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Heterogeneity in Consumers Preference for Environmental Quality Attributes of Cook Stove

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Abstract Harmful emission from traditional cook stoves contributes to outdoor air pollution, and becomes a cause to global climate change. Using improved cook stove leads to a more sustainable and cleaner environment. In spite of this, nearly half of world populations cook on rudimentary cookstoves that are fueled by coal or solid biomass each day. Reducing pollution through promotion of improved cook stove demands proper understanding of consumers' preference related to environmental quality attributes of stove. The objective of the study is investigating households' preference to outdoor pollution related attributes of cooking stove and the preference

heterogeneity among them. Unlike previous studies, this study handles indoor and outdoor smoke attributes separately. The study employed multi-stage sampling method. The study applied choice experiment design to elicit respondents' preference and latent class model to analyze the data. Cost of stove, fuel cost, indoor smoke and outdoor smoke were attributes under consideration. The result indicates that there is preference heterogeneity to outdoor smoke but not to indoor smoke. The utility of large share of the society (81 percent) with low income and education do not significantly depend on environmental quality related attributes and they do not consider this attributes during stove choice. Respondent with higher income and better educations are highly concerned to the environment. Improving the livelihood and increasing the awareness of individuals contribute to environmental quality protection.

Keywords Environmental emission, improved, cook stove, choice experiment, LCM

Introduction

World population has reached 7 billion and is expected to be 9 billion by 2050 (PRB, 2012). Facing incredible challenges in a resources-limited environment to accommodate the 9-billion populations, one can expect that these challenges will be further exacerbated in a changing climate (Bogardi, et al. 2012). The average global temperature is projected to increase throughout the century (IPCC, 2007; McMullen and Jabbour, 2009). There is an adverse environmental phenomenon that is causing enormous concern all over the world. Global environmental changes and assessments of those changes have become gradually more common elements in international, national, and even local policymaking and decision making. It has become a widespread topic in recent years. Climate change and global warming has an adverse effect on livelihoods, such as crop production, livestock production, fisheries, forestry and post-harvest activities (Idowu et al., 2011). It produces environmental effects and exacerbates current vulnerabilities that make it difficult for people to survive where they are. It is expected to alter the availability of freshwater, the productive capacity of soils, and patterns of human settlement. Moreover, it to make the world hotter, rainfall more intense, and result in more extreme weather events such as droughts, storms and floods. There is now a wide range of local, regional and global environmental issues that are affecting our ability to meet the basic human needs of the large majority of the world's citizens (Pereira, 2015).

Emissions of greenhouse gases that affect our environment are thought to be the main contributor to climate change (Kadoo, 2019). Recent work has shown that greenhouse gas (GHG) emissions from biomass burning may rival or exceed fossil fuel-based GHG emissions in many less developed countries. Linkages between household energy technology, indoor air pollution, and greenhouse gas (GHG) emissions have become increasingly important in understanding the local and global environmental and health effects of domestic energy use *(Bailis et al*. 2003).

Poor biomass combustion in stoves entails three major environmental liabilities. First, poor combustion contributes directly to low energy efficiency, with its attendant problems of onerous human labor requirements and pressure on biomass resources from harvesting. Second, some PICs are hazardous to health when breathed in the concentrations commonly found in homes using unvented biomass stoves. Third, a different set of PICs are strong direct or indirect greenhouse gases, potentially contributing to global warming (Smith et al., 2014).

Biomass-burning cookstoves are widely recognized as a significant source of pollutants impacting human health, local and regional air quality, and global climate change (WHO, 2014). Harmful emission from traditional cook stoves and fuels contributes to outdoor air pollution, and becomes a cause to global climate change (GACC, 2011). Nearly four million people are estimated to die prematurely each year due to household air pollution from biomass burning (Smith et al., 2014).

In spite of this, nearly 3 billion people cook on open fires or rudimentary cookstoves that are fueled by solid biomass each day (GACC, 2011). Cooking over open fires using solid fuels is both common practices throughout much of the world (GACC, 2011). Almost all of these people who are deprived of access to modern cooking facilities live in developing countries, particularly in Sub-Saharan Africa and developing Asia. Ethiopian household also daily use biomass fuels and traditional cook stoves to meet household energy demand (IEA, 2011; CSA, 2012; Alem et al., 2013; Kooser, 2014). The central statistics authority 2011 demographic and health survey data (CSA, 2012) showed that nearly 95 per cent of Ethiopian households use biomass fuel sources for cooking and almost all rural households depend on traditional fuel sources.

