6 stove purchase experiment villages and the 6 improved stove intervention villages participated in both surveys. The baseline survey was conducted two weeks before the stove purchase experiment and free distribution of the improved stoves. After short introductions 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 all 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 survey.

3.3. *Experimental Procedure and Treatments*

In the villages where the stove purchase experiment was conducted, 10 husbands, 10 wives and 30 joint couples from each village were randomly recruited to participate in the experiment. First, we selected the sample households from each village following the procedure discussed in the previous sub-section. Then we used a lottery to assign individual spouses and couples to the five treatment groups, which we describe below.[11] 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 exper-

[10] We had to replace 12 households (i.e., 2% of the sample) selected through our sampling procedure, because they did not satisfy the sampling requirement of living with a spouse, i.e., they were either widowed or divorced.

[11] We wrote down the house numbers of each recruited household (50 per village) on small pieces of paper. We rolled these pieces of paper and collected them in a bag. Then, one of the co-authors randomly drew the samples for each of the five treatment groups from the bag.

iment 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 (Thaler, 1990; Hoffman, 2009; Clingingsmith, 2015). 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 times. Husbands and wives who were invited to come alone arrived at 8:00 a.m. and 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 husbands and wives who came alone were told to weed for four hours per person in the center plots and stay for two more hours for the study, while the 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.[12] They were also informed that, at the end of the study, remuneration would be paid in proportion to the time spent on the weeding task. A husband/wife who worked alone for four hours would earn ETB 150 (USD 7.5)[13] and a couple who worked together for two hours would also earn ETB 150. We anchored the earning from the work to the market price of the stove.[14] Thus, if subjects were willing to pay, they would have the financial resources to pay the market price of the stove. 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 offered if they did not participate in both activities. All subjects agreed to these terms and participated in both activities.

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

[13]At the time of the experiment, 1 ETB = 0.05 USD.

[14]The earnings from the public work (ETB 150) represents 1 to 1.5 days of wage in the study area. It is common for rural households in Ethiopia in general and in Tigray region in particular to engage in remunerated public work activities, such as building roads and water ponds through different safety net and aid initiatives (Alem et al., 2010; Gilligan and Hoddinott, 2007; Gilligan et al., 2009).

After completing the weeding task, we gathered all the subjects 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 treatment groups and gathered them in separate places that were far apart. The groups were: a group of wives who were invited alone and would make the stove purchase decision alone using the income they had earned individually (Treatment 1 or T1); a group of husbands who were invited alone and would make the stove purchase decision alone using the income they had earned individually (T2); 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 (T3); 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 (T4); and a group of couples who would make the stove purchase decision jointly using the income the couple had earned (T5).

As explained above, we 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; Orfei, 2012; Miller and Mobarak, 2013).

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 the purchase of 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 and instructed 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.

4. Descriptive Statistics and Covariate Balance

Table 1 presents summary statistics from the baseline survey both at the spouse level and the household level. First, means and standard deviations are reported in Columns 1 (Husbands) and 2 (Wives). 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 involved 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

Our measure of autonomy (or autocracy) is a continuous variable constructed from the response of husbands and wives to separate survey questions about decisions regarding purchase of the wife's personal items (e.g., clothes and shoes).[15] Taking the patriarchal nature of the society into account, a wife is considered to have "high autonomy" if she makes the purchase decision on her own, "moderate autonomy" if she makes the decision with her husband and "low autonomy" if her husband makes the decision. Conversely, we use the term "autocratic" if the husband makes the decisions regarding the wife's personal expenditures on his own, "moderate" if he makes the decisions with his wife and "non-autocratic" if he lets his wife decide on her own. For robustness checks, we also asked questions on decisions regarding the purchase of household durables.[16] For each of these two decision categories,

[15]The specific question we asked both spouses about decision-making autonomy regarding purchase of the wife's personal items was: "who makes the decision concerning expenditures on purchase of your (the wife's) personal items, like clothes, shoes etc.?". The possible responses are: wife, both spouses, husband, another person.

[16]The specific question we asked both spouses about decision-making autonomy regarding purchase household durables was: "who makes the decision concerning expenditures on purchase of household durables, like cattle, furniture etc.?". The possible responses are: wife, both spouses,

we assign a value of 1 when the wife reports she has full autonomy to decide (i.e., the husband is non-autocratic), 2 when she reports both make the decision (the husband is moderately autocratic), and 3 when she reports her husband makes the decision (the husband is autocratic). 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.

Table 2 shows descriptive statistics on the decision-making autonomy of wives in the purchase of their own material items. 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 B.1 in the appendix presents descriptive statistics on autonomy in decision-making regarding purchase of household durables, showing dominance of husbands in decision-making. 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., Miller and Mobarak, 2013; Anderson and Baland, 2002; Hoddinott and Haddad, 1995; 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

Randomisation of treatment assignment should ensure that on average, the five treatment groups have similar baseline characteristics. In order to check for this, we present means of several key baseline individual and household characteristics for the different treatment groups in the wives and the husbands samples in Tables 3 and 4 respectively. We also report test results for the null hypothesis that the difference in means is statistically significantly not different from zero in columns 4-6 of both tables. For nearly all the variables presented, the difference in means is not statistically different from zero. The only exceptions are that there is a statistically significant difference in the mean of the variable "Number of females aged 7-15 years" between T1 and T5 in Table 3; and in "Wealth in 1000 ETB" between T2 and T4 in Table 4. Although these differences are unfortunate, we don't think they will bias our results in a major way for two reasons. First, the mean differences are only weakly significant, i.e., at the 10% level. Second, in the "Results" section, we will re-estimate our treatment effects after controlling for all the baseline covariates in the regressions, which will hopefully help us show the robustness of the treatment effects.

Table 3 about here

husband, another person.

Table 4 about here

5. Results

5.1. Empirical Strategy

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 a tobit model, which considers the censored nature of the data. The regression equation of interest (WTP) can be specified for an unobserved latent variable, WTP^*:

$$WTP^*_{ihj} = \beta_0 + \beta_1 autonomy_{ihj} + \mathbf{\Gamma} \boldsymbol{T}_i + \mathbf{\Psi} \boldsymbol{T_i} * \boldsymbol{autonomy}_{ihj} + \mathbf{\Theta} \boldsymbol{X}_{ihj} + \varepsilon_{ihj} \quad (1)$$

where $i = 1, ..., N$ represents participants in the experiment; h and j represent household and village respectively; *autonomy* is a categorical ordered variable coding reported decision-making autonomy of wives or autocracy of husbands; $\boldsymbol{T}_i$ is a vector of the treatments that are assigned randomly; $\boldsymbol{T_i} * \boldsymbol{autonomy}_{ihj}$ is a vector of interaction terms of the treatments with decision-making autonomy; $\boldsymbol{X}_i$ is a vector of baseline control variables; $\mathbf{\Gamma}$ and $\mathbf{\Psi}$ are vectors of the key parameters of interest which measure the impact of the treatments on WTP, and the interaction effects of the treatments with the decision-making autonomy, respectively; $\mathbf{\Theta}$ is the vector of parameters of baseline covariates; and ε_{ihj} is a random error term, $\varepsilon_{ihj} \sim (0, \sigma^2)$. WTP^*_i is not observable to the researcher; instead the researcher observes

$$WTP_{ihj} = \begin{cases} a & WTP^*_{ihj} < a \\ WTP^*_{ihj} & a \leq WTP^*_{ihj} \leq b \\ b & WTP^*_{ihj} > b \end{cases} \quad (2)$$

In order to take account of all the information in the dependent variable, WTP_{ihj}, one should fit the model with the tobit estimator, which uses the maximum likelihood framework. The regression can be estimated in standard packages such as STATA using the *tobit* command, which also allows marginal effects to be computed in a straightforward manner.

5.2. *Experimental Results*

We begin by reporting mean WTP elicited through the BDM method for the improved cookstove for the overall sample. Figure 1 reports mean and median WTP

and the density of WTP for the whole sample (wives, husbands and couples combined). The mean WTP for the improved stove is 77.16 ETB (USD 3.86), while the median WTP is 62 ETB (USD 3.1). The mean and median WTP represent 51.4% and 41.3% of the market price of the stove. In addition, all participants bid for a positive price, the minimum bid being 6 ETB (USD 0.3) and the maximum bid being 150 ETB (USD 7.5), which was very likely anchored by the maximum amount of income the subjects earned from the manual labor. Using experimental methods, Mobarak et al. (2012) in rural Bangladesh; Beltramo et al. (2015) in rural Uganda, Pattanayak et al. (2019) in the Indian Himalayas, and Alem and Ruhinduka (2020) in urban Tanzania show that liquidity constraint is the key reason that explains the observed low adoption rate of new cooking technologies.[17] Here we show that even when households are endowed with cash enough to cover the market price of the stove through the public work, on average, they are only willing to pay half of the market price of the stove. In fact, the proportion of subjects who are willing to pay over 90% and 100% of the market price of the stove is only 19% and 14% respectively. These findings provide important insights to policymakers who aim to improve access to improved cookstoves and reduce the adverse consequences of biomass fuel use in developing countries. Policymakers can, for example, consider remunerating households for public work in the form of an improved stove (i.e., in kind) rather than in cash to speed up adoption of the stove.

Figure 1 about here

One of the key objectives of this paper is spelling out the difference in WTP for ICS by gender, which very likely is driven by the difference in the intra-household division of labor between wives and husbands. Figure 2 displays WTP of wives, husbands and couples including statistical t-test results on mean differences. We pooled the five treatment groups into three groups which consist of wives only (group 1 = T1 + T3), husbands only (group 2 = T2 + T4), and couples (group 3 = T5). Pooling the treatments this way will enable us to identify WTP for the stove by gender, whether subjects made the stove purchase decision using the income they earned individually or together with their spouse. Figure 2 clearly shows that wives who made the stove purchase decision alone are willing to pay 98.17 ETB, while husbands who make the stove purchase decision alone are willing to pay only 62.50 ETB and couples are willing to pay 70.83 ETB. Wives are therefore on average willing to pay 57% and 39% more than husbands and couples respectively. The differences in the mean WTP between the "wives only" group and the other two groups is statistically significant. The results clearly provide the first evidence in support of Hypothesis 1, i.e., women value the benefits of the improved cookstove significantly

[17] Mobarak et al. (2012) document that the adoption rate of the fuel-saving and smoke-reducing stoves at their market prices were only 5% and 2% respectively. Alem and Ruhinduka (2020) find that the adoption rate of two-burner LPG gas stoves in urban Tanzania was 69% when the stoves were offered through subsidy and on credit. The adoption rate drops to zero for the control group who were required to pay the market price of the stove upfront.

more than men.

