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Clean Cooking: The Value of Clean Cookstoves in Ethiopia

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Abstract

This project investigates how demographic differences affect the way people value clean cookstoves in Ethiopia. Previous research indicates that traditional cooking methods are harmful to human health as well as the environment, as people need to cut down trees or collect other biomass sources for fuel. However, clean stoves can solve both these environmental and health problems, as well as provide a sustainable method for cooking and heating in developing countries. Using choice survey data, this study examines Ethiopian households' valuations of different characteristics of stoves, including durability, fuel reduction, smoke reduction and the amount of time they may save using new technology. It also considers demographic factors that may affect a household's willingness to pay for stoves, in an effort to determine what makes these clean technologies desirable in an Ethiopian context. Results demonstrate that various demographic differences affect the valuation of clean cookstoves, as households with few females and children are willing to pay more for new stoves. The results of this study have implications for global sustainable development initiatives in many parts of the world.

Keywords

Economics, Sustainability, Cookstoves, Ethiopia, Stoves

Cover Page Footnote

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1. *Introduction:*

Ethiopia, located in east Africa, has made considerable developmental progress in the past several years. Despite regular droughts, the nation's GDP has grown, the number of aid beneficiaries has dropped, and according to the United States Agency for International Development (2014), the child mortality rate has been reduced by more than five percent per year over the past decade. However, Ethiopia is still one of the poorest nations in the world. The World Bank (2014) reports that nearly a third of the population lives below the national poverty line, meaning they live on less than $0.60 per day. Ethiopia's population is growing rapidly, which puts a strain on limited food sources, and about 82 percent of people survive on subsistence agriculture (USAID, 2014). Recent efforts have focused on improving these issues of food insecurity and creating a sustainable food production model to support the increasing population. One method of doing so is transforming the cooking methods that most Ethiopian households use every day.

Traditional cookstoves can be particularly dangerous to human health as well as to the environment. Many developing countries use wood or other biomass sources as fuel for cooking and heating. Inefficient stoves create a hazardous indoor environment, as smoke often pollutes the insides of homes. According to the World Health Organization (2014), over four million people die each year from indoor air pollution. Inefficient stoves also require people to cut down a lot of trees for fuelwood, which leads to deforestation, forest degradation and, ultimately, global warming. These cooking methods are not particularly sustainable, and various initiatives such as Reducing Emission from Deforestation and Forest Degradation (REDD+) programs have been implemented around the world to encourage people to act in more carbon-efficient ways. Traditional stoves also foster gender inequalities because women are typically the ones who spend hours collecting wood and who are exposed to smoke while cooking in the home. Furthermore, children are often expected to collect firewood, which can be time-consuming and dangerous.

These problems from unclean cooking and heating, however, are preventable. Replacing traditional stoves with affordable, clean and fuel-efficient ones could save lives and protect natural resources in developing nations, as well as contribute to growing environmental protection and economic development efforts around the world. In order to realistically promote these stoves among people in developing nations, however, organizations have to meet the needs of the people who will use them. Traditions, social interactions, and family dynamics differ across cultures but they play an integral role in people's willingness to adopt and ultimately use the clean technology. Therefore, it is important to note which aspects of this technology are important to families in their specific contexts.

Ethiopia provides an interesting context for these clean stove initiatives, as most of the nation's energy consumption is based on biomass sources. Indeed about 94% of the country's energy demand is fulfilled by wood, charcoal, branches, dung and agricultural residues, which all produce smoke and harmful emissions when they are burned. Also, sub-Saharan Africa has the highest rates of deforestation in the world, and Ethiopia's rapidly-growing population is adding to the strain on the increasingly scarce supply of firewood. Every year, nearly 200,000 hectares of land are destroyed in an effort to collect wood, and every year, firewood becomes more difficult to find. Clearly, Ethiopian households could benefit significantly from new stove technology.

Because Ethiopia is a developing nation in a region that suffers from vast environmental degradation, clean stove technology could play a significant role in promoting sustainable development. However, in order to encourage stove adoption, it is important to determine what factors make the new technology attractive to households. This study will examine how to best promote clean stove adoption in Ethiopia by determining what features of clean stove technology are important to households in the Ethiopian context, as well as what kinds of households are more likely to place a high value on this new technology.

