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Article

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Energy Reports

Provided in Cooperation with:

Elsevier

Suggested Citation: Twumasi, Martinson Ankrah; Jiang, Yuansheng; Ameyaw, Bismark; Danquah, Frank Osei; Acheampong, Monica Owusu (2020) : The impact of credit accessibility on rural households clean cooking energy consumption: The case of Ghana, Energy Reports, ISSN 2352-4847, Elsevier, Amsterdam, Vol. 6, pp. 974-983, <https://doi.org/10.1016/j.egy.2020.04.024>

This Version is available at:

<https://hdl.handle.net/10419/244094>

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Research paper

The impact of credit accessibility on rural households clean cooking energy consumption: The case of Ghana

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ARTICLE INFO

Article history:

Received 8 October 2019

Received in revised form 28 March 2020

Accepted 14 April 2020

Available online xxxx

Keywords:

Credit

Clean cooking energy

Instrumental variables

Ghana

ABSTRACT

This study examined the impact of credit received on rural household clean cooking energy consumption. The study pays more attention to clean energies, such as liquefied petroleum gas (LPG) and kerosene. Due to the endogenous issue of credit, we employed an instrumental variable approach (IV-Probit and IV-Tobit). We analyzed the survey data collected from four regions, Savannah, Bono East, Eastern and central, in Ghana. The result of the econometrics model depicted that household head relationship with an individual in the city, education level, access to off-farm employment, age, household size, and amount of credit received influences the household's probability of consuming and spending on clean cooking energies. Concerning the amount of credit received impact on clean cooking energy expenditure, rural households in the eastern region compared to their counterparts were more pronounced. Our findings explored the importance of credit on energy consumption and provided policy implications to enhance clean cooking energy consumption.

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1. Introduction

About 2.5 million people in rural households rely on biomass which includes, animal dung, agricultural waste, and charcoal for cooking purposes (Anon, 2006). There is an expectation that the number of biomass users in the population of the rural areas will increase to 2.7 billion by 2030 due to rapid population growth (Anon, 2010). Cooking is essential, but the choice of energy needs attention since non-clean energy has severe consequences for human welfare and the environment at large. Evidence from several studies has revealed that heavily relying on solid fuel (mostly biomass and coal) is associated with severe human health and environmental problems (Gamtesa, 2003; Armah et al., 2015; de la Sota et al., 2018; Han et al., 2018). There are approximately 1.3 million people who die prematurely due to exposure to indoor air pollution from biomass (Anon, 2009). Aside from the health issues raised from heavy dependence on solid fuel (biomass and coal), there is a tendency of economic consequences. For example, productivity loss due to poor health

as well as time spent for gathering fuelwoods, animal dungs, and many others at the expense of working or doing something profitable to improve household welfare.

In Ghana, there has been a reduction in fuelwood usage from 69% in 1990 to 58% in 2005 (Ghana Statistical Service, 2009). This reduction can be as a result of various policies undertaken by the government with the support of the United Nations Development Program (UNPP). Policies such as the national liquefied petroleum gas (LPG) promotion Program and the West African Gas Pipeline (WAGP) project undertaken by the government can also serve as factors to this reduction. Despite the disadvantages that high dependence on dirty fuel poses on human health and the environment and the various policies implemented by the government of Ghana to reduce the use of biomass, it is still the primary cooking energy choice for households in Ghana. Besides, regarding cooking energy in Kwakwa et al. (2013), using a sample size of 507, reported that 53.5%, 30.6% and 9.5% of households use wood, charcoal, and gas respectively in Ghana. The rampant use of solid fuel such as fuelwood and charcoal in Ghana is due to its affordability, availability and low access to clean energy sources (Rahut et al., 2016b).

Furthermore, urban households are more likely to consider the use of clean energy such as kerosene and liquefied petroleum gas (LPG) compared to their rural household counterparts (Rahut

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et al., 2016a, 2017). According to Mottaleb et al. (2017), rural residents prefer to depend on dirty fuel such as charcoal and fuelwood than to spend on clean fuels such as gas and electricity. This means that there is energy consumption inequality between rural and urban residents. Therefore, it is essential to curb this menace because the existence of consumption inequality may cause societal havoc. Again, putting down measures to reduce this energy consumption inequality gap between these parties will improve the living standards of rural households and leads to the promotion of economic and social development (Ma et al., 2019).