Figure 2 about here

Does entitling women to their own income improve their decision-making power within the household? To shed light on this question, we present mean WTP of subjects by treatment in Figure 3. Results suggest that wives in T1, i.e., wives who participated in the income-generating manual labor alone and made the stove purchase decision alone, reveal the highest WTP for the improved cookstove (102.42 ETB). This clearly indicates that the income earning opportunity we offered to subjects empowered wives to bid for a higher price. Treatment T3 (the group of wives who were invited with their husbands, but made the stove purchase decision alone using the income the couple had earned) allows us to determine to what extent wives feel empowered to make the purchase decision using the household's resources. Wives in this treatment group reveal the next highest WTP (93.92). Considering the group in T2 (husbands who earned the income alone and made the stove decision alone) as the reference group, we note that wives in T1 are willing to pay about 67% more, and wives in T3 are willing to pay 53% more. Both these differences are statistically significant.

The average WTP revealed by the two husbands groups (T2 and T4) presented in Figure 3 are closer to the average WTP by the couples group (T5), implying that 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 from this part of the experiment have important implications for the role of empowering women in improving their decision-making power within the household. Taken together, the results in both Figures 2 and 3 provide suggestive evidence in support of Hypotheses 1 and 3. There is strong preference difference between wives and husbands (wives are willing to pay substantially more than husbands) for the improved cookstove, and enabling women to earn their own income increases their WTP.

Figure 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 autonomy of wives. Figure 4 presents the mean WTP by all five treatment groups by wives' decision-making autonomy in the purchase of their material items. Panel "a" presents WTP of wives in T1 and T3 by decision making autonomy. Panel "b" presents WTP of husbands in T2 and T4 by their level of autocracy. Panel "c" presents WTP by the couples group (T5) by decision making autonomy of wives. Note that, based on the responses to a survey question on who makes the final decision on the purchase of the wife's personal items, we classified wives as high-autonomy wives (1), moderate autonomy (0), and low-autonomy (-1). We also classified husbands based on their response to the same question as low dominance or non-autocratic (1), moderately autocratic (0) and high dominance or autocratic (-1).

Autonomy in decision making appears to consistently play a role in WTP. Results

in panel a (left) of Figure 4 suggest that wives in T1, who have high autonomy in purchase decisions of their material items, are willing to pay 106% more than wives with low autonomy in the same treatment group. To the contrary, husbands, who are autocratic are willing to pay consistently less than non-autocratic husbands. Panel c shows that couples with autonomous wives are willing to pay almost three times more than couples with low-autonomy wives. This clearly suggests that autonomous wives are able to negotiate with their spouse more and bid more for the improved stove. These findings provide supportive evidence for Hypothesis 2 that a wife reveals low WTP for the improved stove if she has low decision-making autonomy. Women's decision-making autonomy appears to be one of the critical correlates of willingness to pay for new technologies that offer large benefits to women themselves and to the household.

Figure 4 about here

5.3. *Econometric Results*

In this section, we investigate the causal impact of our treatments on willingness-to-pay for the improved stoves. We also explore the relationship between the reported decision-making power of spouses and WTP by wives, husbands and couples. Given that we asked subjects to bid for the stoves using the money they earned from the manual work, their WTP may be bounded at 150 ETB, the amount they earned. We therefore estimate our regression for WTP using a tobit estimator. In the interest of checking robustness of the results, we also estimate and report OLS results. We begin with regressions which pool the five treatment groups into three gender treatment groups as in Figure 2. Marginal effects from tobit regressions and OLS results are reported in Table 5. In columns [1] & [2], we report marginal effects from a tobit regression and OLS results controlling for village fixed effects. In columns [3] & [4] we report the same regressions controlling for village fixed effects and interaction terms with wives' decision-making autonomy. In the last two columns, we control for the full set of baseline control variables reported in Table 1. In all regressions, we cluster the standard errors at the village level.

Table 5 about here

For convenience in interpreting the parameter estimates, we also run the same regressions using the log of WTP instead of WTP in levels and report the results in Table 6. Consistent with the descriptive results reported in Figure 2, both sets of regressions reported in Tables 5 and 6 show that wives reveal the highest WTP for the improved cookstove. Compared to couples, wives who made the stove purchase decision alone are willing to pay 32.6% more (columns 5 & 6 of Table 6). Husbands on the other hand are willing to pay around 7.6% less than couples. The coefficient is, however, weakly significant in the tobit results (column 5) and statistically insignificant in the OLS results (column 6). Results in all columns of regressions in both tables suggest that wives' autonomy in decision-making when purchasing their

material items has a strong positive correlation with their willingness to pay for the improved stove. This effect is statistically significant at the one percent level.[18] Subjects (wives, husbands, or couples) with an autonomous wife in general reveal around 33% more WTP for the improved stove than subjects with a moderate level of decision-making autonomy for the wife. The interaction effects between gender and autonomy of wives do not appear to be statistically significant, as all the effects are likely captured by the reported autonomy of wives (autocracy of husbands). Taken together, the regression results robustly confirm that women are willing to pay substantially more than men, and decision-making autonomy of wives is significantly correlated with WTP for the stove.

Table 6 about here

Tables 7 and 8 report the impact of the treatments on WTP and the log of WTP from tobit and OLS regressions respectively. The regression results robustly confirm the suggestive evidence we presented in Figure 3. Compared to couples (the reference group), wives in both T1 and T3 are willing to pay substantially more for the stove. Results in the last column of Table 8 suggest that wives in T1 (the group of wives who were invited alone for the public work and made the stove purchase decision alone using the income they had earned individually) are willing to pay 38.4% compared to T5 (couples). This is the treatment effect estimated after accounting for the full set of controls (village fixed effects, interaction terms and baseline covariates) and is significant at the 1% level. Wives in T3 (the group of wives who were invited with their husbands and made the stove purchase decision alone using the income the couple had earned) are willing to pay 27.6% more than couples. The coefficients on husbands in both T2 and T4 reveal the opposite effect on WTP. Compared to T5 (couples), husbands in T2 (the group of husbands who were invited alone and made the stove purchase decision alone using the income they had earned individually) are are willing to pay about 12.8% less for the stove (Table 8, column 5). Regression results in all columns suggest that wives' autonomy has a strong positive correlation with their willingness to pay for the improved stove. This effect is statistically significant at the one percent level as well. Subjects (wives, husbands, or couples) with autonomous wife in general reveal around 33.6 % more WTP for the improved stove than subjects with a moderate level of decision-making autonomy for the wife.

Table 7 about here

Table 8 about here

The regression results, supported by the mean comparison tests presented in the preceding sub-section, have significant implications for adoption and diffusion of improved household technologies and empowerment of women in developing countries. First, the consistent finding that wives are willing to pay more than husbands for the improved cookstove clearly indicates that intra-household differences in division

[18] As discussed in the "Conceptual Framework" section, the reported level of decision-making autonomy/autocracy by wives and husbands respectively is likely endogenous. Consequently, we do not establish a causal relationship with WTP.

of labor and women's decision-making autonomy should be taken into account while promoting improved cookstoves. Thus, the conventional approach of communicating with household heads - who are men by default - in cookstove technology campaigns won't result in socially optimal uptake. Second and most importantly, decision-making autonomy matters and women lack the autonomy to make the decision that benefits themselves, and possibly their children. Thus, providing them with income earning opportunities, such as the public work we created for this project, will undoubtedly enable them to make decisions that are in their best interest.

5.4. *Robustness Checks*

We investigate robustness of our results using alternative estimation techniques and definitions of intra-household bargaining power. First, we check for the robustness of the estimated treatment effects using the wild bootstrap-t procedure proposed by Cameron et al. (2008). This procedure is proposed to address the issue of making inferences based on clustered standard errors when the number of clusters is small. In our case, the number of clusters (villages) is 6. Thus, the wild bootstrap-t procedure is warranted.[19] We implement the procedure and report the respective p-values for the OLS estimators under each treatment effect in all regression tables. The null hypothesis in all cases is that the coefficient of the respective treatment is zero, i.e, the treatment doesn't have any effect on WTP. In all regressions, the wild cluster bootstrap-t p-values match the statistical significance levels of the respective treatment coefficient. This clearly indicates that the treatment effects are robust.

Second, we re-construct the decision-making power (autonomy/autocracy) variable using the response to the question regarding decision-making on purchase of household durables. The coding of the response to the question regarding autonomy in purchase of household durables is the same as the coding of the responses to the question regarding wives' autonomy in purchase decisions of their material items. Based on the responses to a survey question on who makes the final decision on the purchase of household durables, we classified wives as high-autonomy wives (1), moderate autonomy (0), and low-autonomy (-1). We also classified husbands based on their response to the same question as low dominance or non-autocrat (1), moderately autocrat (0) and high dominance or autocrat (-1). Table B.1 in the appendix shows that 49.5% of wives lack any 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

[19]Bootstrap methods compute statistical significance levels by creating many pseudo-samples. They estimate the parameters for each pseudo-sample and then examine the distribution of the parameters across the different pseudo-samples. The wild cluster bootstrap-t creates pseudo-samples by holding the regressors constant while re-sampling with replacement group-specific residuals to create new dependent variables. Using Monte Carlo simulations, Cameron et al. (2008) demonstrate that statistical tests based on the wild cluster bootstrap-t procedure have the appropriate size and offer valid inferences. See their paper for a detailed description of the procedure.

wives in purchase of their own material items presented in Table 2.

We then report WTP for the improved stoves by treatment and autonomy in purchase of durables in Figure B.1 in the appendix. Panel "a" presents WTP of wives in T1 and T3 by decision-making autonomy. Panel "b" presents WTP of husbands in T2 and T4 by their level of autocracy. Panel "c" presents WTP by the couples group (T5) by decision-making autonomy of wives. Consistent with the results reported in Figure 4, Figure B.1 in the appendix suggests that wives' autonomy in decision making regarding household durables is strongly correlated with WTP. The mean WTP by all treatment groups and the statistical significance in mean differences appear to be similar to those presented in Figure 4. Autonomous wives are willing to pay more and autocratic husbands are willing to pay less.

Third, we re-estimate both the tobit and OLS regressions using decision-making autonomy for household durables. Table B.2 in the appendix presents the regression results for the treatment effects by the gender of subjects, where we pooled the five treatment groups into three. Table B.3 presents the regression results for all the treatment groups. The results are consistent with the ones we documented in the preceding section: wives are on average willing to pay substantially more than husbands and couples; wives in T1 and T3 reveal the highest WTP for the stove; wives' autonomy in decision-making in the purchase of household durables is also a strong and statistically significant correlate of WTP. Moreover, we implemented and reported the wild bootstrap-t cluster p-values. The statistical significance implied by the p-values is consistent with the statistical significance of the treatments.

Finally, we investigate whether the treatments and decision-making autonomy are correlated with how quickly the improved stove is put in use. We conducted a follow-up survey on the households who participated in the stove purchase experiment 15 months after the stoves were acquired. We collected detailed information on stove use, fuelwood collection, fuelwood consumption and time allocation. Table B.4 in the appendix reports OLS regression results on the correlates of stove use measured by the number of months since the stove was put to use by the households who actually bought the stove through the BDM experiment. The results suggest that neither how the stove was acquired (i.e., the treatment type) nor decision-making autonomy have any impact on how quickly the stove is put to use once the household acquires it. These findings very likely support our hypothesis that decision-making autonomy and liquidity constraint of women, rather than inability to understand the stove's benefits, are the most important factors that hinder wives from purchasing the stove.