Significant gains for both health and climate can be attained by providing access to clean cookstoves and fuels. Access to modern energy is assumed to be a precondition for poverty alleviation, sustainable development and the attainment of the millennium development targets (Yesuf, 2014). Using improved cook stove leads to a more sustainable and cleaner environment, in addition to the health and economic empowerment benefits associated with their use. If appropriately designed and disseminated, clean cookstoves can reduce a large share of emissions from cooking with biomass. These reductions also bring other benefits, such as reduced indoor and outdoor pollution, less pressure on forests, and economic and time savings due to the reduced need to search for or purchase costly fuels (GACC, 2011). To shift to improved cooking alternatives, households consider the benefit and cost of using it. Consideration or overlooking of the environmental attribute of cooking stove affect the net benefit and households' decision to adopt improved cooking stove. Hence, whether households consider the benefit related to environmental impact of improved stoves in their stove choice is an important issue for policy makers and requires further research and exploration. However, consumer preference for goods and services is characterized by heterogeneity. Accounting for this preference heterogeneity is important to get unbiased result and estimating demand by different consumers with different characteristics. Recent developments in nonmarket valuation have focused on identifying preference heterogeneity and examining its impact on willingness to pay (Boxall and Adamowicz, 2002).

Many studies were conducted to identify product related factors, in general and smoke related attributes in particular, that determine cook stove choice. There were also studies which assessed preference heterogeneity in cook stove demand. However, either they considered indoor smoke only or they managed indoor and outdoor smoke together as one variable or they did not use latent class model to show preference heterogeneity. For example; Takama et al. (2012) tried to identify product-specific attributes that affect household cook stove choice and assessed the tradeoffs among these attributes. However their study considered indoor smoke emission level only. Jeuland et al. (2014) used latent class model to assess preference heterogeneity in cook stove attributes and smoke emission was one of the attributes. But the study did not differentiate indoor and outdoor smoke. Kooser (2014) also managed indoor and outdoor emission together. Van der Kroon et al. (2014) used indoor some and environmental impact attributes separately, but they did not use latent class to account unobserved heterogeneity.

Separation of smoke from solid fuel to indoor and outdoor is very important from consumers view point; because the former has private impact (private bad) and the later has social impact (public bad) (Sexon and Repetto, 1982). Therefore, individuals may not have much concern to public good relative to private good (Hardin, 1968). Hence, separate treatment of the variables is very essential to understand the concern of the society to the quality of the environment and their preference heterogeneity with respect to the variable in question. To the best of the knowledge of the researcher, there is no any study which addressed this issue so far. The objective of this study is to examine households concern to environmental quality and the extent of heterogeneity of attitudes.

Material and Method

Description of the Study Area

Ethiopia is a rural society with only about 15 percent of the population living in the capital city, secondary cities and small urban towns in different regions of the country. The livelihood of the population in rural areas is mainly based on agriculture – typically mixed farming. Based on evidences, majority of population is engaged in agricultural activity which is typically characterized by small holder and subsistence farming which is highly dependent on rainfall. In terms of economic development, Ethiopia is one of the least developed and therefore the poorest country in the world with income per head of only US $ 100 in 1999, compared to the sub-Saharan Africa (SSA) average of US $ 500 (World Bank, 2000). Agriculture constituted the principal source of income and employment for the majority of the population. The sector has been the dominant sector accounting over 50% of GDP share and 85% of employment for decades. Greater proportion of the foreign exchange the country earns also came from this sector (Tafesse, 2005).

However, Since the 2000s, Ethiopia has emerged as one of the fastest-growing economies in Africa. During the last decade it has become one of the fastest growing economies in the world with an average gross domestic product (GDP) growth rate of about 10% per annum (Shiferaw, 2017). The country is getting an economic structure which is shifting from the traditional agriculture sector to the modern service sector. Currently, the service sector is growing fast in

terms of the structure of GDP. Nevertheless, Ethiopia's manufacturing sector is still far from being an engine of growth and structural change. The manufacturing sector plays a marginal role in employment generation, exports, output, and inter-sectoral linkages (Ejigu and Singh, 2017).