2. Literature Review:

Several previous studies have examined the effects of traditional cookstoves and analyzed how to effectively encourage others to adopt clean models. Duflo, Greenstone and Hanna (2008) found that in rural India, there was a high correlation between using a traditional stove and having symptoms of respiratory illness. Parikh (2008) furthered this research and observed connections between gender, energy use, and health in the Himachal Pradesh region in India. Certain groups suffer from the negative effects of these traditional stoves and fuels more than others. Survey data provided evidence that women generally walk the most to collect fuel, they lose potential work days, and they suffer from physical stress from the long and often strenuous walks. Parikh also found that girls below age 5 as well as females age 30 to 60 show more symptoms of respiratory illness than do males of similar ages, because women and female children are the ones who spend the majority of their days inside their smoky homes.

There is, however, a solution to the environmental and development problems caused by stoves. A study by Simon, Bumpus and Mann (2012) explored possibilities of "win-win" programs for climate and development, and found that distributing sustainable stoves and using carbon finance could both protect the environment and stimulate economic growth and development in a poor country. These programs set both local and global goals, and results showed that development success was linked directly to environmental improvements. There are, however, various challenges for stove adoption, as not everyone in developing countries is willing to pay for or wants to use the new technology.

Previous efforts to encourage people to adopt and use new stoves in Ethiopia have been met with limited success. The government has tried to promote clean technology, and adoption rates have steadily increased over time, but there has been no evidence of a swift increase in stove adoption. Beyene and Koch (2013) examined the correlation between speed of adoption of new stoves and different socioeconomic factors, and found that the price of the stove, household income, and household wealth all have a significant effect on a household's willingness to adopt or use new stoves. Furthermore**,** if traditional stove technology is available, families are less likely to want a new stove. A different study by Takama, Tsephel and Johnson (2012) examined household decision-making regarding cookstove choices in Addis Ababa, and found that preferences for higher quality fuels and products increased with increasing wealth. Analyses by Lewis and Pattanayak (2012) determined that for various clean stove adoption initiatives, income, education and urban location were positively associated with stove adoption, and Blackman and Bannister (1998) found that in many developing nations, firms will adopt more expensive, clean technology under pressure from the community. The influence of fuel availability and prices, as well as household size, household composition and gender is unclear.

Besides considering household-level factors that lead families to adopt clean technology, numerous studies in different parts of the world have examined how attributes of the technology itself affect valuations. Adkins et al. (2010) found that in Sub-Saharan Africa, an individual's valuation of new stove technology was determined by a combination of different attributes of the stove, including cooking time, stove size and how easy the stove was to use. Another study by Mobarak et al. (2012) studied households in rural Bangladesh and found that women in these communities did not consider indoor air pollution to be a considerable problem or danger to their health. Households relied on traditional cookstoves and they were not willing to pay much for new, clean stoves. Indeed, even though clean stove technology is better for human health and the environment, many families wanted to use the technology that was familiar to them. However, Mobarak et al. found that organizations were more successful in promoting the adoption of these clean stoves if they highlighted the features that were highly valued by users, instead of focusing of the health and environmental benefits of the stoves. Nyrud et al (2008) added to this analysis and determined that, when distributing new technology, it is most effective to emphasize attributes that relate to the "users' perception of subjective norm" including the perceived status of those who use advanced technology, instead of focusing on objective benefits of the equipment. While household-level factors may affect willingness to adopt clean technology, various attributes and perceptions of clean stoves also dictate what people think they are worth.

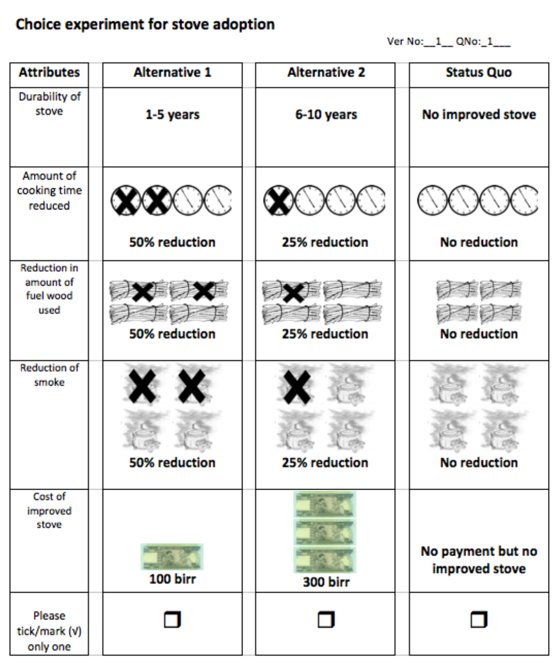
In order for clean cookstoves to be effective, they have to be accepted by the people who are going to use them, and they therefore have to fit in with the greater cultural context in which they are distributed. Further, stoves will not have any significant effects if they are not used long-term; when new stoves are brought to a home, there is usually a period during which families use several different technologies until they determine which devices work best for specific purposes (Ruiz-Mercado et al. 2011). Indeed, there may be advantages and disadvantages of the new technologies. If people have clean stoves but continue to use their old cooking methods, there will be no positive impacts for reduced indoor air pollution or greenhouse gas contributions.