5.5. *Mechanisms*

In this section, we attempt to shed light on the mechanisms that possibly explain our treatment effects. The incentive-compatibility of the BDM method which we used to elicit WTP for the improved cookstove has been questioned by previous studies. In

the case of choices involving a lottery, Karni and Safra (1987) show that experimental methods, such as the BDM, are not reliable elicitation methods to estimate certainty equivalents of given lotteries unless the preference of the subject is characterized by the expected utility function. Later on, Horowitz (2006) extended the conclusion to the case of elicitation of preferences for items that do not involve uncertainty, because the circumstances in which an individual is asked to bid for an item likely affect the value she/he places on the item. This implies that, when bidding, an individual very likely reveals a certain WTP considering the distribution of potential prices. Consequently, what the individual places as a bid is not necessarily her/his true WTP for the item; it is instead the price that has a higher chance of being accepted.[20] Moreover, consistent with the predictions of Gul (1991), an individual may bid for a higher price due to "disappointment or regret aversion", rather than to reveal her/his true maximum WTP. Using the British Household Panel Survey spanning two decades, Dawson and de Meza (2018) show that, compared to men, women's preferences are characterized by disappointment aversion.[21]

We provide robust evidence showing that wives in rural Ethiopia reveal substantially higher WTP for the improved cookstove than husbands. However, considering the systematic preference difference between women and men documented by previous studies, it would be plausible to question whether the revealed WTP of women in our sample is driven by disappointment aversion, and whether the preferences of our subjects is characterized by the expected utility theory. Unfortunately, we don't have enough information to characterize the utility functions of the subjects in our experiment, neither do we have access to preference-related data by a comparable sample in the study area. Nevertheless, we have detailed information on the gender roles and division of labor within the household that shed light on the mechanisms that explain the high revealed WTP by wives. In our sample, women are 100% responsible for cooking in the household. The descriptive statistics presented in Table 1 show that, 82% women are involved in fuelwood collection, while the figure is only 27% for men. Women on average spend 32.5 hours/month on collecting fuelwood, while men spend only 1.4 hours/month. Our survey team demonstrated the fuel-saving and smoke reduction benefits of the stove to all participants using the same demonstrator. Given the descriptive statistics on the role of women in fuelwood collection and cooking, it is safe to conclude that the benefits of the stove directly accrue to them. While it would be difficult to completely rule out the possibility of disappointment-aversion, we believe that the demonstrated benefits of the stove largely explain the larger WTP women reveal relative to men.

We also collected detailed information at baseline through a household survey that helps us tease out the mechanisms that explain the low willingness to pay by husbands. In order to assess the knowledge and preference of households related to

[20] See Horowitz (2006) for details.

[21] We thank an anonymous reviewer for encouraging us to discuss this and for providing a reference.

different development services, including improved cookstoves, we asked husbands and wives to make hypothetical choices between receiving a good (service) and receiving cash of different amounts. The hypothetical goods (services) asked about include an improved cookstove that saves fuel by half; an improved cookstove that saves smoke by half; improved seed that increases productivity by 25%; and three months of free health care service. We asked the respondents to choose between receiving these goods (services) versus cash offers of ETB 50, 150, 250 and 500 respectively. For example, we asked "would you prefer to receive an improved stove that saves fuel by half or ETB 50?". The responses to these questions help us understand husbands' and wives' relative preferences along the lines of gender-based division of labor.[22]

We present the responses to the hypothetical choices by both wives and husbands in Figure 5. We note that the demand for quality healthcare is price insensitive for both husbands and wives, while their demand for improved cookstoves and improved seeds is price sensitive. Consistent with intra-household division of labor, husbands reveal relatively high preference for improved seeds, but low preference for both types of improved cookstoves. On the contrary, wives have higher preference for fuel-saving stoves than for improved seeds. Figure 5 also suggests that both genders prioritize healthcare over improved cookstoves, and both prioritize fuel-saving attribute over smoke-reducing attributes of stoves. Taken together, these descriptive statistics suggest that both husbands and wives are able to evaluate the attributes of the improved cookstove and reveal preferences that are consistent with their intra-household division of labor. After earning income from the public work we designed, husbands very likely felt like spending it on other goods (services) rather than on improved cookstoves, and this likely explains their low WTP for the stove. Given their default role as the head of the household, they also likely imposed their preference on wives, which very likely explains the similarity in WTP of the two husbands treatment groups (T2 and T4) with the WTP of couples (T5).

Figure 5 about here

6. Conclusions

This paper uses a field experiment to analyze the effects of differences in preferences and intra-household decision-making autonomy on willingness to pay for a new household durable. The experiment was conducted using a sample of wives, husbands and couples from the Tigray region of Ethiopia. We invited 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. Subjects were randomly assigned to five treatment groups: wives who were invited alone and would make the stove

[22] Our survey team was trained to take the necessary precautions to present these questions as hypothetically as possible without creating any expectation of receiving the goods (services) by households.

purchase decision alone using the income they had earned individually (Treatment 1 or T1); husbands who were invited alone and would make the stove purchase decision alone using the income they had earned individually; wives who were invited with their husbands and would make the stove purchase decision alone using the income the couple had earned (T3); husbands who were invited with their wives and would make the stove purchase decision alone using the income the couple had earned (T4); and couples who would make the stove purchase decision jointly using the income the couple had earned (T5).

The stoves we used in our stove purchase experiment 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 offer a large potential for improving the wellbeing of all members of the household, but most importantly that of women, because of their responsibility for cooking and fuelwood collection, which they often perform while caring for children. Our experimental design therefore allows us to tease out the role of both preference difference and decision-making autonomy between women and men within the household on willingness to pay (WTP) for an important household durable, which is the key contribution of our paper.

We find strong evidence that differences in both preferences and intra-household bargaining power drive WTP for the improved cookstove. Wives in general are willing to pay on average 57%, and 39% more than husbands and couples respectively. This suggests that, since women benefit more than men from owning the stove, they value the stove more and are willing to pay more. The results also reveal that offering income-earning opportunities to wives substantially improves their WTP for the stove. Wives who participated in the income-generating manual labor alone and made the stove purchase decision alone (T1) reveal the highest WTP for the improved cookstove, followed by the group of wives who participated in the public work together with their husbands, but made the stove purchase decision alone using the income they earned with their husbands (T3). Wives in the two treatment groups were willing to pay 67% and 53% more than husbands who were using the income they earned alone and who made the stove purchase decision alone. WTP by spouses who earned income together and made the stove purchase decision together is much closer to WTP by husbands who made the stove purchase decision alone. We also find that reported decision-making autonomy of wives is an important correlate of WTP. Taken together, the results suggest that there is a strong preference difference between wives and husbands (wives are willing to pay substantially more than husbands) for the improved cookstove; there is a clear spousal influence (dominance by husbands) in household-level decisions; and the income earning opportunity we offered to subjects enabled women to make a purchase decision that is in their (possibly their children's) best interest.

We conducted a comprehensive follow-up survey 15 months after the stoves were purchased by the experimental participants. In addition to fuelwood collection, con-

sumption and sales data, we collected detailed information on stove use behaviour. Regression results of stove use on the treatments, wives' decision-making autonomy, village fixed effects and a set of baseline covariates suggest that the type of treatment and decision-making autonomy do not have any effect on how quickly the improved stove is put to use. This supports our hypothesis that, if wives do not purchase the stove, it is very likely because of lack of autonomy to make the purchase decision and the ability to pay, rather than due to lack of interest in the stove. Women seem to understand the significant fuelwood, time and smoke reduction attributes of the improved cookstove. Our results remain robust to an alternative definition of decision-making autonomy, alternative specifications, and the wild bootstrap-t procedure, which has been proposed to address the issue of making inferences based on clustered standard errors when the number of clusters is small.

The results here suggest that preference differences, mainly driven by division of labor in the household and women's lack of decision-making autonomy, have significant implications 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 inconsistent household decisions. The 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 income-generating opportunities entitle women to their own earnings, improve their decision-making power and benefit women themselves and other vulnerable 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. and Ruhinduka, R. (2020). Saving Africa's tropical forests through energy transition: A randomized controlled trial in Tanzania. Working Paper.

Allen, J. C. and Barnes, D. F. (1985). The causes of deforestation in developing countries. *Annals of the Association of American Geographers*, 75(2):163–184.

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.

Angelucci, M., Karlan, D., and Zinman, J. (2013). Win some lose some? Evidence from a randomized microcredit program placement experiment by Compartamos Banco. NBER Working Paper 19119, National Bureau of Economic Research, Cambridge, MA.

Ashraf, N. (2009). Spousal control and intra-household decision making: An experimental study in the Philippines. *American Economic Review*, 99(4):1245–1277.

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, G. S. (1973). A theory of marriage: Part i. *Journal of Political Economy*, 81(4):813–846.

Becker, G. S. (1981). *A Treatise on the Family*. Harvard University Press.

Beltramo, T., Blalock, G., Levine, D. I., and Simons, A. M. (2015). The effect of marketing messages and payment over time on willingness to pay for fuel-efficient cookstoves. *Journal of Economic Behavior and Organization*, 118:333–345.

Bensch, G. and Peters, J. (2015). The intensive margin of technology adoption: Experimental evidence on improved cooking stoves in rural Senegal. *Journal of Health Economics*, 42:44–63.

Berniell, M. I. and Sánchez-Páramo, C. (2011). Overview of time use data used for the analysis of gender differences in time use patterns. Background paper for World Development Report 2012.

Beyene, A. D., Bluffstone, R., Gebreegziabher, Z., Martinsson, P., Mekonnen, A., and Vieider, F. (2015). Improved biomass stove saves wood, but how often do people use it? Evidence from a randomized treatment trial in Ethiopia. Policy Research Working Paper 7297, The World Bank Group.

Beyene, A. D. and Koch, S. F. (2013). Clean fuel-saving technology adoption in urban Ethiopia. *Energy Economics*, 36:605 – 613.

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., Bourguigno, 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.

Bruce, J. (1989). Homes divided. *World Development*, 17(7):979–991.

Burda, M., Hamermesh, D. S., and Weil, P. (2013). Total work and gender: facts and possible explanations. *Journal of Population Economics*, 26:239–261.

Cameron, A. C., Gelbach, J. B., and Miller, G. L. (2008). Bootstrap-based improvements for inference with clustered errors. *The Review of Economics and Statistics*, 90(3):414–427.

Campbell, B., Angelsen, A., Cunningham, A., Katerere, Y., Sitoe, A., and Wunder, S. (2007). Miombo woodlands, opportunities and barriers to sustainable forest management. *CIFOR*.

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.

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.

Dawson, C. and de Meza, D. (2018). Wishful thinking, prudent behavior: The evolutionary origin of optimism, loss aversion and disappointment aversion. SSRN Working Paper.