The Amhara National Regional State (ANRS) is the second largest regional states of Ethiopia. The total estimated area of the Amhara region was 170,752 square kilometers. Based on 2007 census, the region has the total population size of 17,221,976 and the number of households was 3,849,140 (CSA, 2007). It is one of the poorest regions in the country. Just 3 percent of rural dwellers in the Amhara region have access to potable water. Adult literacy stands at 35 percent of the total population and only 22 percent of children in the relevant age bracket attend primary school.

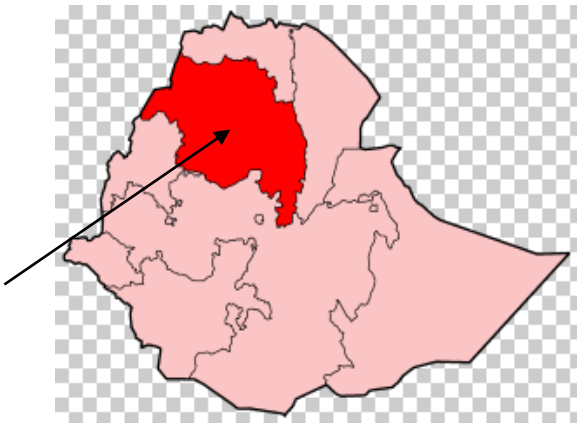

Figure-1: Map of the Study Area

Sampling and Data Collection Technique

The study used multiple sampling methods. Clustering is used at the first stage. Then, considering budget and time resources, three study districts were selected randomly. Final1y, respondents were sampled randomly proportionately to the household size of each district. Yamene (1967) sample size determination formula was used to determine the sample size. Household survey was the main source of cross-sectional primary data. Structured questionnaires were prepared and administered to collect primary data from the respondent (households).

Methods of Analysis

The study used choice experiment design to elicit respondents' preference and Latent Class Model (LCM) to analyze the data. It helps to understand households' preference heterogeneity to environmental quality related attribute of cookstove. In the choice experiment, respondents were provided with two improved cookstoves choice and one traditional biomass cookstove (status quo). The improved alternative have different combinations of attribute levels across choice sets while the status quo option has the same combination of attribute levels across all choice sets. The study used fractional factorial design and each respondent was provided with 9 choice sets with three alternatives each. The Table-1 shows the attributes under consideration and their levels. As it is depicted in the table smoke is considered as one of the attributes under investigation.

Table 1. Attributes and Levels

Attributes	Levels	Status quo
Stove cost (ETB)	0, 120, 1400	0
Fuel cost (ETB)	36, 59.86	86
Indoor smoke	High, Medium Low	High
Outdoor smoke	High, Medium, Low	High

The theory of consumer states that consumer's objective is maximizing their utility subject to income constraint. Choice experiment has utilized this theory by borrowing from Lancastrian microeconomics approach that states consumers derive utility from the characteristics of the good rather than directly from the good itself (Lancaster, 1966). A change in price of the good will causes discrete change from one bundle to the other that will provide the most cost effective combination of attributes. The choice experiment provides respondents with attributes of the resource being valued and then they will choose the attribute that offer highest utility.

Assume two alternatives (i & j) are provided to the respondents. Rational respondents will choose alternative j if its utility higher than utility of state i.

$$u_{nj} = v_j[Aj, X_n] ---------------------------- 1$$

$$u_{ni} = v_i[A_i, X_n\ ] ---------------------------- 2$$

Where Aj = attribute j, Ai= attribute i, Xn = socioeconomic characteristics of individual n, Unj/i = total utility derived from attribute j or i by individual n,

According to Lancaster(1966), utility derived from the consumption of a good is the sum of deterministic and stochastic (random) components. Hence

$$U_{nj} = v_j[A_j, X_n, \varepsilon_{nj}] = v_j[A_j, X_n] + \varepsilon_{nj} \text{----------3}$$

$$U_{ni} = v_i[A_i, X_n, \varepsilon_{ni} = v_i[A_i, X_n] + \varepsilon_{ni} \text{----------4}$$

Thus, an individual n will choose attribute j if:

$$U_{nj}\text{-}U_{ni} \geq 0 \text{----------5}$$

The probability that an alternative "j" is chosen is equals to the probability that the utility obtained from this alternative (j) is greater than or equals to the utility obtained from other alternatives (i).