This study will assess how households in Ethiopia value different attributes of clean stove technology, and determine how different demographic factors affect this valuation. These results will contribute to the existing literature about what factors matter for valuations and will provide an insight about what attributes of stoves are most important to Ethiopian households, in an effort to best encourage people to adopt and use clean technology. Results from this study also contribute to the growing body of research about global sustainable development, as clean cookstoves provide a solution for both human health and environmental issues and may promote development in many parts of the world.

3. Data:

Data for this study was collected from various sites around Ethiopia. In 2012, 84 sites were surveyed about their preferences for REDD+ contracts, and 36 of the 84 were chosen using a stratified-proportionate random sampling technique. Those 36 sites were distributed to three different regions and within each site, 14 households were chosen. Sites were randomized into six equivalent treatment groups using indicators. In total, 504 households were surveyed, from different regions that represent 80% of Ethiopia's population and 70% of Ethiopia's land cover. Ultimately, two observations were dropped due to incomplete data. Respondents were asked a variety of different questions regarding demographic data and fuel use, and respondents were asked to complete a choice experiment survey about adoption of new stove technology.

Figure 1 – Choice Experiment Survey Example



Choice experiments are a stated preference valuation tool used to determine someone's marginal willingness to pay (WTP) or willingness to accept (WTA) for goods that do not have easily attainable market values, and they provide information about the value of individual features of the goods. A survey presents several alternatives with varied levels of different attributes, and respondents have to choose one of the alternatives or a status quo option. This particular survey included five different attributes of clean stoves: durability of the stove, the reduction of fuel use, the reduction of smoke, the amount of cooking time reduced, and the cost of the appliance to the user. Every attribute had 3 or 4 systematically-assigned levels, in order to gauge a respondent's marginal willingness to pay. Each respondent answered seven different choice questions, but in order to combat learning biases throughout the survey, the first and seventh question were identical, and the first question was dropped for data analysis. Figure 1 shows an example of the choice experiment.

Several different ethnicities are represented in the study area; the largest groups represented are the Oromos (39.04%), the Amharas (24.5%), and the Wolaytas (13.74%). Most respondents live in rural areas, and the average walk time to the nearest road is 63.8 minutes. Figures 2 and 3 provide information about household composition, and demonstrate that the average number of children in a household is 3.38, and most households consist of about 6 people. Only 5.38% of the households have a female head of the household.

Figure 2 – The Distribution of Number of Children in a Household (%)

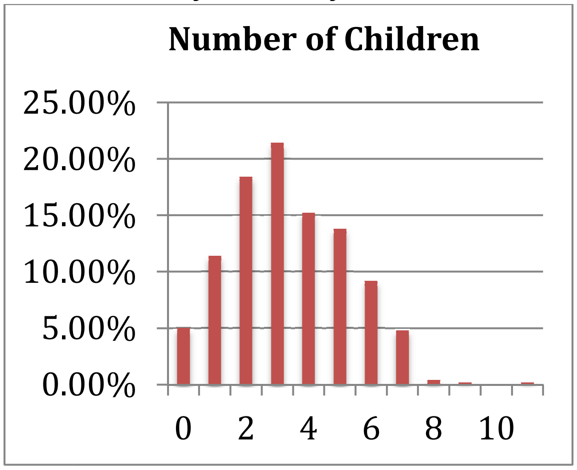
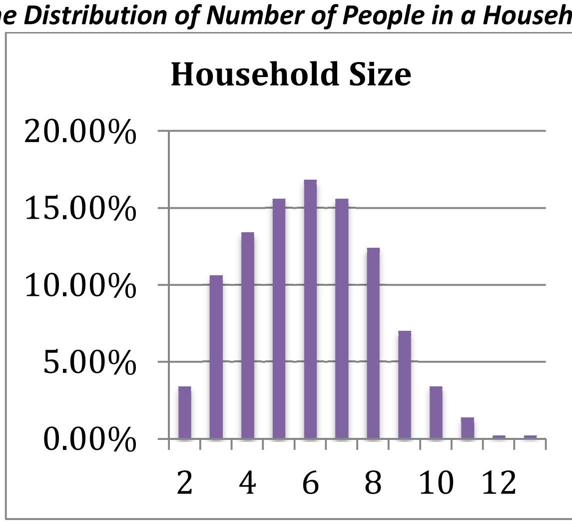