Deininger, K., Goyal, A., and Nagarajan, H. (2013). Women's inheritance rights and intergenerational transmission of resources in India. *Journal of Human Resources*, 48(1):114–141.

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 intra-household allocation in South Africa. *The World Bank Economic Review*, 17(1):1–25.

Duflo, E. (2012). Women empowerment and economic development. *Journal of Economic Literature*, 50(4):1051–1079.

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.

Fafchamps, M. and Quisumbing, A. R. (2005). Marriage, bequest, and assortative matching in rural Ethiopia. *Economic Development and Cultural Change*, 53(2):347–380.

Fernández, R. (2007). Women, work, and culture. *Journal of European Economic Association*, 5(2):305–332.

Fernandez, R., Fogli, A., and Olivetti, C. (2004). Mothers and sons: Preference formation and female labor force dynamics. *Journal of Political Economy*, 119(4):1249–1299.

Fernández, R., Guner, N., and Knowles, J. (2005). Love and money: A theoretical and empirical analysis of household sorting and inequality. *Quarterly Journal of Economics*, 120(1):273–344.

Fiszbein, A., Schady, N., Ferreira, F. H., Grosh, M., Keleher, N., Olinto, P., and Skoufias, E. (2009). Conditional cash transfers: Reducing present and future poverty. Policy Research Report 47603, The World Bank Group.

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.

Gebreegziabher, Z., Mekonnen, A., Kassie, M., and Kohlin, G. (2012). Urban energy transition and technology adoption: the case of Tigray, northern Ethiopia. *Energy Economics*, 34:410–418.

Gebreegziabher, 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.

Geist, H. J. and Lambin, E. F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *BioScience*, 52(2):143–150.

Gilligan, D. O. and Hoddinott, J. (2007). Is there persistence in the impact of emergency food aid? Evidence on consumption, food security and assets in rural Ethiopia. *American Journal of Agricultural Economics*, 89(2):225–242.

Gilligan, D. O., Hoddinott, J., and Taffesse, A. S. (2009). The impact of Ethiopia's productive safety net programme and its linkages. *Journal of Development Studies*, 45(10):1684–1706.

Giné, X., Townsend, R., and Vickery, J. (2008). Patterns of rainfall insurance participation in rural India. *World Bank Economic Review*, 22(3):539–566.

Grieshop, A. P., Marshall, J. D., and Kandlikar, M. (2011). Health and climate benefits of cookstove replacement options. *Energy Policy*, 39:7530–7542.

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.

Gul, F. (1991). A theory of disappointment aversion. *Econometrica*, 59(3):667–686.

Hanna, R., Duflo, E., and Greenstone, M. (2016). Up in the smoke: the influence of household behavior on the long-run impact of improved cookstoves. *American Economic Journal: Economic Policy*, 8(1):80–114.

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.

Hofstad, O., Köhlin, G., and Namaalwa, J. (2009). How can emissions from woodfuel be reduced? *Realising REDD+: National Strategy and Policy Options*, pages 237–248.

Horowitz, J. H. (2006). The Becker-Degroot-Marschak mechanism is not necessarily incentive compatible, even for non-random goods. *Economics Letters*, 93:6–11.

Jayasuriya, D. S. and Burke, P. J. (2013). Female parliamentarians and economic growth: evidence from a large panel. *Applied Economics Letters*, 20(3):304–307.

Kandlikar, M., Reynolds, C. C., and Grieshopdy, A. P. (2009). A perspective paper on black carbon mitigation as a response to climate change. *Copenhagen Consensus on Climate*.

Kandpal, E. and Baylis, K. (2019). The social lives of married women: Peer effects in female autonomy and investments in children. *Journal of Development Economics*, 140:26–43.

Karni, E. and Safra, Z. (1987). "Preference reversal" and the observability of preferences by experimental methods. *Econometrica*, 55(3):675–685.

Kishor, S. and Subaiya, L. (2008). Understanding women's empowerment: A comparative analysis of demographic and health surveys (DHS) data. *DHS Comparative Reports*, (20).

Köhlin, G., Sills, E. O., Pattanayak, S., and Wilfong, C. (2011). Energy, gender and development: What are the linkages? where is the evidence? *Social Development Papers*, (125).

Kremer, M. (1997). How much does sorting increase inequality? *Quarterly Journal of Economics*, 112(1):115–139.

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.

Mazzocco, M. (2007). Household intertemporal behaviour: A collective characterization and a test of commitment. *Review of Economic Studies*, 74:857–895.

Mercer, B., Finighan, J., Sembres, T., and Schaefer, J. (2011). Protecting and restoring forest carbon in tropical Africa: A guide for donors and funders. Electronic.

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.

Miller, G. and Mobarak, A. M. (2014). Learning about new technologies through social networks: Experimental evidence on nontraditional stoves in Bangladesh. *Marketing Science*, 34(4):480–499.

Mobarak, A. M., Dwivedi, P., Bailis, R., Hildemann, L., and Miller, G. (2012). Low demand for nontraditional cookstove technologies. *Proceedings of the National Academy of Sciences*, 109(27):10815–10820.

Orfei, A. E. (2012). *Essays on female empowerment and its health consequences in West Africa*. PhD thesis, University of Maryland.

Pattanayak, S. K., Jeuland, M., Lewis, J. J., Usmani, F., Brooks, N., Bhojvaid, V., Kar, A., Lipinski, L., Morrison, L., , Patange, O., Ramanathan, N., Rehman, I. H., Thadani, R., Vora, M., and Ramanatha, V. (2019). Experimental evidence on promotion of electric and improved biomass cookstoves. *Proceedings of the National Academy of Sciences*, 116(27):13282–13287.

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.

Robinson, J. (2012). Limited insurance within the household: Evidence from a field experiment in Kenya. *American Economic Journal: Applied Economics*, 4(4):140–164.

Roy, S. (2015). Empowering women? inheritance rights, female education and dowry payments in india. *Journal of Development Economics*, 114:233–251.

Rubiano-Matulevich, E. and Viollaz, M. (2019). Gender differences in time use: Allocating time between the market and the household. Policy Research Working Paper 8981, World Bank.

Sagar, A. D. and Kartha, S. (2007). Bioenergy and sustainable development? *Annual Review of Environment and Resources*, 32(1):131–167.

Schaner, S. (2015). Do opposites detract? Intrahousehold preference heterogeneity and inefficient strategic savings. *American Economic Journal: Applied Economics*, 7(2):135–174.

Shurz, S. (2020). Economic and intergenerational decision-making in families. PhD Dissertation 243, University of Gothenburg, Department of Economics, Gothenburg.

Smith-Sivertsen, T., Díaz, E., Pope, D., Lie, R. T., Díaz, A., John McCracken, P. B., Arana, B., Smith, K. R., and Bruce, N. (2009). Effect of reducing indoor air pollution on women's respiratory symptoms and lung function: The respire randomized trial, Guatemala. *American Journal of Epidemiology*, 170(2):211–220.

Strauss, J. and Beegle, K. (1996). Intrahousehold allocations: A review of theories, empirical evidence and policy issues. Technical Report 54688, Food Security International Development Working Paper, Michigan State University.

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.

WHO (2009). *Global Health Risks: Mortality and Burden of Disease Attributable to Major Risks*. World Health Organization, WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.

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.

Table 1: Descriptive Statistics of Variables at Baseline

Variable	(1) Husbands	(2) Wives	(3) Mean Diff.
Panel A: Individual Characteristics			
Age	48.14	45.16	2.983**
	(13.41)	(12.96)	(2.15)
Years of schooling	1.339	1.606	-0.267
	(2.187)	(1.676)	(-1.30)
Member of the ruling party (1= yes, 0= no)	0.556	0.272	0.283***
	(0.498)	(0.446)	(5.68)
Participates in fuelwood collection (1= yes, 0= no)	0.272	0.822	-0.550***
	(0.446)	(0.381)	(-12.57)
Hours spent on fuelwood collection/month	1.476	32.50	-31.03***
	(2.971)	(27.88)	(-14.85)
Participates in off-farm activities (1= yes, 0= no)	0.683	0.300	0.383***
	(0.466)	(0.454)	(7.90)
Panel B: Household Characteristics			
Hours spent collecting 1kg of fuelwood (Shadow price)	0.44		
	(0.42)		
Hours spent on fuelwood collection/month	48.81		
	(41.54)		
Monthly fuelwood collection	234.40		
	(180.13)		
Livestock owned in Tropical Livestock Units (TLU)	4.93		
	(4.12)		
Wealth in 1000 ETB	35.23		
	(39.04)		
Land size (in Timad)	3.05		
	(2.21)		
Number of trees owned	12.04		
	(33.47)		
Number of males over 15 years)	0.63		
	(0.98)		
Number of females over 15 years	0.64		
	(0.97)		
Number of males aged 7-15 years	0.69		
	(0.97)		
Number of females aged 7-15 years	0.94		
	(1.10)		
No. of children aged under 7 years	0.86		
	(0.99)		
Household size	5.76		
	(1.77)		
Owns a separate kitchen (1= yes, 0= no)	0.51		
	(0.50)		
Observations	360		

Notes: Columns [1] & [2] of panel A of this table presents summary statistics from the experimental sample collected before the experiment and in individual surveys conducted separately with husbands and wives based on their own reports. Column [3] reports statistical test results on mean differences between the two samples. Panel B of the table reports household-level summary statistics from the experimental sample prior to the experiment. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table 2: Decision-making autonomy (autocracy)

Variable	(1) Freq.	(2) Percent
Panel A: Wives		
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
Panel B: Husbands		
Husbands' autocracy in purchase of wives' material items		
High dominance (autocratic)	82	45.56
Moderate	62	34.44
Low dominance (non-autocratic)	36	20.00
Total	180	100.00

Notes: Panel A of this table shows descriptive statistics on reported decision-making autotomy of wives in purchase of their own material items; survey data collected before the experiment. Panel B shows descriptive statistics on reported autocracy of husbands on purchase of wife's material items; survey data collected before the experiment.

Table 3: Participant characteristics and randomization balance - wives sample.