$$p(j/A_c) = p\{v_j[A_{nj}, X_n] + \varepsilon_{nj} > p\{v_i[A_{ni}, X_n] + \varepsilon_{ni} \text{----------6}$$

$$p(j/A_c) = p\{v_j[A_j, X_n]\text{-}v_i[A_i, X_i] > \varepsilon_{ni}\text{-}\varepsilon_{nj}\} \text{----------7}$$

If the random terms are assumed to be distributed independently the conditional or multinomial logit model (MNL) assumed by McFadden (1974) can be used to estimate the probability that an alternative is chosen. This choice probability can be expressed as:

$$P_{ni} = \frac{\exp(Vni)}{\sum_{j=1}^{J} \exp(Vnj)} \text{----------8}$$

The main disadvantage of using MNL or CL is that the parameters are assumed fixed in the population. These models ignore the existence of preference heterogeneity across respondents and their independence from irrelevant alternative (IIA) assumption. One alternative model which tackles these problems is using Latent Class (LC) model. In LCM respondents are categorized in to different class based on their preference and each latent class consists of individuals that have homogeneous preference for alternatives (Lee et al., 2003). However an individual's true class is unobservable by researchers. LCA puts individuals into probabilistic groups based on the likelihood that they belong in that group. The probability of being in a class can be estimated as a function of socio-demographic characteristics of the student (Dillingham, 2016). Hence, the probability than individual n choosing alternative *j* conditional upon the individual's class membership has the following form for a choice with two alternative (i and j).

$$P_{nj} = P\left(U_{\frac{nj}{c}} > U_{\frac{ni}{c}}\right) = \frac{e^{\frac{u_{nj}}{c}})}{e^{\frac{u_{nj}}{c}} + e^{\frac{u_{ni}}{c}}} \text{----------9}$$

Result and Discussion

This study examined whether there is preference heterogeneity among households with respect to environmental quality. In order to investigate if heterogeneity in households' preferences reflect systematic variation that could be attributed to groups, the study used latent class model (LCM). Table-2 contains the results from the estimated utility functions.

In this LCM model, the dependent variable is respondent's choice of stove model in the choice task, while the explanatory values are the attributes of those stoves (indoor smoke, outdoor smoke, fuel-cost and the stove's cost). Socio economic characteristics of respondents were also included in the model.

The in results Table-2 reveal that households in both classes exhibit a positive preference for low indoor smoke (lowismoke), medium indoor smoke (medismoke), and low outdoor smoke (lowosmoke), and negative preference to more fuel requirement cost and stove cost as demonstrated by the positive and negative sign of the coefficients of these attributes respectively .This result is consistent with the prior expectation of the research. However, the coefficient of medium outdoor smoke (medosmoke) is negative (although it is not significant), which is against the expectation.

LCM results, further, show that the coefficients of stove cost (stove_cost) and fuel cost (fuel_cost) relatively high for the first latent class. This indicates that respondents belonging to the first class are sensitive to monetary attributes of the stove. On the other hand, the coefficients of indoor smoke and outdoor smoke related attributes are higher for the second latent class, indicating that households belonging to the second class are more sensitive to non monetary attributes of cooking stove.

Despite this difference in coefficient values across classes, the all coefficient, except outdoor smoke related attributes, are significant in both models at one percent level of significance. Fuel cost, stove price and indoor smoke related attributes of stove significantly affect the utility of households in both classes; their purchasing behavior is influenced by the attributes mention above.

There is no significant heterogeneity across classes in relation indoor smoke attributes; however, there is substantial heterogeneity in preference for outdoor smoke related attributes across classes. The effects of outdoor related attributes are significantly different across the two classes. The coefficients of outdoor smoke related attributes (lowosmke and medosmake) are positive and significant in the second latent class but not in the first latent class. This revealed the utility of households' belonging the second latent class is significantly affected by outdoor related attributes of cook stove. On the contrary, households in the first group do not bother about outdoor related attributes and their utility is not significantly influenced by this attribute.