Figure 3 – The Distribution of Number of People in a Household (%)



As seen in Figure 4, which presents the primary sources of fuel used by respondents, using the forest sustainably should be paramount for Ethiopians. Over 91% of respondents use firewood as their main source of fuel, while only 7.18% of people use dung and 1.1% use small branches to fuel their stoves. Figure 5 reports the different types of fuel that people said they would use if firewood collection from forests were prohibited; most respondents reported that they would find fuelwood on their own property, or use dung or crop residues for fuel. Just under half of the respondents (44.6%), had seen an improved stove before they took the survey, and nearly all (more than 92%) of respondents said they used a three stone stove method. Most households (over 77%) reported that children were usually in the kitchen when food was being cooked, and nearly all households (88%) belong to forest user groups (FUGs), which are groups of community-members that are involved in forest management and land use decisions. Of respondents who did not use an improved stove at the time of the survey, most reported that they did not because new stoves were unavailable (64.25%), they did not know how to use one (20.11%) or because they were expensive (11.17%).

Figure 4 – Primary Fuel Sources (%)

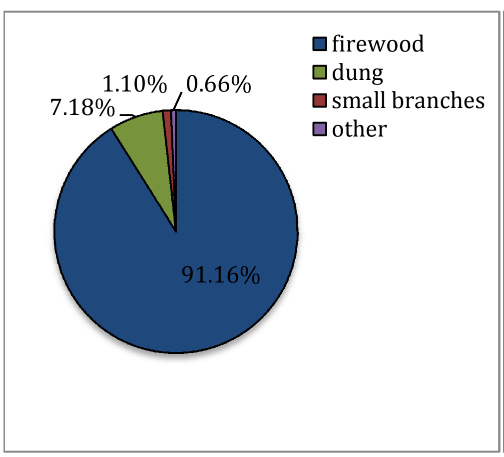
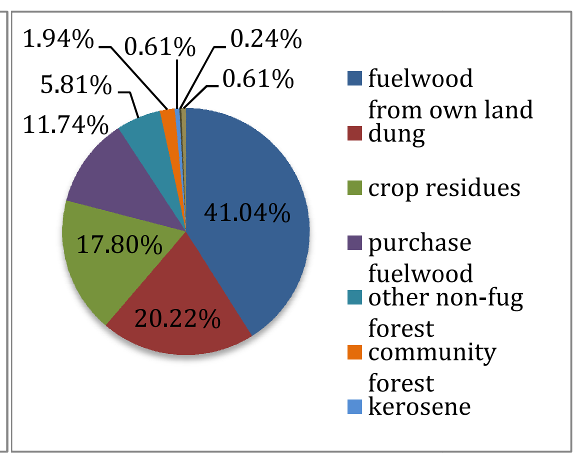


Figure 5 – Fuel Sources Used if Respondents were Restricted from Collecting Fuelwood in the Forest (%)



4. Methods:

With the choice experiment data, a conditional logit and a mixed multinomial logit model were used to find estimates as well as to determine respondents' willingness to pay for each attribute. As noted previously, in each of the models, the attributes considered were the durability of the stove, the amount of time saved by using the new technology, the reduction in fuel needed for the stove, the reduction in smoke produced by the stove, and how much the stove would cost. The general form of the conditional logit (CL) model includes attributes as linear summation in the following general form:

$$V_j = \sum_{k=1}^{K} \beta_k x_{kj} + \beta_p p_j + \varepsilon_j \qquad (1)$$

With the specific attributes included in this choice survey, the model takes the form:

$$V_{qi} = \beta_1 Z_{durability} + \beta_2 Z_{time} + \beta_3 Z_{fuel} + \beta_4 Z_{smoke} + \beta_5 Z_{cost} + \varepsilon_{qi} \qquad (2)$$

A main effects model provides coefficients for each parameter, and the marginal value of attribute k is equal to the ratio between the attribute's parameter estimate and the parameter of the cost attribute:

$$MWTP_k = -\frac{\beta_k}{\beta_p} \qquad (3)$$

The conditional logit model assumes that respondents all have homogeneous preferences and thus it provides a limited analysis of unobserved heterogeneity.