Variable	(1) T1	(2) T3	(3) T5	(4) T1 vs T3	(5) T1 vs T5	(6) T3 vs T5
Panel A: Individual Characteristics						
Wife's autonomy	-0.22	-0.18	-0.18	-0.03	-0.03	0.00
	(0.88)	(0.85)	(0.81)	(0.16)	(0.16)	(0.15)
Age	44.05	45.32	46.10	-1.27	-2.05	-0.78
	(12.96)	(12.82)	(13.24)	(2.35)	(2.39)	(2.38)
Years of schooling	1.87	1.55	1.40	0.32	0.47	0.15
	(1.75)	(1.58)	(1.69)	(0.30)	(0.31)	(0.30)
Member of the ruling party (1= yes, 0= no)	0.27	0.32	0.23	-0.05	0.03	0.08
	(0.45)	(0.47)	(0.43)	(0.08)	(0.08)	(0.08)
Participates in fuelwood collection (1= yes, 0= no)	0.85	0.80	0.82	0.06	0.04	-0.02
	(0.32)	(0.43)	(0.39)	(0.07)	(0.07)	(0.07)
Hours spent on fuelwood collection/month	36.15	28.83	32.54	7.32	3.61	-3.71
	(29.12)	(26.69)	(27.75)	(5.10)	(5.19)	(4.97)
Participates in off-farm activities (1= yes, 0= no)	0.30	0.35	0.25	-0.06	0.05	0.10
	(0.50)	(0.43)	(0.44)	(0.08)	(0.09)	(0.08)
Panel B: Household Characteristics						
Hours spent collecting 1kg of fuelwood (Shadow price)	0.41	0.48	0.48	-0.07	-0.08	-0.01
	(0.52)	(0.45)	(0.35)	(0.09)	(0.08)	(0.07)
Hours spent on fuelwood collection/month	51.17	46.75	52.87	4.42	-1.70	-6.12
	(47.66)	(41.59)	(39.19)	(8.17)	(7.97)	(7.38)
Monthly fuelwood collection	203.95	213.03	239.47	-9.08	-35.52	-26.43
	(170.18)	(186.24)	(174.29)	(32.57)	(31.45)	(32.93)
Livestock in TLU	5.50	6.10	5.63	-0.61	-0.14	0.47
	(4.70)	(4.99)	(4.83)	(0.89)	(0.87)	(0.90)
Wealth in 1000 ETB	37.03	43.22	32.72	-6.18	4.32	10.50
	(38.76)	(47.05)	(38.39)	(7.87)	(7.04)	(7.84)
Land size (in Timad)	3.04	3.09	3.08	-0.05	-0.05	0.00
	(2.12)	(2.29)	(2.24)	(0.40)	(0.40)	(0.41)
Number of trees owned	10.78	12.30	14.30	-1.52	-3.52	-2.00
	(30.96)	(33.90)	(39.14)	(5.93)	(6.44)	(6.68)
Number of males over 15 years)	0.63	0.78	0.53	-0.15	0.10	0.25
	(1.12)	(1.04)	(0.93)	(0.20)	(0.19)	(0.18)
Number of females over 15 years	0.68	0.43	0.60	0.25	0.08	-0.17
	(1.05)	(0.81)	(1.06)	(0.17)	(0.19)	(0.17)
Number of males aged 7-15 years	0.67	0.50	0.70	0.17	-0.03	-0.20
	(1.05)	(0.79)	(0.94)	(0.17)	(0.18)	(0.16)
Number of females aged 7-15 years	0.67	0.85	1.05	-0.18	-0.38*	-0.20
	(0.99)	(1.13)	(1.25)	(0.19)	(0.21)	(0.22)
No. of children aged under 7 years	1.07	0.98	0.80	0.08	0.27	0.18
	(0.99)	(1.13)	(0.99)	(0.19)	(0.18)	(0.19)
Household size	5.72	5.55	5.60	0.17	0.12	-0.05
	(1.98)	(1.68)	(1.75)	(0.33)	(0.34)	(0.31)
Owns a separate kitchen (1= yes, 0= no)	0.42	0.47	0.57	-0.05	-0.15	-0.10
	(0.50)	(0.50)	(0.50)	(0.09)	(0.09)	(0.09)
Observations	60	60	60			

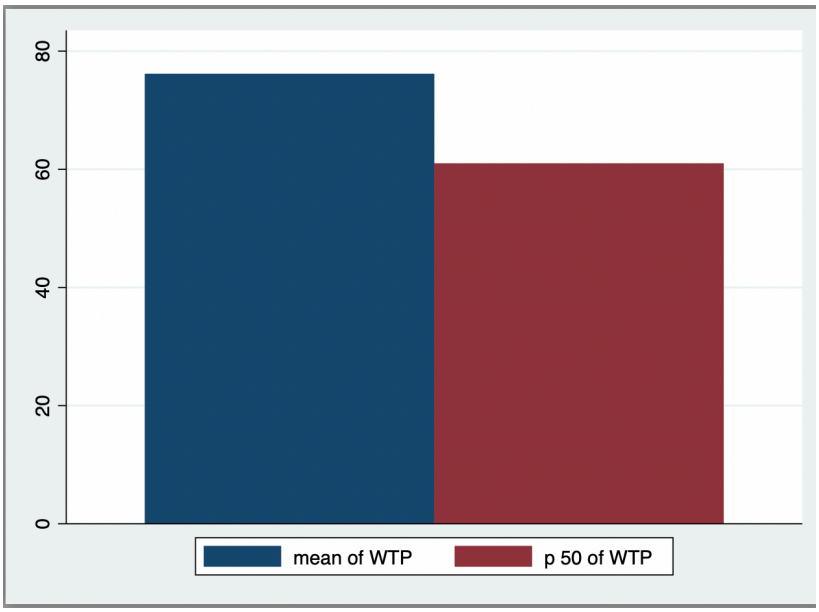
Notes: This table presents summary statistics of variables at baseline for the three groups of the wives sample, and the corresponding statistical t-test results on mean differences. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table 4: Participant characteristics and randomization balance - husbands sample.

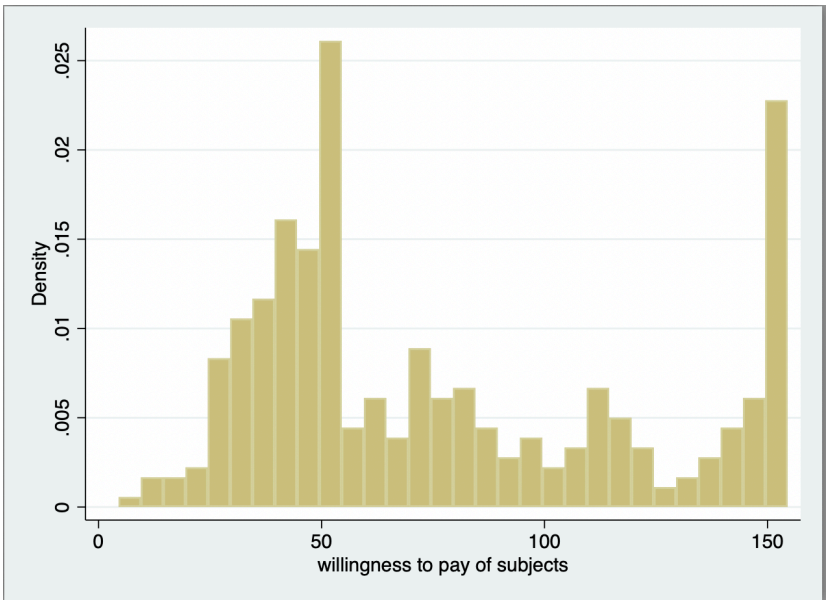
Variable	(1) T2	(2) T4	(3) T5	(4) T2 vs T4	(5) T2 vs T5	(6) T4 vs T5
Panel A: Individual Characteristics						
Husband's autocracy	-0.33	-0.25	-0.18	-0.08	-0.15	-0.07
	(0.75)	(0.75)	(0.81)	(0.14)	(0.14)	(0.14)
Age	49.10	49.15	46.17	-0.05	2.93	2.98
	(13.76)	(13.12)	(13.35)	(2.45)	(2.48)	(2.42)
Years of schooling	1.42	1.43	1.17	-0.02	0.25	0.27
	(2.29)	(2.19)	(2.11)	(0.41)	(0.40)	(0.39)
Member of the ruling party (1= yes, 0= no)	0.55	0.58	0.53	-0.03	0.02	0.05
	(0.50)	(0.50)	(0.50)	(0.09)	(0.09)	(0.09)
Participates in fuelwood collection (1= yes, 0= no)	0.22	0.27	0.33	-0.05	-0.12	-0.07
	(0.42)	(0.45)	(0.48)	(0.08)	(0.08)	(0.08)
Hours spent on fuelwood collection/month	1.25	1.36	1.82	-0.11	-0.57	-0.46
	(2.78)	(2.82)	(3.30)	(0.51)	(0.56)	(0.56)
Participates in off-farm activities (1= yes, 0= no)	0.68	0.63	0.73	0.05	-0.05	-0.10
	(0.47)	(0.49)	(0.45)	(0.09)	(0.08)	(0.09)
Panel B: Household Characteristics						
Hours spent collecting 1kg of fuelwood (Shadow price)	0.39	0.43	0.48	-0.03	-0.09	-0.05
	(0.39)	(0.40)	(0.35)	(0.07)	(0.07)	(0.07)
Hours spent on fuelwood collection/month	45.39	43.80	52.87	1.59	-7.47	-9.07
	(45.11)	(36.21)	(39.19)	(7.47)	(7.71)	(6.89)
Monthly fuelwood collection	231.35	279.12	239.47	-47.77	-8.12	39.65
	(168.45)	(202.87)	(174.29)	(34.04)	(31.29)	(34.53)
Livestock in TLU	4.09	4.11	4.13	-0.02	-0.04	-0.02
	(2.97)	(3.08)	(3.20)	(0.55)	(0.56)	(0.57)
Wealth in 1000 ETB	38.33	27.37	32.72	10.96*	5.61	-5.35
	(40.07)	(29.21)	(38.39)	(6.40)	(7.16)	(6.23)
Land size (in Timad)	2.86	3.16	3.08	-0.30	-0.22	0.08
	(2.20)	(2.28)	(2.24)	(0.41)	(0.40)	(0.41)
Number of trees owned	11.03	9.50	14.30	1.53	-3.27	-4.80
	(27.62)	(29.39)	(39.14)	(5.21)	(6.18)	(6.32)
Number of males over 15 years)	0.62	0.67	0.53	-0.05	0.08	0.13
	(0.99)	(0.88)	(0.93)	(0.17)	(0.18)	(0.16)
Number of females over 15 years	0.77	0.78	0.60	-0.02	0.17	0.18
	(0.96)	(0.87)	(1.06)	(0.17)	(0.18)	(0.18)
Number of males aged 7-15 years	0.90	0.68	0.70	0.22	0.20	-0.02
	(1.08)	(1.00)	(0.94)	(0.19)	(0.19)	(0.18)
Number of females aged 7-15 years	1.05	0.98	1.05	0.07	0.00	-0.07
	(0.96)	(0.97)	(1.25)	(0.18)	(0.20)	(0.20)
No. of children aged under 7 years	0.68	0.85	0.80	-0.17	-0.12	0.05
	(0.91)	(0.92)	(0.99)	(0.17)	(0.17)	(0.17)
Household size	6.05	6.02	5.60	0.03	0.45	0.42
	(1.95)	(1.49)	(1.75)	(0.32)	(0.34)	(0.30)
Owns a separate kitchen (1= yes, 0= no)	0.55	0.52	0.55	0.03	0.00	-0.03
	(0.50)	(0.50)	(0.50)	(0.09)	(0.09)	(0.09)
Observations	60	60	60			

Notes: This table presents summary statistics of variables at baseline for the three groups of the husbands sample, and the corresponding statistical t-test results on mean differences. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Figure 1: Overall WTP for ICS by Subjects