The finding of this study is somewhat consistent with the study of Jeuland et al. (2014). They conducted a research in India and assed variation in household preferences for improved cook stove. The study used mixed logit model and latent class model. The finding of the mixed logit model shows that there is no significant preference variation among respondents. However, the latent class model shows that the coefficient of smoke emission is positive significant at 1 percent and 10 percent for the first and the second class. But the coefficient of this variable is negative and insignificant for the third class. So, there is unobserved preference heterogeneity among consumers for smoke emission. The result of Kooser (2014) also reveals that there is preference heterogeneity with respect to environmental impact attributes of stove although their study used mixed logit model

The result in table-3 shows the probability that a randomly chosen respondent belongs to first latent class and second latent class is 0.87 % and 0.193 % respectively. The finding, thus, revealed that much of households do not consider outdoor smoke related characteristic cook stove when they make decision to purchase cooking appliance. Only about 19 percent of respondent are concerned to environmental quality and consider outdoor smoke attributes during cooking appliance choice.

Table 2. Latent Class Model Result

Attributes	Level	Coefficient	Std. Err	P>|z|	Coefficient	Std. Err	P>|z|
		Latent Class-1			Latent Class-2		
Indoor Smoke	lowismok	.7213651	.2493922	0.004	3.147	.1605724	0.000
	medismok	1.208166	.2573808	0.000	2.272	.1649533	0.000
Outdoor Smoke	lowosmok	.2865062	.2143619	0.181	2.477	.1431534	0.000
	medosmok	-.60021	.3899427	0.124	1.787	.1477718	0.000
fuel_cost	fuel_cost	-.0339001	.0042761	0.000	-0.014	.0015333	0.000
stove_cost	stove_cost	-.0038132	.000306	0.000	-0.001	.0000804	0.000

The study used sex, age, marital status, income, education, labor force size and awareness to differentiate households into groups. Table-3 shows the effects of household's characteristics on the probability of class membership. The probability of getting a respondent who are belonged to group one is 80.7 and the probability of getting group two members is 19.3 percent. Income, education and labor force size increase the probability of belonging to class two. Hence, class two members are those who have better income, large labor force size and attain high level of education. On the other hand being married increases the probability of belonging to class one.

Based on this classification, households whose utility significantly affected by outdoor smoke related attributes of stove are those with high income, better education and large labor force. This confirms that education and income increase the concern to environmental quality. But, the utility of respondents with low income and low level education does not significantly influenced by outdoor related attributes. So, this group of respondents does not cautious about environmental pollution.

Table 3. Class membership

Variable	First Class			Second Class
Class Share (%)	80.7			19.3
	Coefficient	Std. Err	P-value	
sexofres	-.2632517	.3134524	0.401	Reference
maritals	.8060189	.3658602	0.028	
income	-.0002436	.0000916	0.008	
edu_primary	-.6792178	.4451331	0.127	
edu_secondary	-1.051198	.4334468	0.015	
edu_diploma	-1.036288	.3857376	0.007	
ageofres	.0227758	.0144946	0.116	
laborforce	-.3920723	.1517692	0.010	
Awareness	-.2404026	.3011908	0.425	
_cons	-.2078605	.5995316	0.729	

Conclusion and Recommendation

Climate change and global warming if left unchecked will cause adverse effects on livelihoods, such as crop production, livestock production, fisheries, forestry and post-harvest activities. Emissions of greenhouse gases that

affect our environment are thought to be the main contributor to climate change. Recent work has shown that greenhouse gas (GHG) emissions from biomass burning may rival or exceed fossil fuel-based GHG emissions in many less developed countries. Biomass-burning cookstoves are widely recognized as a major source of pollutants impacting local and regional air quality, and global climate change. Harmful emission from traditional cook stoves and fuels contributes to outdoor air pollution, and becomes a cause to global climate change. In spite of this, nearly 3 billion people cook on open fires or rudimentary cookstoves that are fueled by coal or solid biomass each day. Significant gains for both health and climate can be attained by providing access to clean cookstoves and fuels. Using improved cook stove leads to a more sustainable and cleaner environment, in addition to the health and economic empowerment benefits associated with their use. Reducing pollution through promotion of improved cook stove demands proper understanding of consumers' preference related to environmental quality attributes of stove. The result indicates there is preference heterogeneity regarding to environmental quality among consumers but not for indoor smoke. Respondent with higher income and better education which constitute only about 19 percent of the society are highly concerned to the environment. Improving the livelihood and increasing the awareness of individuals contribute to environmental quality protection.

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