Numerous studies have investigated the determinants of rural energy consumption and its transition. For instance, investigation of the factors influencing the rural household choice of energy consumption, consumption intensity, and expenditure has been examined (Armah et al., 2015; Rahut et al., 2016a; Mottaleb et al., 2017; Ma et al., 2019; Song et al., 2018; Edwards and Langpap, 2015). Most of the findings of these researchers revealed that householders (e.g., age, gender, education, and occupation), household characteristics (e.g., household size, location, wealth, income level and household health) and other environmental and social factors affect energy choice and expenditures. The critical determinant among the influential factors was income. For example, Ma et al. (2019) and He et al. (2018) studies in China and Mottaleb et al. (2017) study in Bangladesh revealed that rural households with higher income prefer the use of modern and clean energy such as LPG and electricity to dirty solid fuel such as biomass. Khandker et al. (2012) reported that affluent households (high-income earners) are willing to pay for modern and quality energy consumption. Edwards and Langpap (2015) also confirmed in their study that due to the high cost involved in the clean fuel usage, most poor rural households are unable to switch from traditional (biomass) fuel to modern (clean) fuel. Therefore, it can be established that without proper income generation, it will be difficult for a household to transit from the use of dirty energy sources to clean energy sources.

Access to credit helps boost the income level of households in rural areas where there is a high level of low-income earners. The provision of credit to low-income earners assists them in creating microenterprises, which leads to employment generation and extra income for poor households and villages (Bateman, 2012). The availability of credit is considered as a powerful tool to help poor people invest and escape from the 'vicious cycle' of poverty. This is because it enhances capital accumulation and reinforces high incomes (Atieno, 2001). Additionally, in most rural areas which is mostly predominated by farmers, access to credit helps to diversify and increase rural households' agriculture productivity, profitability, income and expenditure (Vishwanatha, 2017; Chandio and Jiang, 2018). Previous studies have also confirmed that access to credit improves household consumption patterns and per capita income (Imai and Azam, 2012; Adjei et al., 2009). Edwards and Langpap (2015) examined how credit access affects firewood consumption in Guatemala. They reported in their study that access to credit plays a statistically significant role in determining firewood consumption through its effect on the household's ability to purchase clean energy products such as gas or kerosene stoves. Again, the part of credit on rural household welfare in Ghana has been confirmed to be positive and significant by previous studies (Owusu, 2017; Akotey and Adjasi, 2016). These studies justify that with access to credit, households may be able to increase their income, hence, switch from dirty fuel to clean fuel consumption.

Given the disadvantages of using solid fuel and the benefits derived from the use of modern fuels, it is essential to understand the key variables that influence rural households' clean cooking energy consumption. This will help policymakers to design the appropriate policies to promote efficient and sustainable cooking

energy consumption. In this present study, we emphasized the impact of access to credit on rural households' clean cooking energy consumption. The main objective of this study is to determine the factors influencing the probability of a rural household to consume clean cooking energy and households' intensity of clean cooking energy consumption. The study focused on the impact of credit on clean cooking energy consumption. This objective is achieved by the use of survey data collected from four regions in Ghana. Despite the relationship between access to credit and household consumption patterns, empirical investigations on the impact of access to credit on rural households' clean cooking energy consumption, to the best of the authors' knowledge, are scanty. Edwards and Langpap (2015) examined how credit access affects firewood consumption in Guatemala. They reported in their study that access to credit promotes the purchase of clean energy products such as gas or kerosene stoves. However, they considered not the problem of endogeneity.

The contribution of this study is twofold. First, this is the first study to examine the role of credit on clean cooking energy consumption in Ghana. According to the energy ladder hypothesis, an increase in household income or wealth leads to the household energy transition; thus, households tend to consume less of non-clean (solid) energy and more of clean (modern) energy (Rahut et al., 2016a; Leach, 1992). Therefore, the authors' test in this study whether credit received, which positively influences households' incomes, promotes rural energy transition. That is, increasing the use of modern cooking energy such as Kerosene and LPG while decreasing the use of solid cooking energy such as fuelwood and charcoal in Ghana. Second, the endogeneity problem associated with access to credit is dealt with by using the IV-Probit and IV-Tobit model.

The paper is organized as follows. Section 2 outlines the methodology. Chapter 3 presents a summary of descriptive statistics. We subsequently present the empirical findings in Section 4, while the fifth section deals with results discussion. The final section concludes with policy implications.