(a) Mean and Median WTP



(b) Density of WTP

Figure 2: WTP for ICS by Gender of Subjects

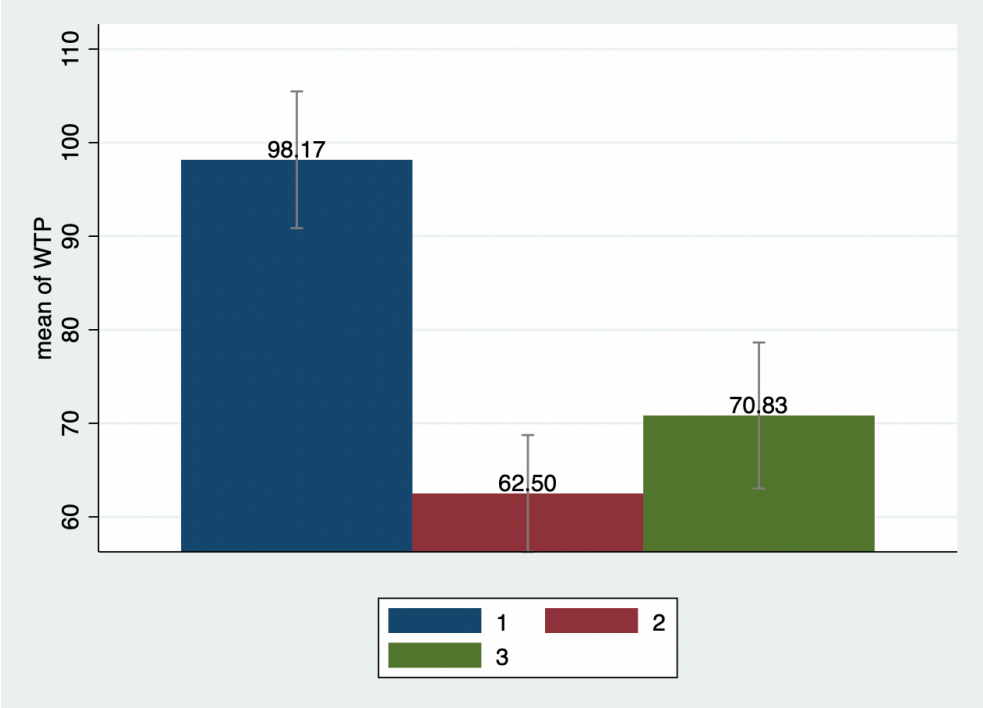
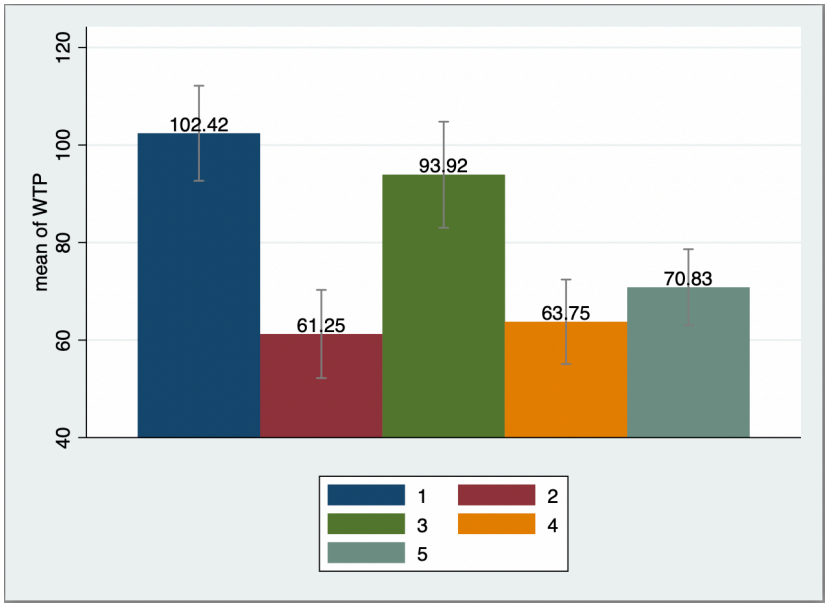
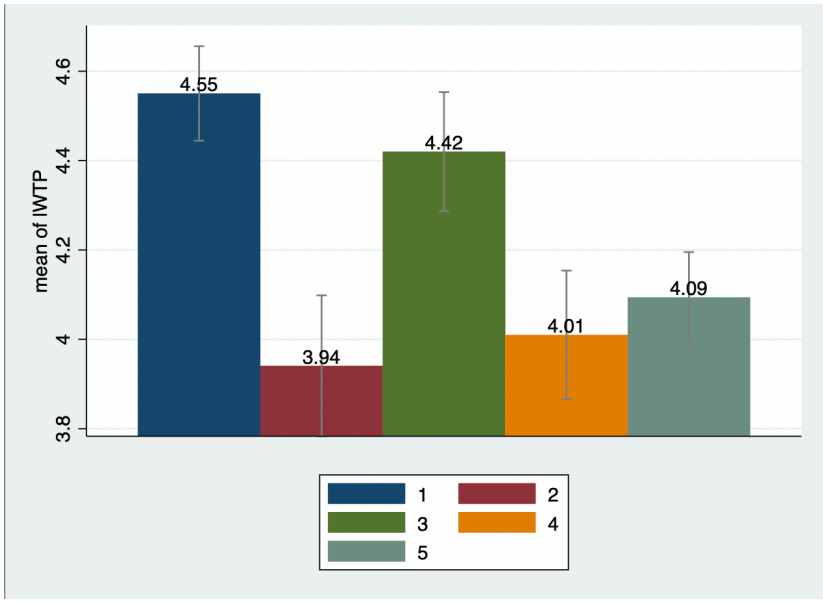


Figure 3: WTP for ICS by Treatment

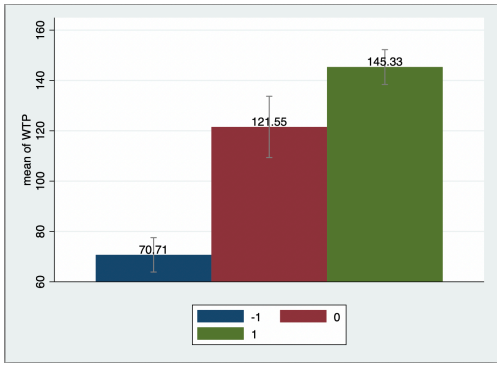


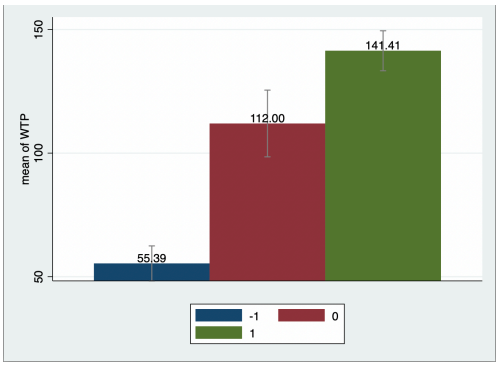
(a) WTP in levels



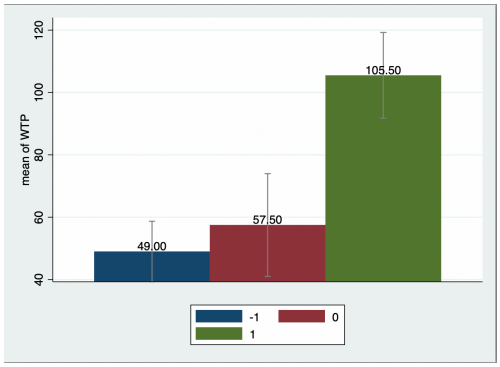
(b) WTP in logs

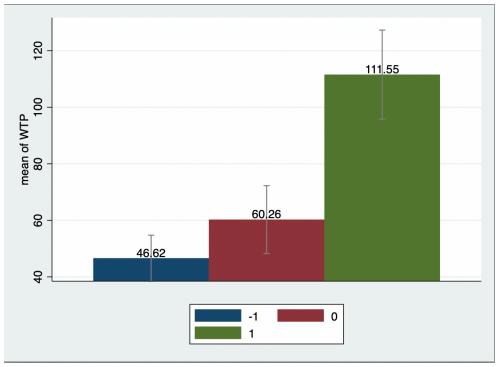
Figure 4: WTP for ICS by Treatment & Autonomy of Wives



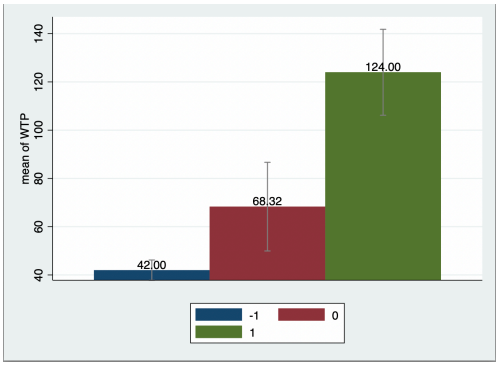


(a) WTP of Wives (T1 & T3)





(b) WTP of Husbands (T2 & T4)



(c) WTP of Couples (T5)

Table 5: Treatment Effects on WTP by Gender: Tobit and OLS Regression Results

	[1] Tobit-1	[2] OLS-1	[3] Tobit-2	[4] OLS-2	[5] Tobit-3	[6] OLS-3
T13	25.900***	27.935**	27.609***	28.405**	23.183***	23.974**
	(3.154)	(7.989)	(3.266)	(8.432)	(2.997)	(5.947)
WC P-value	-	[0.031]	-	[0.031]	-	[0.000]
T24	-4.597	-4.423	-8.268**	-7.870	-6.813**	-5.900
	(3.130)	(5.862)	(3.224)	(6.221)	(3.018)	(5.358)
WC P-value	-	[0.438]	-	[0.219]	-	[0.250]
Aut_wife	33.612***	36.098***	35.729***	38.975***	27.145***	28.670***
	(1.472)	(2.588)	(2.643)	(4.425)	(2.494)	(6.150)
T13_aut_wife			5.284	2.109	3.056	0.755
			(3.895)	(3.874)	(3.401)	(6.175)
T24_aut_wife			-13.130***	-12.888**	-4.305	-3.123
			(4.028)	(3.876)	(3.621)	(4.332)
Village Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	Yes
R-squared	-	0.64	-	0.65	-	0.76
Observations	360	360	360	360	360	360

Notes: This table reports results on the impact of the treatments pooled by gender on WTP from tobit and OLS regressions. Columns [1] & [2] report marginal effects from a tobit regression and OLS results controlling for village fixed effects. Columns [3] & [4] report marginal effects from a tobit regression and OLS results controlling for village fixed effects and interaction terms with wives' decision-making autonomy. Columns [5] & [6] report marginal effects from a tobit regression and OLS results controlling for village fixed effects, interaction terms with wives' decision-making autonomy and baseline individual and household level controls reported in Table 1. Standard errors clustered at the village-level are reported in parentheses. Wild cluster bootstrap-t p-values of treatment effects are reported in square brackets. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table 6: Treatment Effects by Gender on Log WTP: Tobit and OLS Regression Results