In order to account for preference heterogeneity, a mixed multinomial logit (MMNL) model was also used to analyze the discrete choice data. The following derivation was used to determine respondents' WTP and the MMNL estimates of each different attribute:

Assuming a linear utility, the utility gained by person *q* from alternative *i* in choice situation *t* is given by

$$U_{qit} = \alpha_{qi} + \beta_q X_{qit} + \varepsilon_{qit} \qquad (4)$$

where X_{qit} is a vector of non-stochastic explanatory variables. The parameter α_{qi} represents an intrinsic preference for the alternative (also called the alternative specific constant). Following standard practice for logit models, one assumes that ε_{qit} is independently and identically distributed (iid) extreme value type I. One can assume the density of β_q is given by $f(\beta \mid \Omega)$, where the true parameter of the distribution is given by Ω. The conditional choice probability of alternative *i* for individual *q* in choice situation *t* is logit[1] and given by:

$$L_q(\beta_q) = \prod_t \frac{\exp(\alpha_{qi} + \beta_q X_{qitq})}{\sum_{j \in J} \exp(\alpha_{qj} + \beta_q X_{qjt})} \quad (5)$$

The unconditional choice probability for individual *q* is given by

$$P_q(\Omega) = \int L_q(\beta) f(\beta \mid \Omega) d\beta \quad (6)$$

The above form allows for the utility coefficients to vary among individuals while remaining constant among the choice situations for each individual (Hensher, et al. 2005, Carlsson, et al. 2003, Train 2003). There is no closed form for the above integral; therefore P_q needs to be simulated. The unconditional choice probability can be simulated by drawing R random drawings of β, β_r, from $f(\beta \mid \Omega)$[2] and then averaging the results to get

$$\tilde{P}_q(\Omega) = \frac{1}{R} \sum_{r \in R} L_q(\beta_r) \quad (7)$$

In the choice experiment questions, option A and option B are both restoration options that can be viewed as being closer substitutes with each other than with option C, the status quo option (Haaijer et al. 2001; Blaeij et al. 2007). One method to incorporate this difference in substitution between options is to use an econometric specification for the mixed multinomial logit model that contains an alternative specific constant (ASC) that differentiates between the status quo option and choices that represent deviations from the status quo. This can be achieved by using a constant that is equal to one for alternative A or alternative B.

The coefficient estimates for the mixed multinomial logit model cannot be interpreted directly. Therefore, the average marginal WTA is calculated for a change in each attribute *i* by dividing the coefficient estimate for each attribute with the coefficient estimate for the payment term, as given in (8) (Dissanayake, 2014).

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[1] The remaining error term is iid extreme value.

[2] Typically $f(\beta \mid \Omega)$ is assumed to be either normal or log-normal but it needs to be noted that the results are sensitive to the choice of the distribution.

$$MWTPA_i = \beta_i / \beta_{cost} \quad (8)$$

In the mixlogit model, cost was not included as a random variable, but rather as a standalone independent variable. Both the CL and the MMNL models were also run including an interaction term of the product of the value of the durability attribute and the value of the cost attribute, in order to determine if durability and cost were substitutes for one another. This model had the following form:

$$V_{qi} = \beta_1 Z_{durability} + \beta_2 Z_{time} + \beta_3 Z_{fuel} + \beta_4 Z_{smoke} + \beta_5 Z_{cost} + \beta_6 S_{durability} * X_{cost} + \varepsilon_{qi} \quad (9)$$

To estimate the WTP in this model, the coefficients for each attribute were divided by the coefficient for the cost term added to the product of the coefficient of the *durability*cost* (*"dur*cost")* interaction and an average level of durability, set at 7.5 years. Finally, for both models, the respondents were split into different groups based on demographic characteristics, to see if these different groups valued clean stoves any differently.

5. Results:

The results of the main effects models report which attributes respondents valued when they were choosing between alternatives in the survey. Table 1 presents the main effects from both the conditional logit and the mixed multinomial logit models, including and excluding the interaction *dur*cost* term. In the basic models, the coefficients for all the attributes were significant and positive; respondents preferred choices that were characterized by higher levels of durability, time reduction, fuel reduction and smoke reduction. Interestingly, the cost variable was also positive and significant, meaning that people were more likely to choose options in which the cost was higher. Each of these coefficients was significant at the .1% level, with the exception of the cost attribute in the CL model, which was significant at the 5% level. Results from the interaction models demonstrate that cost and durability were substitutes, as the *dur*cost* variable had a negative coefficient. Essentially, people may have thought that a more expensive stove would last longer. In both interaction models, the results were significant at the .1% level, with the exception of smoke reduction, which was significant at the 5% level in the interaction model in the CL model and 1% in the MMNL model.

