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Determinants of Household Adoption of Electric Injera Mitad in Urban Ethiopia: A Case Study of Woliso Town

Mebratu Negera Feyisa

Department of Economics, School of Business and Economics, Ambo University Woliso Campus, Woliso, Ethiopia

Abstract Adoption of modern cooking stoves plays a significant role in improving standard of living of urban households and in reducing adverse effects of human activities on the environment. However, household adoption of modern cooking stove is challenged by several factors. The main objective of this study is to investigate factors affecting adoption of electric injera mitad by urban households in Ethiopia, focusing on Woliso town. The study used primary data collected from 123 sample households. The sample households were selected randomly, and systematic random sampling technique was empoyed to select the sample households. Fuelwood constitutes the major fuel in baking injera, followed by electricity in the study area. Only 33 percent of the sampled households have adopted electric injera mitad. Even some households who already adopted electric injera mitad still use fuelwood besides electricity. This implies adoption of electric injera mitad does not enable households to switch to modern energy sources. The study specified the logit model to identify factors that significantly affect adoption of electric injera mitad at household level. Accordingly, estimation of the logit model showed that household income, wife's education level, sex of household head, price of electricity, price of fuelwood and refrigerator ownership are variables that significantly affect household adoption of electric injera mitad in the study area. Policy interventions aimed to enhance adoption of electric injera mitad in the study area need to be diversified with emphasis on increasing household's income, promoting access to at least basic education to women and subsidizing residential consumption of electricity.

Keywords Cooking stove, Adoption, Electric injera mitad, Logit model, Woliso town

1. Introduction

Nearly fifty-percent of the world's population relies on solid fuels, such as wood and charcoal, for cooking (IEA, 2014). Ensuring access to clean and efficient household energy for cooking is the major challenge faced especially by developing countries today. Many people in developing countries remain dependent on traditional biomass fuels for cooking. As of 2011, about 1.26 billion people lack access to electricity and about 2.64 billion people rely on traditional biomass (fuelwood, charcoal, animal dung and agricultural residues) for cooking mainly in rural areas in developing countries (IEA, 2011). In Sub-Saharan Africa, 68 to over 90% of the population rely on biomass solid fuels (Rehfuess et al., 2006; Smith et al., 2004). High reliance on traditional biomass fuels contributes a lot to human health, economic and environmental problems (Malla & Timilsina, 2014; GACS, 2011). Inefficient combustion of the solid traditional biomass fuels, mainly in developing countries, emits substantial quantities of harmful air pollutants and contaminants, which threaten human health. Moreover, dependence on biomass fuels for domestic consumption is one of the major anthropogenic causes of deforestation in developing countries (Jan, 2011). The use of biomass in inefficient ways in developing countries increases fuelwood and charcoal demands of households.

Ethiopia is one of the least developed countries in the world. Approximately about 34% of its over 100 million inhabitants live below poverty line (UNDP, 2018). It has one of the lowest rates of access to modern energy services, whereby the energy supply is based on biomass. With a share of 91.6% of Ethiopia's energy supply, waste and biomass are the country's primary energy sources, followed by oil, 6.1% and hydropower, 1.7% (OECD/IEA, 2017). Moreover, over 90% of Ethiopian population depends on biomass solid fuels (Beyene et al., 2015). Unsustainable use of biomass results in deforestation and consequently land degradation in Ethiopia. In addition to this, incomplete combustion of biomass inside the home generates indoor air pollution, which causes adverse health effects.

* Corresponding author:
moneibsa2014@gmail.com (Mebratu Negera Feyisa)
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Nowadays, Ethiopia is facing increasing population and urbanization, causing increasing demand for biomass fuels by urban households in the country. In Ethiopia, urban centers highly depend on rural hinterlands for their fuel (Gebreegziabher et al., 2010). According to Gebreegziabher et al (2010), urban households depend on rural areas for about 85 percent of their fuel needs, which is a significant cause of deforestation and forest depletion, resulting in growing fuel scarcity and higher firewood prices.