	[1] Tobit-1	[2] OLS-1	[3] Tobit-2	[4] OLS-2	[5] Tobit-3	[6] OLS-3
T13	0.399***	0.399***	0.389***	0.389***	0.315***	0.326***
	(0.048)	(0.087)	(0.049)	(0.094)	(0.044)	(0.059)
WC P-value	-	[0.000]	-	[0.000]	-	[0.000]
T24	-0.069	-0.069	-0.094*	-0.094	-0.076*	-0.075
	(0.048)	(0.076)	(0.051)	(0.084)	(0.046)	(0.070)
WC P-value	-	[0.344]	-	[0.250]	-	[0.344]
Aut_wife	0.453***	0.453***	0.502***	0.502***	0.344***	0.332***
	(0.025)	(0.045)	(0.043)	(0.050)	(0.039)	(0.075)
T13_aut_wife			-0.051	-0.051	-0.070	-0.056
			(0.058)	(0.035)	(0.050)	(0.063)
T24_aut_wife			-0.102	-0.102	0.055	0.059
			(0.063)	(0.054)	(0.055)	(0.072)
Village Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	Yes
R-squared	-	0.59	-	0.60	-	0.74
Observations	360	360	360	360	360	360

Notes: This table reports results on the impact of the treatments pooled by gender on the log of WTP from tobit and OLS regressions. Columns [1] & [2] report marginal effects from a tobit regression and OLS results controlling for village fixed effects. Columns [3] & [4] report marginal effects from a tobit regression and OLS results controlling for village fixed effects and interaction terms with wives' decision-making autonomy. Columns [5] & [6] report marginal effects from a tobit regression and OLS results controlling for village fixed effects, interaction terms with wives' decision-making autonomy and baseline individual and household level controls reported in Table 1. Standard errors clustered at the village-level are reported in parentheses. Wild cluster bootstrap-t p-values of treatment effects are reported in square brackets. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table 7: Treatment Effects on WTP: Tobit and OLS Regression Results

	[1] Tobit-1	[2] OLS-1	[3] Tobit-2	[4] OLS-2	[5] Tobit-3	[6] OLS-3
T1	31.775***	32.788***	34.436***	32.711***	29.451***	27.871***
	(3.899)	(6.551)	(4.214)	(7.333)	(3.740)	(5.445)
WC P-value	-	[0.000]	-	[0.031]	-	[0.000]
T2	-4.172	-4.161	-9.273**	-9.053	-8.921**	-8.002
	(3.804)	(6.648)	(3.994)	(6.088)	(3.606)	(5.457)
WC P-value	-	[0.531]	-	[0.156]	-	[0.219]
T3	20.389***	23.083*	21.733***	24.086*	18.059***	20.609**
	(3.829)	(9.588)	(3.894)	(9.877)	(3.452)	(6.712)
WC P-value	-	[0.031]	-	[0.063]	-	[0.031]
T4	-4.971	-4.674	-7.500*	-6.979	-5.311	-4.573
	(3.796)	(5.922)	(3.882)	(6.654)	(3.503)	(5.801)
WC P-value	-	[0.500]	-	[0.25]	-	[0.500]
Autonomy of wife	33.785***	36.146***	35.749***	38.981***	27.197***	28.857***
	(1.465)	(2.687)	(2.617)	(4.453)	(2.459)	(6.055)
T1_aut_wife			6.322	-0.793	3.762	-2.605
			(4.913)	(4.744)	(4.282)	(5.905)
T2_aut_wife			-15.938***	-15.951**	-8.540*	-7.683
			(4.975)	(4.929)	(4.419)	(6.216)
T3_aut_wife			5.600	5.466	3.277	3.860
			(4.629)	(3.735)	(3.937)	(7.250)
T4_aut_wife			-10.425**	-9.977**	-0.318	0.789
			(4.901)	(3.379)	(4.306)	(3.437)
Village Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Village Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	Yes
R-squared	-	0.64	-	0.65	-	0.77
Observations	360	360	360	360	360	360

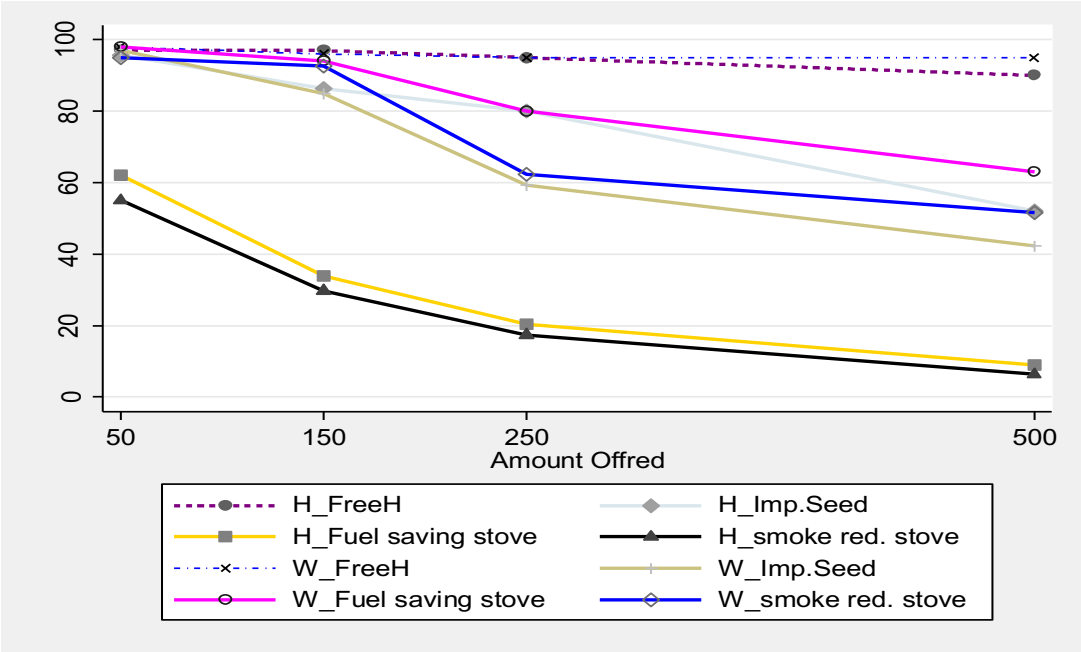
Notes: This table reports results on the impact of the treatments on WTP from tobit and OLS regressions. Columns [1] & [2] report marginal effects from a tobit regression and OLS results controlling for village fixed effects. Columns [3] & [4] report marginal effects from a tobit regression and OLS results controlling for village fixed effects and interaction terms with wives' decision-making autonomy. Columns [5] & [6] report marginal effects from a tobit regression and OLS results controlling for village fixed effects, interaction terms with wives' decision-making autonomy and baseline individual and household level controls reported in Table 1. Standard errors clustered at the village-level are reported in parentheses. Wild cluster bootstrap-t p-values of treatment effects are reported in square brackets. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table 8: Treatment Effects on Log WTP: Tobit and OLS Regression Results

	[1] Tobit-1	[2] OLS-1	[3] Tobit-2	[4] OLS-2	[5] Tobit-3	[6] OLS-3
T1	0.472***	0.472***	0.448***	0.448***	0.371***	0.384***
	(0.059)	(0.063)	(0.060)	(0.078)	(0.053)	(0.058)
WC P-value	-	[0.000]	-	[0.000]	-	[0.000]
T2	-0.085	-0.085	-0.128**	-0.128	-0.128**	-0.117
	(0.059)	(0.101)	(0.063)	(0.101)	(0.055)	(0.092)
WC P-value	-	[0.438]	-	[0.250]	-	[0.219]
T3	0.326***	0.326**	0.330***	0.330**	0.268***	0.276***
	(0.059)	(0.114)	(0.060)	(0.113)	(0.052)	(0.061)
WC P-value	-	[0.031]	-	[0.031]	-	[0.000]
T4	-0.054	-0.054	-0.065	-0.065	-0.038	-0.045
	(0.059)	(0.093)	(0.061)	(0.095)	(0.053)	(0.081)
WC P-value	-	[0.500]	-	[0.469]	-	[0.563]
Aut_wife	0.453***	0.453***	0.502***	0.502***	0.348***	0.336***
	(0.025)	(0.047)	(0.042)	(0.051)	(0.038)	(0.073)
T1_aut_wife			-0.114*	-0.114*	-0.123**	-0.114
			(0.069)	(0.051)	(0.059)	(0.073)
T2_aut_wife			-0.150*	-0.150**	-0.010	-0.002
			(0.078)	(0.051)	(0.067)	(0.076)
T3_aut_wife			0.020	0.020	-0.020	-0.001
			(0.070)	(0.036)	(0.059)	(0.078)
T4_aut_wife			-0.059	-0.059	0.108*	0.109
			(0.077)	(0.084)	(0.066)	(0.071)
Village Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	Yes
R-squared	-	0.60	-	0.61	-	0.74
Observations	360	360	360	360	360	360

Notes: This table reports results on the impact of the treatments on the log of WTP from tobit and OLS regressions. Columns [1] & [2] report marginal effects from a tobit regression and OLS results controlling for village fixed effects. Columns [3] & [4] report marginal effects from a tobit regression and OLS results controlling for village fixed effects and interaction terms with wives' decision-making autonomy. Columns [5] & [6] report marginal effects from a tobit regression and OLS results controlling for village fixed effects, interaction terms with wives' decision-making autonomy and baseline individual and household level controls reported in Table 1. Standard errors clustered at the village-level are reported in parentheses. Wild cluster bootstrap-t p-values of treatment effects are reported in square brackets. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Figure 5: Wives' and husbands' preferences for hypothetical goods (services)



Notes: This figure plots wives' and husbands' choices among hypothetical goods and services: an improved cookstove that saves fuel by half; an improved cookstove that saves smoke by half; improved seed that increases productivity by 25%; and three months of free health care service. The respondents were asked to choose between receiving these goods (services) versus cash offers of ETB 50, 150, 250 and 500 respectively. H_FreeH: husbands' preference for 3 months of free healthcare service to the amount of cash offered; H_Imp. seed: husbands' preference for improved seed that increases productivity by 25% to the amount of cash offered; H_Fuel-saving stove: husbands' preference for fuel-saving stove to the amount of cash offered; H_smoke red. stove: husbands preference for smoke reducing stove to the amount of cash offered; W_FreeH: wives' preference for 3 months of free healthcare service to the amount of cash offered; W_Imp. seed: wives' preference for improved seed that increases productivity by 25% to the amount of cash offered; W_Fuel-saving stove: wives' preference for fuel saving stove to the amount of cash offered; W_smoke red. stove: wives' preference for smoke reducing stove to the amount of cash offered.