2. Methodology

2.1. Data source

The study was conducted in Ghana from January 2018 to May 2018. Interview schedules and questionnaires were used for data collection from rural households in Ghana. We did an in-depth interview because of the complex nature of the questionnaire. A pre-test of the questionnaire was carried out to clear all uncertainty. The survey data questionnaires covered information on socioeconomic characteristics, access to credit, energy consumption pattern and other various variables that contribute to the aim of the study. The sampling technique employed was the multi-stage technique. In the first stage, four (4) regions, namely Savannah region in northern Ghana, Bono East region in central Ghana, Central region in southwestern Ghana and Eastern region in southeastern Ghana were selected. In the second stage, one district was randomly chosen from each selected region. They include; East Gonja District in Savannah region, Atebubu Amantin District in the Bono East region, Ekumfi District in Central region and Kwahu Afram Plains District in the Eastern region. In the third stage, three (3) communities were randomly selected from each selected district. They were Yankanjia, Akyenteteyi and Salaga in East Gonja District; Asempanye, Dobidi Nkwanta and Atebubu in Atebubu Amantin District; Essarkyir, Otum, and Kontankore in Ekumfi District; Tease, Bumpata, Ahiatroga in Kwahu Afram Plains District. Finally, with the help of lists provided to us by financial institutions as well as support from association and opinion leaders, 40–60 rural households were randomly selected

from each community based on the size of the community. In all, a total sample size of 602 households was gathered, thus, Savannah (124), Eastern (159), Central (168), and Bono East (151). However, out of the 602 questionnaires administered, 572 of those returned were found analyzable and thus utilized for the study.

2.2. Conceptual analysis

Many factors, including income, influence household consumption. At a particular time where income is low or difficult to generate to smooth consumption, credit becomes necessary. As established by previous studies, credit enables households to participate in the input and output markets, which improve their income, smooth their consumption and accumulate assets (Imai and Azam, 2012; Gonzalez-Vega, 2003). In addition to the existing literature on access to credit and economic development, we examined the impact of access to credit on rural household modern cooking energy expenditure in Ghana.

The role of credit on clean cooking energy consumption may be uncertain. There may be a positive impact of credit on clean cooking energy fuel consumption on the one hand. For instance, an individual who has received credit would be able to consume and spend on better and clean energy cooking fuel such as LPG and kerosene and other things needed for a better standard of living. This is because credit improves households' welfare. On the other hand, obtaining credit may inversely influence clean energy fuel consumption. For example, rural households who have borrowed, especially those associated with rural–urban migration, may spend less time at home to use their clean energy fuel product bought. The reason is that they might be working hard to pay off their loan. Again, in a rural area where farming is the main occupation and education is low, borrowers may be swallowed up by huge debts after selling their harvest due to financial illiteracy and the high interest rate charged by the financial institutions (van Rooyen et al., 2012; Coleman, 1999). Therefore, even with access to credit, these rural residents cannot switch from the use of solid fuel to non-solid fuel.

Besides the positive and negative effects of credit, the availability of credit may contribute to rural household energy consumption patterns since it may increase their income level. The energy ladder theory posits that as income increases, energy consumption patterns of rural households tend to shift from solid such as fuelwood and coal to non-solid fuels such as electricity and gas. Analysis from the above has been the motivation for this study. The study can contribute significantly to sustainable energy policies designed for rural developments by policymakers.

2.3. Definition of model variables

Influential factors of rural households to switch from non-clean cooking energy to clean cooking energy are the focus of this study. This study emphasized the impact of credit accessibility on rural households' probability and intensity of clean cooking energy consumption. Therefore, the total amount of credit received from formal and informal financial institutions becomes the core independent variable for this present study. Based on this, the two dependent variables selected in this study include; a binary variable, whether a rural household consumes a clean cooking energy product such as gas or kerosene; and a continuous variable, the intensity of clean cooking energy consumption measured by the annual expenditures on gas and kerosene in Ghana cedis (Ghc). Also, based on previous literature on energy consumption (Dong et al. 2012; Edwards and Langpap, 2015; Ma et al. 2019; Mottaleb et al. 2017), some household demographics and socioeconomics characteristics such as gender, age,

education, urban, off-farm employment, household size, presence of a household member with a chronic disease, presence of a household member living in the city, distances to the nearest LPG station together with some regional dummies on were added as control variables. Table 1 depicts all the definition and assignment of all the variables in this study.

2.4. Econometric model

The random utility function approach can be used to model the effect of clean cooking energy consumption. Assume that U_{i1}^* represents a latent variable of the expected utility that the i th household derives by consuming clean energy compared with the one who does not consume clean energy, U_{i0}^* . Where there is cost, clean cooking energy is consumed by a household if the net benefit exceeds the cost, that is, $CE_i^* = U_{i1}^* - U_{i0}^* > 0$, where whether a household consumes gas or kerosene (consumes clean energy) is CE_i^* . The net benefit CE_i^* therefore is a function of latent variables determined by observable household characteristics (both exogenous and endogenous variables) and the error term. Thus, CE_i^* which is a binary probit model is constructed below as;

$$CE_i^* = \beta_0 + \beta_1 CREDIT_i + \gamma Z + \mu_i \quad (1)$$

$$CE_i = \begin{cases} 1 & \text{if } CE_i^* > 0 \\ 0 & \text{if } CE_i^* \leq 0 \end{cases}$$

where CE_i^* refers to clean energy consumption status (1 for a household that consumes clean energy such as gas and kerosene and 0 otherwise). $CREDIT_i$ represents the total amount of credit received from formal and informal financial institutions by respondents. Z is a vector of control variables that determines respondents' probability of consuming clean cooking energy and the total amount of annual expenditure on clean energy consumption. They include household demographic and socioeconomic characteristics (see Table 1), β_0, β_1, γ are the vector of parameters for the control variables that need to be estimated and μ_i is a random disturbance term.