The MMNL model also provides information about heterogeneity of preferences. In the basic model, the standard deviations for durability, time reduction and fuel reduction are significant, which means that there was heterogeneity within the sample and significant variation among responses regarding these attributes. In that model, responses about smoke reduction and cost were relatively similar because the standard deviations of their coefficients were not significant. In the interaction MMNL model, there was significant variation regarding responses about time reduction, fuel reduction and the interaction between durability and cost, but relatively homogeneous responses regarding durability, smoke reduction and cost.

Table 1 – Parameter Estimates from Main Effects Models

	Conditional Logit	Conditional Logit with Dur*Cost	Mixed Multinomial Logit		Mixed Multinomial Logit with Dur*Cost	
	Coeff (SE)	Coeff (SE)	Coeff (SE)	Significant SD	Coeff (SE)	Significant SD
Durability	0.0311 (0.00771)***	0.186 (0.0173)***	0.0332 (0.00974)***	Yes	0.269 (0.0242)***	
Time reduction	0.0184 (0.00193)***	0.0210 (0.00192)***	0.0213 (0.00227)***	Yes	0.0275 (0.00250)***	Yes
Fuel reduction	0.0282 (0.00152)***	0.0258 (0.00155)***	0.0339 (0.00253)***	Yes	0.0359 (0.00300)***	Yes
Smoke reduction	0.0262 (0.00287)***	0.00717 (0.003343)*	0.0382 (0.00376)***		0.0124 (0.00441)**	
Cost	0.00150 (0.000637)*	0.00845 (0.000973)***	0.00300 (0.000753)***		0.0129 (0.00126)***	
Durability*Cost Interaction		-0.000885 (0.0000877)***			-0.00132 (0.000124)***	Yes

$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
n = 9036

Besides the coefficient estimates, these models also provide information about respondents' WTP for each attribute. In both the CL and MMNL models, the WTP was positive for each of the attributes, except for the interaction term. Table 2 presents WTP estimates for each attribute in the CL and MMNL models, and separates results into various demographic groups. In the basic conditional logit model, the WTP for each attribute was between $12.24 and $20.74. Durability was the most valuable attribute, as people were willing to pay $20.74, followed by fuel reduction at $18.81, smoke reduction at $17.46 and time reduction was the least valuable, at just over $12. Each of these values was significant at the 5% level, except for durability. When the durability and cost interaction was added, the WTP for durability jumped to $102.20, and the values for fuel, time and smoke reduction dropped to $4.20, $11.55 and $3.945, respectively. The durability and cost interaction was valued at $-.487. All of the WTP values in the interaction model were significant at the 5% level, with the exception of smoke reduction.

In the mixed multinomial logit model, the results were comparable to the conditional logit model. In the basic model, the WTP for smoke reduction was the highest, at $12.71, followed by fuel use reduction at $11.29, increased durability at $11.05, and reduced time use at $7.085. When the interaction term was included, the WTP for durability increased to $89.20, the WTP for fuel reduction increased to $11.92, and the WTP for time reduction increased to $9.132. However, the valuation for smoke reduction dropped to $4.10. In both MMNL models, each of these results was significant at least at the 5% level.

In an effort to determine what factors make clean stove adoption attractive, this study also explores how different types of families value this new, clean technology. As seen in Table 2, there are demographic differences that have a significant effect on the way households value each attribute of the stoves. For example, in both the CL and MMNL models, households that had three or fewer children had a higher WTP for each of the attributes than households with more than three kids. Similarly, households with a smaller percentage of females have a higher WTP for each attribute than do households with a large percentage of females. This trend is exaggerated in the comparison of households with fewer daughters than sons. If the household has more boys than girls, the WTP for each attribute is even higher than in households with more males than females overall.

In order to gauge the community attitudes about these clean stoves, the WTP values were recalculated after dividing the sample into groups of those who had seen a new stove before and those who had not. Among those who had seen new stove technology before, the WTP was higher for each of the attributes, but only the WTP results for those who had not seen new stoves were significant. Similarly, households that belonged to forest user groups were more willing to pay for each of the attributes than families that were not members of the groups. In the MMNL model, each of the values were significant at the 5% level, except for the WTP for durability among both FUG members and non-members, and the WTP for fuel reduction among non-members.