Improving access to affordable and reliable energy services for cooking is essential for developing countries in reducing adverse impacts of solid fuels usage. Urban households need to shift from solid biomass fuels to modern energy sources, like electricity. However, household switch to electricity use for cooking highly depends on the adoption of appropriate cooking appliances or stove technologies. In developing countries, including Ethiopia, plenty of programs and initiatives have been working to disseminate improved and modern cooking stoves, which have health, economic and environmental benefits. In spite of this, household demand and awareness of benefits of improved and modern cooking stoves (such as reducing indoor air pollution) remain low in Ethiopia. As a result, there are various challenges for modern stove adoption, as not everyone in developing countries is willing to pay for or wants to use such new technologies (Lewis and Pattanayak, 2012; Bensch et al., 2015; Hanna et al., 2016). Previous efforts to encourage people to adopt and use new stoves in Ethiopia have met with limited success. The government has tried to promote clean stove technology, and though adoption rates have steadily increased over time, the large-scale adoption of stoves necessary to achieve climate benefits has not occurred. In contrast, if traditional stove technology is available, households are less likely to want a new stove. The central question that this research is interested to answer is why urban households do not adopt new cooking stove, like electric injera mitad when they have access to electricity.

A number of studies have been conducted to address this question, and have come up with different findings, in which the findings vary based on study area. Therefore, their findings might not be applied in different contexts. For instance, based on Chines literatures, Shen et al (2014) concluded that many subjective and objective factors affect the adoption and sustainable use of cleaner fuels and cook stoves. These factors include fuel/stove technology, household and setting characteristics, knowledge and perception, policy and regulations, financial support, market development and government role. Beyene and Koch (2013) examined the correlation between adoption of new stoves and different socio-economic factors in Ethiopia, and found that the price of stove, household income and household wealth all have significant effects on a household's willingness to adopt new stoves.

Understanding of determinants of adoption of new cooking stoves is important for the design and implementation of effective policies to enhance access to clean cooking. Therefore, this study aims to examine factors affecting household adoption of electric injera[1] mitad[2] in urban Ethiopia, specifically in Woliso town.

2. Methods and Materials

2.1. Data Collection

This study used mainly primary data, which was collected from sample households in Woliso town using questionnaire. The questionnaire was distributed to heads of households through interviews by trained enumerators. The primary data was collected on households' demographic and socio-economic characteristics, household fuel wood, charcoal, kerosene and electricity consumptions, adoption of improved cooking stove, etc. It is known that households do not keep records of data on different aspects. Therefore, the household survey entirely depended on recall method.

The target population of this study is urban households living in in Woliso town. There are 103, 584 households in Woliso town (SWSZANRO, 2018). The study used a simplified formula provided by Yamane (1967) to determine the sample size at 95% confidence level and 5% degree of variability (Israel, 2002). In addition, 9% level of precision was used in order to get the sample size which represents a true population. According to Hussey & Hussey (1997), no survey can ever be believed to be free from error or provide 100% surety and error limits of less than 10% and confidence levels of higher than 90% can be regarded as acceptable. The formula provided by Yamane (1967), which is used to determine the sample size is as follows (Israel, 2002).

$$n = \frac{N}{1 + N(e)^2}$$

where n is the sample size

N is total number of households in Woliso town, which is 103,584.

e is the level of precision or sampling error, which assumed to be 9% for this study.

$$n = \frac{103{,}584}{1 + 103{,}584(0.09)^2} \cong 123$$

Therefore, this study randomly selected 123 households from the target population, and systematic random sampling based on a given interval between houses was employed during household selection.

2.2. Model Specification

The logit model was specified to analyze determinants of household adoption of electric injera mitad in Woliso town. The dependent variable (electric injera mitad adoption status) is binary, which takes a value of y = 0 if the household is non-adopter of electric injera mitad and the value y = 1 if the household adopter of electric injera mitad. In this study, we are interested in estimating the probability that the household

[1] Injera is Ethiopian staple food which is baked on circular pan

[2] Mitad is Amharic name of stove used to bake injera

is adopter of electric injera mitad, given the explanatory variables. This probability can be expressed by logistic distribution function as (Gujarati, 2004),

$$P(y_i = 1|X_i) = \Lambda(\beta_0 + \beta X_i) = \frac{e^{(\beta_0+\beta X_i)}}{1 + e^{(\beta_0+\beta X_i)}}$$

where $P(y_i = 1|X_i)$ is the probability that household i is adopter of electric injera mitad, given the explanatory variables, Λ is logistic cumulative distribution function, X_i column vector of explanatory variables and β row vector of slope of coefficients to be estimated.