Furthermore, as stated previously, the authors again examined the intensity of clean cooking energy consumption (annual expenditures on gas and kerosene). In rural areas, not all of the households consume clean cooking energy. This implies that some households may record zero value for gas and kerosene expenditure. When this happens, the Tobit model becomes the appropriate model to employ because using ordinary least square (OLS) to estimate, for instance, the impact of credit on energy expenditure may be inconsistent and biased (Foster and Kalenkosi, 2013). The Tobit model is useful for continuous values that are censored at or below zero. Since the model of factors influencing the amount of gas and kerosene expenditures can be perceived as a model of energy demand, it is reasonable to include households with zero expenditure. The Tobit model supposes that there is a latent unobserved variable A_i^* that depends linearly on Z_i through a parameter vector β . There is a normally distributed error term v_i to capture the random influence on this relationship. The observed variable A_i is defined as being equal to the latent variable whenever the latent variable is above zero and equal to zero otherwise. The Tobit model is therefore expressed as:

$$A_i = \begin{cases} A_i^* & \text{if } A_i^* > 0 \\ 0 & \text{if } A_i^* \leq 0 \end{cases} \quad (2)$$

$$A_i^* = \beta Z_i + v_i, v_i \sim N(0, \sigma^2) \quad (3)$$

where A_i^* is a latent variable, that is, total annual expenditures on gas and kerosene.

Table 1

The definition and data description of the variables in the model.

Source: Survey results, January 2018 to May 2018. Cedis (Ghc) is a Ghanaian currency (\$1=Ghc4.9).

Variables	Description of variables and measurement	Mean	SD
Dependent variable			
Clean cooking energy consumption	Whether the respondent consumes clean energy (0=no, 1=yes)	0.46	0.49
Clean cooking energy expenditure	Annual clean energy expenditures in 2018 (in Ghc)	224.71	268.34
Independent variables			
Credit	The total amount of credit received from the financial institutions in 2018 (in Ghc)	1465.83	956.38
Education	Whether the respondent has high school or higher education (0=no, 1=yes)	0.44	0.49
Urban	Whether household member(s) lives in an urban area (0=no, 1=yes)	0.56	0.49
Off-farm employment	Whether the respondent has off-farm work (0=no, 1=yes)	0.59	0.49
Chronic disease	Whether household member(s) has a chronic disease (0=no, 1=yes)	0.17	0.37
Gender	Gender of the respondent (0=no, 1=yes)	0.69	0.46
Age	Age of respondent (in years)	41.72	12.21
Household size	Total number of members in a household	6.61	3.21
Distance	Distance to the nearest LPG station (in km)	2.32	1.59
Social network	Whether a household head is connected with a top official in the community (0=no, 1=yes)	0.56	0.50
Assets ownership	Whether a household head owns a land (0=no, 1=yes)	0.64	0.48
Eastern	Whether a household is located in the Eastern region (0=no, 1=yes)	0.27	0.44
Central	Whether a household is located in the Central region (0=no, 1=yes)	0.29	0.45
Bono East	Whether a household is located in the Bono East region (0=no, 1=yes)	0.26	0.43
Savannah	Whether a household is located in the Savannah region (0=no, 1=yes)	0.18	0.37

The reference region is Savannah.

The explanatory variables in the Tobit model are also a function of latent variables determined by observable household characteristics (both exogenous and endogenous variables) and the error term. The empirical model is presented implicitly below as:

$$A_i^* = \beta_0^* + \beta_1^* CREDIT_i + \gamma^* Z + \mu_i^* \quad (4)$$

where A_i^* represents the amount of annual expenditure on clean energy consumption of the rural resident of household i . In this formula, the meaning of each variable is similar to that of Eq. (1).