In each of these comparisons, respondents were willing to pay a large amount for each attribute. In the overall sample, all of the attributes had significant WTP values. Once the sample was split into demographic groups, however, the WTP for time, smoke and fuel reduction were significant in most MMNL models, but many of the CL values were insignificant. However, the MMNL model is more computationally advanced and produces more accurate results than the CL model because it accounts for preference heterogeneity, so this lack of significance in the CL model is not a major problem. In general, after dividing the sample into these different demographic groups, fuel and smoke reduction and increased durability had higher marginal WTP values than did time reduction, but the durability values were insignificant at all reasonable levels.

Table 2 – WTP Estimates for Each Attribute in CL and MMNL Models ($)

	Basic model		Dur*cost Interaction		≤ 3 kids		> 3 kids	
	CL	MMNL	CL	MMNL	CL	MMNL	CL	MMNL
Durability	20.74	11.05*	102.2*	89.20**	71.10	12.08	12.29	10.94
Time reduction	12.24*	7.085***	11.55*	9.132***	47.45	9.886*	6.304*	5.293**
Fuel reduction	18.81*	11.29***	14.20**	11.92***	77.86	17.25*	8.932**	7.679**
Smoke reduction	17.46*	12.71***	3.945	4.10*	64.99	17.83*	9.805**	9.581***
Durability*Cost Interaction			-.487**	-.438***				
Observations	9036	9036	9036	9036	5058	5058	3978	3978

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

	≤ 50% female		> 50% female		≤ 50% daughters		> 50% daughters	
	CL	MMNL	CL	MMNL	CL	MMNL	CL	MMNL
Durability	31.19	15.16	12.11	8.073	56.59	20.02	7.935	5.587
Time reduction	17.09	8.402*	8.165	5.862*	26.57	10.06	7.117*	5.249**
Fuel reduction	27.13	14.19*	11.86*	8.716**	46.34	18.23*	8.975**	6.814***
Smoke reduction	28.37	18.40**	8.391*	7.464**	44.23	21.07*	7.941*	7.477***
Durability*Cost Interaction								
Observations	6030	6030	3006	3006	5598	5598	3438	3438

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

	Seen Stove		Not Seen Stove		FUG Member		Non-FUG Member	
	CL	MMNL	CL	MMNL	CL	MMNL	CL	MMNL
Durability	65.23	25.33	8.264	6.302	32.42	14.04	3.262	2.423
Time reduction	20.84	8.587	7.362*	5.513**	18.10	8.350**	3.654*	3.395*
Fuel reduction	31.13	13.24	11.09*	8.690**	31.21	15.23**	1.224	1.192
Smoke reduction	22.34	12.69	11.82*	10.68**	26.59	15.92**	5.032*	5.059**
Observations	2898	2898	3582	3582	7956	7956	1026	1026

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6. Discussion:

These results provide important information about the way Ethiopian households value clean cookstove technology. Each of the attributes considered (durability, time reduction, fuel reduction, smoke reduction and cost) all have significant and positive correlations with a respondent's likelihood of choosing a certain alternative, meaning that each of these attributes was important in determining Ethiopians' choices. In the total sample, the basic MMNL model reports that smoke reduction is the most valuable attribute, but once the interaction term is added, durability is considered the most valuable. Organizations trying to foster sustainable economic growth and development in Ethiopia through stove use should focus on these specific aspects of stove technology in order to encourage stove adoption.

Demographic differences play a role in determining valuation for stove attributes in Ethiopia. Specifically, the gender and age composition of a household determines how much a family is willing to pay for new and improved stove technology. Households with more children or females are likely to assign a lower value to a new stove because they have more people who can take care of the cooking and fuel collection. As females are traditionally the ones who stay home and cook, in families that have fewer females, either women would have to work harder, or men might have to spend time helping with cooking or firewood collection. These households would be more receptive to adopting a cleaner, more efficient stove so women could provide sufficient food for the family more easily, or so men could instead spend more time working outside the home or doing other tasks. Further, as most heads of the surveyed households were male (94.62%), if men have to help with cooking tasks in households with fewer females, they would then realize that cooking with traditional technology was not safe. These male heads of households might then be more willing to spend money and invest in clean stoves. In families with many females, a male head of the household would most likely be removed from the cooking process and might not even realize the detrimental effects of the traditional stoves. Similarly, it is likely that families with more children, and specifically more female children, do not value stoves as highly because they have more children who can collect firewood and help with the cooking tasks.