Decision-making within the Household: The Role of Autonomy and Differences in Preferences **Supporting Information for Online Publication** *

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1. Appendix A: Photo of the Improved Cookstove

Pic.pdf

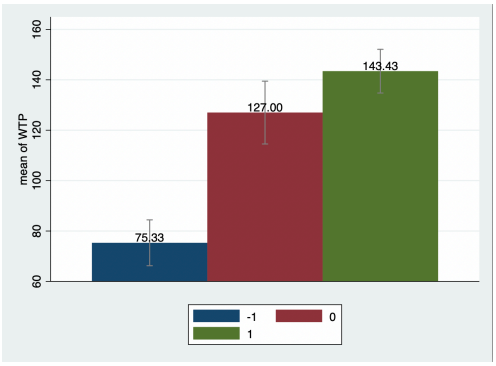
2. Appendix B: Robustness Checks

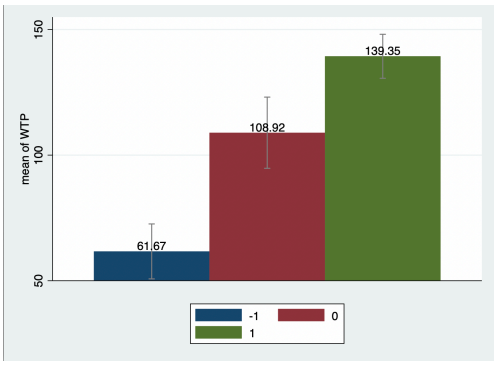
Table B1: Decision-making autonomy (autocracy)

Variable	(1) Freq.	(2) Percent
Panel A: Wives		
Wives' autonomy in purchase of household 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 household durables		
High dominance (autocrat)	91	50.56
Moderate	52	28.89
Low dominance (non-autocrat)	37	20.55
Total	180	100.00

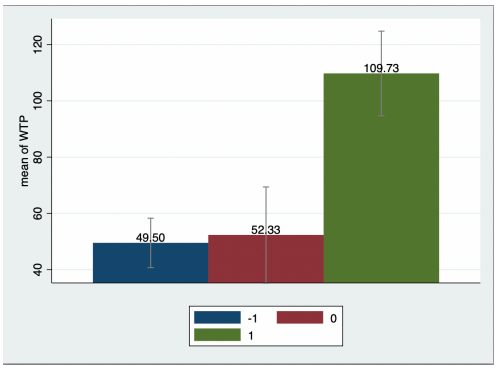
Notes: Panel A of this table shows descriptive statistics on reported decision-making autotomy of wives in purchase of household durables collected before the experiment. Panel B shows descriptive statistics on reported autocracy of husbands in purchase of household durables collected before the experiment.

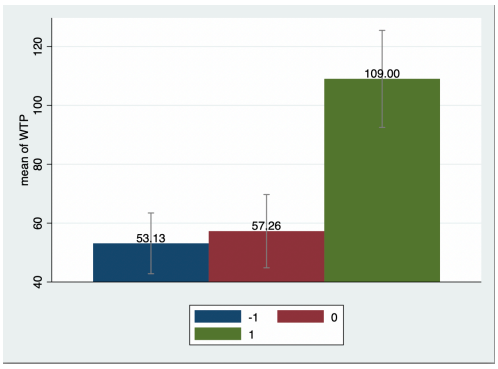
Figure B1: WTP for ICS by Treatment & Autonomy of Wives on Household Durables



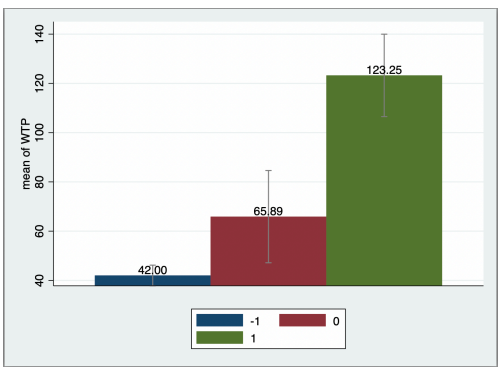


(a) WTP of Wives (T1 & T3)





(b) WTP of Husbands (T2 & T4)



(c) WTP of Couples (T5)

Table B2: Treatment Effects by Gender: Tobit and OLS Regression Results

	[1] Tobit-1	[2] OLS-1	[3] Tobit-2	[4] OLS-2	[5] Tobit-3	[6] OLS-3
T13	28.151***	30.742**	29.510***	31.012**	23.741***	25.094***
	(3.308)	(8.094)	(3.462)	(8.716)	(3.137)	(5.549)
WC P-value	-	[0.031]	-	[0.031]	-	[0.000]
T24	-1.880	-1.516	-6.473*	-5.870	-5.264*	-3.410
	(3.308)	(5.086)	(3.469)	(4.768)	(3.190)	(4.620)
WC P-value	-	[0.750]	-	[0.218]	-	[0.468]
aut_dur	31.617***	34.088***	35.322***	38.559***	25.932***	27.079***
	(1.561)	(2.667)	(2.751)	(4.236)	(2.560)	(5.682)
T13_aut_dur			2.219	-0.665	0.413	-0.841
			(4.092)	(4.252)	(3.511)	(5.745)
T24_aut_dur			-14.165***	-14.313***	-4.485	-2.945
			(4.185)	(2.071)	(3.705)	(2.895)
Village Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	Yes
R-squared	-	0.59	-	0.61	-	0.75
Observations	360	360	360	360	360	360

Notes: This table reports results on the impact of the treatments pooled by gender on WTP from tobit and OLS regressions. Columns [1] & [2] report marginal effects from a tobit regression and OLS results controlling for village fixed effects. Columns [3] & [4] report marginal effects from a tobit regression and OLS results controlling for village fixed effects and interaction terms with wives' decision-making autonomy in purchase of durables. Columns [5] & [6] report marginal effects from a tobit regression and OLS results controlling for village fixed effects, interaction terms with wives' decision-making autonomy and baseline individual and household level controls reported in Table **??**. Standard errors clustered at the village-level are reported in parentheses. Wild cluster bootstrap-t p-values of treatment effects are reported in square brackets. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table B3: Treatment Effects: Tobit and OLS Regression Results

	[1] Tobit-1	[2] OLS-1	[3] Tobit-2	[4] OLS-2	[5] Tobit-3	[6] OLS-3
T1	34.756***	36.719***	37.506***	36.647***	31.016***	30.187***
	(4.063)	(6.954)	(4.521)	(8.026)	(3.953)	(5.116)
WC P-value	-	[0.000]	-	[0.031]	-	[0.000]
T2	-2.250	-2.165	-6.938	-6.545	-6.913*	-5.161
	(4.009)	(4.922)	(4.278)	(4.702)	(3.807)	(4.262)
WC P-value	-	[0.687]	-	[0.187]	-	[0.250]
T3	21.874***	24.795**	22.750***	25.370**	17.940***	20.762**
	(4.020)	(9.459)	(4.126)	(9.675)	(3.621)	(6.288)
WC P-value	-	[0.031]	-	[0.062]	-	[0.031]
T4	-1.399	-0.806	-5.977	-5.212	-3.555	-1.856
	(3.999)	(6.098)	(4.232)	(5.571)	(3.761)	(5.465)
WC P-value	-	[0.875]	-	[0.312]	-	[0.718]
aut_dur	31.854***	34.238***	35.319***	38.553***	25.948***	27.201***
	(1.548)	(2.776)	(2.722)	(4.269)	(2.529)	(5.685)
T1_aut_dur			4.268	-2.270	2.997	-1.853
			(5.289)	(5.491)	(4.520)	(5.763)
T2_aut_dur			-13.781***	-13.865***	-6.065	-4.657
			(5.072)	(2.737)	(4.437)	(3.705)
T3_aut_dur			2.180	1.658	-0.249	0.582
			(4.807)	(4.644)	(4.044)	(7.674)
T4_aut_dur			-14.575***	-14.848***	-2.713	-1.439
			(5.147)	(3.476)	(4.455)	(3.835)
Village Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	Yes	Yes
R-squared	-	0.60	-	0.62	-	0.75
Observations	360	360	360	360	360	360

Notes: This table reports results on the impact of the treatments on WTP from tobit and OLS regressions. Columns [1] & [2] report marginal effects from a tobit regression and OLS results controlling for village fixed effects. Columns [3] & [4] report marginal effects from a tobit regression and OLS results controlling for village fixed effects and interaction terms with wives' decision-making autonomy in purchase of durables. Columns [5] & [6] report marginal effects from a tobit regression and OLS results controlling for village fixed effects, interaction terms with wives' decision-making autonomy and baseline individual and household level controls reported in Table **??**. Standard errors clustered at the village-level are reported in parentheses. Wild cluster bootstrap-t p-values of treatment effects are reported in square brackets. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table B4: Decision-making Power and Stove Use: OLS results

	(1) OLS-1	(2) OLS-2	(3) OLS-3
T1	-1.942	-1.682	1.380
	(1.416)	(1.394)	(1.630)
T2	0.018	0.154	0.248
	(0.780)	(0.857)	(1.167)
T3	-0.108	-0.079	2.026
	(1.212)	(0.867)	(1.111)
T4	-1.488	-1.046	-0.932
	(1.188)	(0.888)	(0.911)
aut_wife	-0.600	-0.118	-0.274
	(0.457)	(0.772)	(0.732)
T1_aut_wife		-0.228	-0.919
		(1.626)	(1.937)
T2_aut_wife		-1.776*	-2.239
		(0.855)	(1.394)
T3_aut_wife		0.449	-0.052
		(1.273)	(1.041)
T4_aut_wife		-1.838	-1.612
		(1.113)	(1.702)
Age			-0.018
			(0.042)
Years of schooling			0.197
			(0.122)
Member of the ruling party (1= yes, 0= no)			-1.375*
			(0.620)
Participates in fuelwood collection (1= yes, 0= no)			-0.023
			(1.199)
Hours spent on fuelwood collection/month			-0.062
			(0.037)
Participates in off-farm activities (1= yes, 0= no)			1.791*
			(0.866)
Hours spent collecting 1kg of fuelwood (Shadow price)			1.692
			(0.903)
Hours spent on fuelwood collection/month			0.024
			(0.018)
Monthly fuelwood collection			0.005
			(0.003)
Livestock in TLU			0.013
			(0.110)
Wealth in 1000 ETB			0.005
			(0.008)
Land size (in Timad)			-0.262
			(0.222)
Number of trees owned			-0.026*
			(0.012)
Number of males over 15 years)			-0.316
			(0.607)
Number of females over 15 years			-0.288
			(0.582)
Number of males aged 7-15 years			-0.801
			(0.497)
Number of females aged 7-15 years			-0.203
			(0.479)
No. of children aged under 7 years			-0.390
			(0.539)
Owns a separate kitchen (1= yes, 0= no)			-0.880
			(1.008)
Village Fixed Effects	Yes	Yes	Yes
Controls	No	No	Yes
R-squared	0.12	0.14	0.31

3. Appendix C: Survey and Experimental Instructions

4. Appendix D: Questionnaires