Also, another issue that needs a critical look in the econometric estimation is the endogeneity problem. This arises, because loans distributed among households is not random, because the decision for farm households to borrow an amount of credit to perform a task is a choice. Also, there may be a causal relationship between credits received and clean energy consumption. Thus, the amount of credit obtained from financial institutions may influence clean cooking energy consumption behavior, and clean cooking energy consumption behavior may also affect the amount of credit obtained from financial institutions. For example, households that received the actual credit applied for may not be limited in resources to increase expenditure on clean energy consumption and other income-generating assets to increase their wealth. Wealthy, educated, or more productive individuals are more likely to have access to credit than others because financial institutions (lenders) prefer to select such individuals to minimize the probability of default by credit receiving clients (Chandio et al., 2018; Awotide et al., 2015; Bocher et al., 2017).

In contrast, individuals whose credit applications were rejected or rationed (credit constrained) may spend their limited resources on dirty and affordable fuels. They may also be unable to acquire any asset, i.e., they may be classified as poor, which in turn may affect their ability to borrow from financial institutions. Thus, the total amount of credit received which is the core independent variables may be endogenous. To solve the endogenous problem, we employ the IV-Probit and IV-Tobit models developed by Newey (1987). The big challenge in the instrumental variable analysis is the identification of a suitable instrument(s). However, following previous studies (Ma et al., 2019; Dong et al., 2012), the authors use social network and assets ownership as instruments for the amount of credit received from financial institutions being formal or informal. Whether a household head is connected with a top official in the community was used to measure social network and to own a land for asset ownership. These instruments were chosen because they are expected

to affect the credit amount received but do not directly affect clean cooking energy consumption expenditures (outcome). For instance, Akudugu (2016) revealed that householder owning land could use it as collateral; therefore, more likely to receive credit compared to their counterpart who owes no land. Owning land is expected to affect the amount of credit received, hence energy expenditure. This implies that asset ownership does not affect the outcome (household's energy expenditures) directly but through the treatment (credit received).

3. Summary of descriptive statistics

The descriptive statistics of respondents are shown in Table 1. The results revealed an average age of the respondents as 42. Most of the household comprises 7 members on average. The mean distance to the nearest LPG station of the respondents in the study was 3.32 km. While 69% of the respondents were males, only 44% of the respondents had access to high school or higher education and 64% had access to land. Moreover, 56% of the respondents had household members residing in the city (urban area) and 17% of their household members with a chronic disease. About 59% had off-farm employment.

Concerning credit accessibility, in our sample, out of 56% of household heads who have a connection with top officials, the average credit (credit from both formal and non-formal financial institutions) received by household was GH¢1465.83 in 2017. Fig. 1 further reveals that credit received by each household in the Central region was much higher than those in the Savannah region. Moreover, Table 1 showed that 45% of the households reported that they use clean cooking energy. Out of those using clean cooking energy, the average clean cooking energy annual expenditures per household was approximately GH¢225 in 2017.

Also, Figs. 2 and 3 illustrate each household consumption pattern of clean energy at the regional level. While it is revealed that households in the Eastern region use and spend more on clean cooking energy, those in the Savannah region recorded the lowest clean cooking energy consumption and expenditure. The variations among the regions may be attributed to the low income rate among the regions. According to the Ghana poverty mapping report, there is a high concentration of poverty in the Northern part of Ghana, including the Savannah region compared with the other selected regions of the study (Anon, 2015). Previous studies have also reported that household income and LPG prices were key determinants of a households' decision to use LPG (Ma et al.,

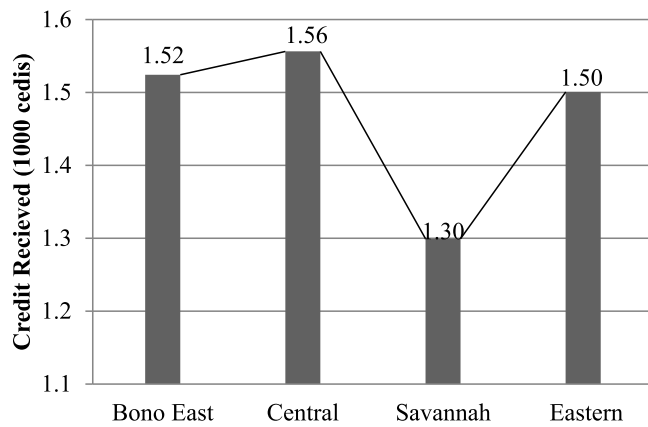


Fig. 1. Household level credit received by survey regions.