If $z_i = \beta_0 + \beta X_i$, the above function can be re-expressed as,

$$P(y_i = 1|X_i) = \Lambda(z_i) = \frac{e^{z_i}}{1 + e^{z_i}}$$

As z_i ranges from $-\infty$ to $+\infty$, $P(y_i = 1|X_i)$ ranges between 0 and 1.

If $P(y_i = 1|X_i)$ is the probability that household i is adopter of electric injera mitad, then the probability that the household is non-adopter of electric injera mitad, $1 - P(y_i = 1|X_i)$, can be expressed as:

$$1 - \mathrm{P}(\mathrm{y_i} = 1|\mathrm{X_i}) = \frac{1}{1 + \mathrm{e}^{\mathrm{z_i}}}$$

Thus, $\frac{P(y_i=1|X_i)}{1-P(y_i=1|X_i)} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i}$

The expression $\frac{P(y_i=1|X_i)}{1-P(y_i=1|X_i)}$ represents the odds ratios in favor of adopter of electric injera mitad. It is the ratio of probability that the household is adopter of electric injera mitad to the probability that the household is non-adopter of electric injera mitad.

By taking the natural log of odds ratio, we obtain the following result known as logit model:

$$L_i = \ln\left(\frac{P(y_i = 1|X_i)}{1 - P(y_i = 1|X_i)}\right) = z_i = \beta_0 + \beta X_i$$

L_i, the log of the odds ratio, is called logit.

Based on empirical literatures reviewed, seven explanatory variables were identified, and the final logit model was specified as follows;

$$Z = \beta_0 + \beta_1 Hincome + \beta_2 Weduc + \beta_3 Hsex$$
$$+\beta_4 Hempyt + \beta_5 Pelect + \beta_6 Pfuel$$
$$+\beta_7 Refr + U_i$$

Description of variables employed in the specification of the logit model is shown in table 1 below;

Table 1. Description variables used in the logit model

Variables	Variable full name	Definition	Type	Measure
Z	Electric injera mitad adoption	Whether the household adopts electric injera mitad or not	Categorical	1 = adopter, 0 = non-adopter
$Hincome$	Household income	Total amount of income the household earns monthly	Continuous	Birr
$Weduc$	Education level of wife	The number of schooling years of the wife	Continuous	years of schooling
$Hsex$	Sex of household head	Whether household head is male or female	Categorical	0=female,1=male
$Hempyt$	Employment status of household head	The employment condition of household head	Categorical	1=government employed, 0 = otherwise
$Pelect$	Price of electricity	Unit price of electricity	Continuous	Birr
$Pfuel$	Price of fuelwood	Unit price of fuelwood	Continuous	Birr
$Refr$	Refrigerator ownership	Whether the household possesses a refrigerator or not	Categorical	0= if the household owns refrigerator, 0 = otherwise

After specification of the logit model, diagnostic tests were conducted to detect the problem of heteroscedasticity and multicollinearity. Some important variables (such as, age of household head, education level of household head, household' family size, etc.) were omitted in the specification of the logit model in order to correct the problem of multicollinearity.

3. Results and Discussion

3.1. Household Energy Consumption Pattern and Electric Mitad Adoption

The sampled households in Woliso town use either fuelwood or a mix of fuel-wood and electricity to bake injera. Table 2 reveals that the entire sampled household use fuelwood for different purposes (cooking, baking, etc.). In other words, fuel-wood, which is the least convenient fuel according to the energy ladder hypothesis, is consumed in combination with electricity, implying households fail to shift from it.

Table 2. Description of energy source usage for different purposes by the sampled households

Energy source	Percentage of users
Fuel-wood	100
Electricity	97.5

Source: Author's computation of survey data (2018)

In the study area, electricity is mainly used for lighting among the sampled households. As shown in Table 2, majority of the sampled households (about 98 percent) were using electricity for different purposes. However, as shown in Table 3 below, only 33 percent of the sampled households adopted the electric injera mitad cooking appliance. Non-adopters responded that expensiveness is the main reason for their non-adoption of electric injera mitad.