Besides these household demographic differences, people who had seen stoves before were willing to pay more for the stoves. This trend might indicate that those who had seen a new stove understood the high value of the stove and were therefore more willing to pay for the new technology. Alternatively, those who had seen how clean stoves worked may also have been more willing to trust an organization that would provide them with new stoves, as they had seen the quality of the clean technology.

Additionally, because the main effects model demonstrates positive coefficients for the cost attribute, and negative coefficients for the cost and durability interaction, cost and durability seem to substitute for one another. People may assume that a more expensive stove will last longer or be of higher quality, and they are therefore willing to pay more for it. They may also have a certain desire for equivalence between expected benefit and payments for the stove. Stoves may have such a good reputation that respondents thought that paying more would be justified by the benefits of the stove. Clearly, in the Ethiopian context, there is a strong desire for clean stove technology, as respondents would be willing to pay a significant amount for each of the attributes considered.

7. Conclusion:

Clean cookstoves provide a promising alternative to traditional cooking methods, and they are important for global sustainable development initiatives in many parts of the world. Results demonstrate that Ethiopians are indeed willing to pay a considerable amount for new stoves. Organizations that are trying to distribute these stoves to households around Ethiopia should consider the various demographic differences that affect a family's willingness to pay for the stoves, and they should target their distribution of stoves to households that value them more. Families with few women or children, as well as those who belong to forest user groups, value these stoves more highly than others, and thus initial phases of stove distribution could be focused on these demographic groups. These families are willing to pay more for the technology, and thus may be more apt to adopt and actually use the clean stoves. Households that do not value these stoves as much may be more reluctant to switch cooking methods, even if they are given a new stove. Because different types of households value this technology differently, in order to target families who are more willing to pay for and adopt the technology, it is important to examine these demographic differences between households.

While these stoves provide considerable benefits for human health and the environment, it may be more effective to emphasize the attributes of the stoves that are most important to the households. To encourage clean stove adoption, results demonstrate that organizations should highlight each of the attributes evaluated, but specifically fuel reduction, smoke reduction and durability. If stove distributors are interested in targeting specific groups of people, these results allow them to focus on promoting various aspects of the technology that are important to a specific demographic group. However, previous research demonstrates that even though clean technology provides various benefits, prospective adopters may care more about perceptions of well-being and status when choosing to use new technology. This desire to appear more well-off may also contribute to the fact that cost and durability were substitutes for one another; households wanted to pay more for the stoves because they wanted them to work longer and an expensive stove may act as an indicator for wealth or elevated social status in Ethiopian communities. This desire for equivalence allows organizations to charge more for stoves and still encourage people to adopt them.

Organizations should also consider large distribution campaigns to advertise stove distribution. Those who had seen new stoves before had higher WTP values for each of the stoves' attributes. Organizations should publicize distribution and encourage clean stove-owners to demonstrate the use of their technology to others, or even hold demonstrations themselves. If more people see and have experience with the clean stoves, more people would want the stoves and their willingness to pay may increase. Also, if people see that the stoves are actually effective, they will trust the distributors more and might be more likely to adopt and use the new technology.

One of the main reasons many Ethiopians have not yet adopted clean stove technology is a lack of availability. Regardless of demographic differences, Ethiopian households would be willing to pay a significant amount of money for new, cleaner stoves. There is thus opportunity for organizations or companies to distribute or even sell these stoves to Ethiopians, because people want to buy them. If organizations are able to sell stoves for profit, organizations may have a greater incentive to increase distribution and get more stoves on the ground in Ethiopia.

Finally, if more people adopt cleaner, healthier, and more environmentally-friendly technology, this shift could have significant benefits for economic development in many countries around the world. If families are able to spend less time using their traditional stoves, they will benefit both in terms of health and in terms of spending time and money on firewood. While there has been debate over the feasibility of simultaneously encouraging environmentally friendly policies and economic development initiatives, the results from this study demonstrate that the two are not mutually exclusive. Environmental and development organizations should work together to promote clean cookstove initiatives. Further, governments of developing nations should consider providing subsidies for these clean stoves as they may lead to development and economic growth. New technology is important for sustainable development, and there exists a realistic opportunity to provide families with new stoves, or even to sell them new stoves. These clean cookstoves are valuable to Ethiopian families, and a switch from traditional stoves to cleaner, more efficient models would benefit Ethiopian households, communities, and the global environment.

8. References

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