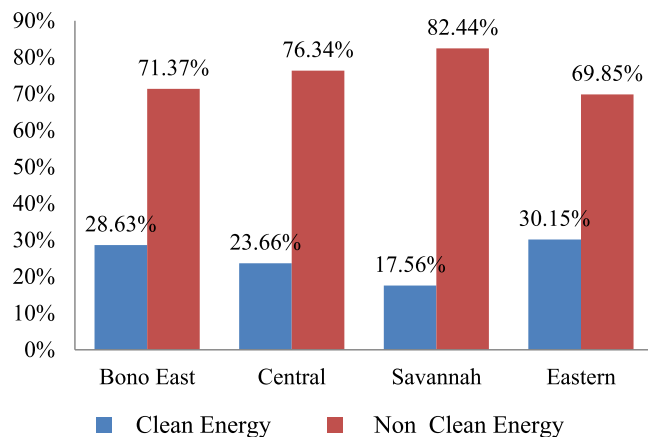


Fig. 2. Household level clean energy consumption distribution by survey regions.

2019; Karimu, 2015). Again, easy accessibility of LPG stations and the affordability of dirty fuels may result in these variations. The study of Dalaba et al. (2018) revealed that the inadequate supply and high cost of LPG in the northern region reduce the probability of consuming LPG. Again, most households in the Central region use clean energy compared to those in the Bono East region. However, concerning household expenditures on clean energy, households in the Bono East region were spending more on clean cooking energy compared to households in the Central region (see Fig. 3). The reason may be attributed to household size and the rate (number of times) clean cooking energies are used in a week by households among these regions.

Table 2 also reported whether there are significant differences between households who use clean cooking energy and those who do not. From the sample size, 262 (45.8%) households were using clean cooking energy, while 310 (54.2%) households were not. There were significant differences between clean cooking energy users and non-clean cooking energy users in terms of credit received, education, household size, whether a household member lives in the city, whether the household head has off-farm employment, a connection with top official, and access to land. Concerning location, households in Eastern and Bono East showed significant differences between clean cooking energy users and non-clean cooking energy users.

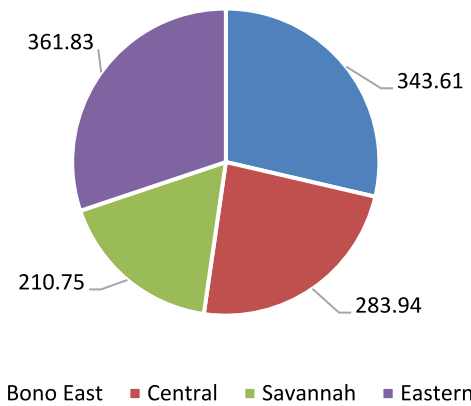


Fig. 3. Household level clean energy expenditures (in Ghc) distribution by survey regions.

4. Empirical results

4.1. Determinants of the amount of credit received

The factors that influenced the amount of credit received are presented in this section using the Tobit model. It is essential to estimate the determinants of credit received when investigating the impact of credit received on clean energy consumption. The interpretation of the empirical results in this section is mainly based on the values of the marginal effect. From Table A.1 in the appendix, it is revealed that the educational level of the household head positively and significantly influences the amount of credit received, suggesting that a large number of credits are given to those who are educated. Relative to household heads with no or less education, educated ones are usually in a more favorable position due to their ability and skills to understand the terminology of the financial market like interest rates and repayment terms and therefore do not fear to borrow (Chandio and Jiang, 2018; Twumasi et al., 2019). Besides, the positive and significant coefficient of household size indicates that households with a large family size are more likely to increase the credit amount received. Households with greater the number of adult dependents have an advantage when approaching the credit market (Li et al., 2016). There is a negative and significant impact of household heads with off-farm employment on credit received. The reason may be that having an off-farm job, which in turn may increase household income, will cause household heads to reduce their amount of credit needed. Asset ownership (access to land) and social network, which served as instrumental variables, appear to have a positive and significant effect on the amount of credit received. This result of asset ownership is similar to Twumasi et al. (2019), Asante-Addo et al. (2017), who reported that access to collateral such as land increase the credit accessibility opportunity in Ghana. The study of Afande (2015) confirms the social network result. The coefficient of the social network is positive and significant, suggesting that a household head connection with a top official in the community has an impact on credit received. Finally, relative to respondents in the Savannah region, respondents dwelling in Central tend to obtain a higher amount of credit, suggesting that using location dummies to capture unobserved institutional and socioeconomic heterogeneities are also important determinants of the amount of credit received.

4.2. Impact of credit accessibility and clean cooking energy consumption

The empirical results of the estimation are presented in Table 3. This table is divided into two sections. Model 1–3 presents

Table 2

Differences between means of the variables for clean and non-clean energy households.

Source: Survey results, January 2018 to May 2018.