Table 3. Description of electric injera mitad adoption by the sampled households

Electric injera mitad adoption	Percentage
Non-adopters	67
Adopters	33

Source: Author's computation of survey data (2018)

Households who adopted electric injera mitad use fuelwood in combination with electricity. This implies fuelwood constitutes the major source of fuel even among adopters of electric mitad. Non-adopters of electric mitad use either the three-stone stove or Mirt stove. As indicated in Table 4 below, about 39% of the sampled households use Mirt stove, which is one of improved cooking stoves used by households in Ethiopia.

Table 4. Description of cooking appliances/injera baking stoves used by sample households

Stove type	Percentage
Three-stone stove	28.68
Mirt stove	38.52
Electric mitad	32.78

Source: Author's computation of survey data (2018)

The Mirt stove burns mostly woody biomass and is used for baking injera and for cooking at the same time. It is made of a sand-cement mixture and can save up to 50% fuel compared to the three-stone open fire with a thermal efficiency of around 22% (EnDev, 2015). About 29% of the sampled households use the traditional cooking stove (the three-stone stove) to bake injera. The three-stone burns solid biomass fuels in inefficient way, which results in adverse health, economic and environmental consequences. Adoption of electric injera mitad can reduce these negative impacts by saving fuelwood substantially.

3.2. Factors Affecting Adoption of Electric Injera Mitad at Household Level

The adoption of cleaner fuels and cooking stoves has many benefits in different aspects. Several studies have examined determinates of adoption of modern cooking stove at household level. This section presents the econometric estimation of the logit model, in which variables that significantly affect adoption of electric injera mitad are identified. The Logit model consisting of seven explanatory variables was estimated, and the result of the regression is shown in Table 5 below.

Table 5. The Logit model regression result for determinants of adoption of electric injera mitad (Z=1)

Electric mitad adoption	Coefficient	Robust standard error	Z-value	P>|z|	Odds ratio
Household income	0.0009401	0.0002944	3.19	0.001***	1.000941
Education level of wife	0.1749224	0.0770593	2.27	0.023**	1.191154
Sex of household head	-4.472788	1.348724	-3.32	0.001**	0.0114154
Employment status	0.1861873	0.6625622	0.28	0.779	1.204648
Price of electricity	-0.9394704	0.5146647	-1.83	0.068*	0.3908348
Price of fuelwood	1.279907	0.4560206	2.81	0.005***	3.596304
Refrigerator ownership	2.156172	0.8571567	2.52	0.012**	8.638009
Constant	-3.188715	2.039766	-1.56	0.118	0.0412248
Number of observation = 123 Wald $chi^2(8)$ = 18.26 Prob > chi^2 = 0.0108** Pseudo R^2 = 0.6866					

Source: Sample Household Survey (2018)
**= P<0.1, **=P<0.05, ***=P<0.01*

The logit model was estimated using Stata software application version 12. From the logit regression result depicted in the above table, we can observe that the explanatory variables identified in the model sufficiently explain variation in the dependent variable, which was shown by high value of Pseudo R^2 (=0.6866). Moreover, probability of chi^2 is statistically significant at 5 percent, which indicates that all explanatory variables taken together are significant in explaining the model. Diagnostic tests were conducted, in which multicollinearity problem was detected. Later, explanatory variables resulting in multicollinearity problem were omitted, and the final regression result is presented in Table 5 above. Therefore, the model can be valid to determine variables that significantly affect adoption of electric injera mitad by households in the study area.

A number of studies have shown several socio-economic factors , such as household income, education, size and age of household, time spent at home, ownership, age and type of dwellings, etc., influence household cooking and cooking stove choices. Likewise, as it is seen from Table 5, six explanatory variables were found to be significant in affecting adoption of electric injera mitad in the study area. These variables are household income, wife's education level, sex of household head, price of fuelwood, price of electricity and refrigerator ownership. Furthermore, the variables came up with the expected sign.

As it is indicated in Table 5, it was found that household income has positive and significant effect on household adoption of electric injer mitad. The odds ratio in favor of adoption will increase by a factor of about one as the income of household increases by one Birr. In other words, the probability that a household adopt electric injera mitad will increase as his/her level of income increases, which confirms the energy ladder hypothesis. This finding is consistent with most of the previous research findings. According to SHEN (2014) and Malla & Timilsina (2014), the household income affects the adoption of clean fuels and cooking stoves significantly. With increase in household income, most households adopt cleaner commercial fuels to improve their living conditions (Masera et al., 2000; Heltberg, 2005; Rajmohan and Weerahewa, 2007; Faye, 2002). This postulate is known as household energy ladder hypothesis in the literature of household fuel-choice. The energy ladder hypothesis states that households with lower incomes use solid biomass fuels, and households with higher incomes tend to use modern fuels.

The maximum likelihood estimate shows wife's education level significantly influences adoption of electric mitad. There is positive association between wife's education level and adoption of electric injera mitad. As it is observed from Table 5, the odds ratio in favor adoption will increase by a factor of 1.2 as the wife's year of schooling increases by one year. In other words, the probability that the household adopts electric injera mitad will increase as the wife's year of schooling increases. This finding is obvious; majority of women in Ethiopia allocate most of their time to domestic activities. As a result, they need energy sources, which are convenient to them. Education equips women with the necessary knowledge how to use modern technologies as well increases their awareness about the possible negative effects associated with the use of biomass fuels (such as respiratory diseases from fuel-wood and charcoal use). Thus, education of the wife plays an important role in urban household energy transition since it helps them to adopt modern technologies, like electric injera mitad. Moreover, Table 5 reveals that the probability that the household adopts electric injera mitad becomes larger when female than male heads the household. As it is known, females are more aware about health problems associated with the use of solid biomass fuels than males are, since most of females' undertakings and the use of fuels are highly interlinked.

As it is expected from the law of demand, which states demand for a good is a decreasing function of its price, adoption of electric injera mitad is negatively related to price of electricity. This negative relationship can be justified in different ways. First, an increase in electricity decreases the capacity of the households to purchase the other commodities, including electric injera mitad, which lowers adoption rate. Second, when the price of electricity increases, households those already adopted electric injera mitad shift back to cheaper energy sources, like fuel wood. In this case, they adopt either three-stone stove or improved cooking stove.

On the other hand, from Table 5, we found that price of fuelwood and adoption of electric injera mitad have positive relationship, which is statistically significant. Households in the study area use either fuelwood or electricity to bake injera, which means the two fuels are substitutes. As a result, as price of electricity increases, households shift to the alternative energy source (such as fuelwood). Therefore, change in the relative price of fuelwood plays an important role in influencing adoption of electric injera mitad.

As we see from Table 5, refrigerator ownership increases the probability that household adopts electric injera mitad in the study area. This is due to that households try to reduce the amount of energy required to bake injera by owning refrigerator, since refrigerator decreases the frequency of fuel use.

4. Conclusions and Policy Implications

Adoption of modern cooking stoves plays a significant role in improving standard of living of urban households and in reducing adverse effects of human activities on the environment. This study investigated factors affecting adoption of electric injera mitad by households living in Woliso town. The household energy consumption of the town indicates that fuelwood constitutes the major fuel in baking injera, followed by electricity. As a result, households in the town lagged behind in adopting electric injera mitad. Only 33 percent of the sampled households adopted electric injera mitad. Even though some households adopted electric injera mitad, they still use fuelwood besides electricity. This implies adoption of electric injera mitad does not enable households to switch completely to modern energy sources. The study found that increase in household income increases the probability that the household adopts electric injera mitad. Therefore, policies and strategies working on promotion of usage of electric injera mitad need to design and implement development projects that improve income of households living in Woliso town. In addition to increasing households' income, the result of the study supports the worth of wife's education in increasing the adoption of electric injera mitad among households in Woliso town. Thus, urban development policies should encourage access to at least basic education to women to improve the adoption of modern cooking fuels by revealing the strong association between wife's education level and adoption rate. Like many empirical studies, this study found negative relationship between price of electricity and adoption of electric injera mitad. This implies that subsidizing residential electricity consumption could promote adoption of electric injera mitad and enhances substitutability of electricity for fuelwood in baking injera. Generally, the results of this study suggest that increasing adoption of electric injera mitad among urban households requires implementation of mixed policies and strategies, which can influence household income, wife's education, price of electricity and price of substitute energy source, like fuelwood. Future research works should pay attention to the present empirical evidences in the study area to investigate issues, which have not been addressed by this research. Moreover, it will be better if the future research works study the problem using panel data analysis.

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