Variables	Total	Clean Energy(262)	Non-clean Energy(310)	Differences
Credit	1465.83 (956.38)	2146.56 (980.13)	890.52 (392.18)	1256.04***
Education	0.44 (0.49)	0.79 (0.41)	0.14 (0.34)	0.65***
Urban	0.56 (0.49)	0.71 (0.46)	0.43 (0.49)	0.28***
Off-farm employment	0.59 (0.49)	0.84 (0.46)	0.31 (0.37)	0.53***
Chronic disease	0.17 (0.37)	0.17 (0.39)	0.19 (0.35)	−0.02
Gender	0.69 (0.46)	0.73 (0.45)	0.66 (0.47)	0.07
Age	41.72 (12.21)	42.05 (12.73)	41.45 (11.76)	0.06
Household size	6.61 (3.21)	6.65 (3.38)	7.57 (3.07)	−0.92*
Distance	2.32 (1.59)	2.35 (1.77)	2.30 (1.42)	0.05
Social network	0.56 (0.50)	0.62 (0.49)	0.51 (0.50)	0.11**
Asset ownership	0.64 (0.48)	0.89 (0.31)	0.42 (0.50)	0.47***
Eastern	0.27 (0.44)	0.23 (0.43)	0.31 (0.46)	−0.08*
Central	0.29 (0.45)	0.30 (0.46)	0.29 (0.45)	−0.01
Brong Ahafo	0.26 (0.43)	0.29 (0.45)	0.24 (0.42)	0.06*
Savannah	0.18 (0.37)	0.18 (0.37)	0.17 (0.37)	0.01

*Represent significant levels at 10%.

**Represent significant levels at 5%.

***Represent significant levels at 1% .

Reference region is Savannah.

the IV-Probit results with the dependent variable (1 if whether household consumes clean cooking energy and 0, otherwise), while model 4–6 presents the IV-Tobit with a dependent variable (annual clean cooking energy expenditures). Among the independent variables include credit received, regional dummies and other control variables such as education, urban, off-farm employment, chronic disease, gender, age, household size, and farm size (see Table 1). The marginal effect results of the IV-Probit and IV-Tobit were displayed in Model 3 and 6, respectively and the interpretation of the Model results is mainly based on these two models (the marginal effect values). There was a 1% significant level for the endogenous Wald X^2 value at all levels of the models (1–6). This implies that the focal variable (credit) is endogenous and therefore, employing IV-Probit and IV-Tobit method of estimation is appropriate.

Analysis from the IV-Probit model, as shown in model 3 (marginal effect), reveals the impact of credit on households' probability of consuming clean cooking fuels. Model 3 in Table 1 shows that credit accessibility significantly and positively influences the likelihood of consuming clean cooking energy. This implies that a GH¢1 increase in the credit received, all other things being equal, will lead to the probability of clean cooking energy consumption by 0.0028. In the same manner, education is positively and statistically significant, suggesting that household heads with high school or higher education are more likely to patronize the use of clean cooking energy. A well-educated individual is more likely to secure credit to increase production, hence income, thereby increasing the affordability of clean cooking energy products. Again a well-educated household head may have acquired knowledge about opportunity cost in using non-clean energy such as health cost. This finding confirms the findings of Mottaleb et al. (2017), Ma et al. (2019),

Karimu (2015). They concluded in their studies that household heads with higher education increase the use of clean energy consumption. In addition, if a household has a member residing in the city, it increases the probability of that household to consume clean cooking energy. A possible explanation for this may be that household members living in the cities do give out remittances that may increase rural household income, therefore, increasing household capacity to afford clean cooking energy. Gyimah-Brempong and Asiedu (2009) pointed out that remittances reduce poverty through income increment.

Similarly, the probability of consuming clean cooking energy by a household head increases when a household head secures off-farm employment. This suggests that household head with additional work aside farming generates off-farm income to increase total annual income and also promote the use of clean energy. This finding agrees with Ma et al. (2019) study in China and Mottaleb et al. (2017) study in Bangladesh who reported that off-farm income increase households' probability of consuming clean energy.

The variable age showed an inverted U-shape for consuming clean fuel, i.e., consumption of clean fuels increases as age increase in the initial stage and later declines. These findings agree with Rahut et al. (2016a) study which concluded that older household heads prefer non-clean fuels because they are cheap and easy to access. Furthermore, household size significantly and negatively influences the use of clean cooking energy consumption, suggesting that as family size grows bigger, the probability of consuming clean cooking energy falls by 0.0281. This may be explained by the fact that the opportunity cost of consuming non-clean energy is low, i.e., a household with more members preferred cheaper fuels since consuming non-clean fuels such as fuelwood relaxes households' limited income due to their easy

Table 3

Econometric models estimating results of the impact of credit accessibility on clean cooking energy consumption.

Source: Survey results, February– April 2018.

Variables	IV-Probit model and its marginal effect			IV-Tobit model and its marginal effect		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Credit	0.0018 (0.0001)***	0.0022 (0.0001)***	0.0028 (0.0001)***	0.2995 (0.0243)***	0.2233 (0.0245)***	0.1571 (0.0178)***
Education		2.3091 (0.6763)***	0.7415 (0.1326)***		209.2189 (41.5486)***	147.2163 (29.6344)***
Urban		0.3231 (0.1415)**	0.1282 (0.0557)**		13.0521 (15.8321)**	9.1841 (11.1591)**
Off-farm employment		1.7097 (0.5487)***	0.6049 (0.1505)***		61.1081 (34.3995)*	42.9985 (24.2393)*
Chronic disease		−0.0151 (0.0516)	−0.0060 (0.0205)		6.2109 (6.3993)	4.3703 (4.4994)
Gender		0.0592 (0.1443)	0.0236 (0.0574)		17.8212 (16.3364)	12.5399 (11.4932)
Age		−0.0887 (0.0355)**	−0.0353 (0.0141)**		−3.1825 (4.1331)	−2.2393 (2.9078)
Age2		0.0009 (0.0004)**	0.0004 (0.0001)**		0.0274 (0.0461)	0.0193 (0.0324)
Household size		−0.0707 (0.0256)***	−0.0281 (0.0102)***		−7.5330 (2.5326)***	−5.3006 (1.7909)***
Distance		−0.0227 (0.0416)	−0.0091 (0.0166)		−6.1910 (4.2940)	−4.3563 (3.0292)
Brong Ahafo		0.2862 (0.2074)	0.1128 (0.0802)		−30.4322 (25.8095)	−21.4136 (18.1294)
Central		−0.0492 (0.1970)	−0.0196 (0.0785)		−30.0469 (26.0822)	−21.1424 (18.3324)
Eastern		0.4755 (0.1837)**	0.1853 (0.0685)**		16.8162 (21.8608)	11.8326 (15.3884)
constant	−2.682475 (0.1419)***	−3.1152 (0.9153)***		−214.2518 (34.8775)***	−119.0822 (90.2520)	
Endogenous Wald χ^2	40.61***	30.95***	30.95***	22.55***	13.11***	13.11***
observation	572	572	572	572	572	572

*Represent significant levels at 10%.

**Represent significant levels at 5%.

***Represent significant levels at 1%.

The reference region is Savannah.

accessibility and affordability compared to clean fuels. This result is consistent with the findings of [Adusah-Poku and Takeuchi \(2019\)](#). The results of this study also depicted that relative to households in the Savannah region, their counterparts in the Eastern region are more likely to consume clean cooking energy.

Results from the IV-Tobit model, as shown in model 6 are also presented in [Table 3](#). Model 6 presented the marginal effect results. At this level, this study would not go into detail because all the results in the IV-Probit are similar to those in the IV-Tobit. This is to save space. The results revealed that credit received has a positive and statistically significant impact on clean cooking energy expenditures. More precisely, all other things remaining constant, increasing household credit received by GH¢1 will cause GH¢0.0131 increase in the expenses on clean cooking energy. Besides, the household head level of education, if a household has a member residing in the city and if a household head has off-farm employment significantly and positively affects the expenditures on clean cooking energy consumption. More precisely, an increase in any of those variables by a unit will increase household clean cooking energy consumption expenditures. On the other hand, a household with a larger family size is more likely to spend less on clean cooking energy consumption.

4.3. Robustness check

The results from the IV-Probit and IV-Tobit (model 1–6) have, although proven that the model is robust, that is, credit which is the focal variable, has a significant impact on the household probability to consume clean cooking energy and the annual expenditures on clean cooking energy. Unfortunately, there might be measurement errors that can affect the robustness of the

result. To check for the robustness of the result, we employed two identification strategies to eliminate the measurement errors impact on the estimated results. First, we changed the IV Tobit estimation method to IV Probit method by replacing the dependent variable (annual total expenditures on clean cooking energy) by a binary variable (1, if the annual household cleans energy expenditure is high and 0, if it is low), i.e., model 1. Here, high expenditure means the expenditure is above the mean household expenditure while 0, takes otherwise. Second, we changed the IV Tobit estimation method to the Poisson model by replacing the IV Tobit dependent variable (total annual expenditure on clean cooking energy) by a new variable (number of times a household uses clean cooking energy in a week), and that is presented in model 2.

From [Table 4](#), it can be shown that the estimated results change for coefficient values in both models, but they are still significant and have a positive sign. The changes in the econometrics method did not alter the significant impact of credit on rural household expenditures on clean cooking energy. Therefore, it can be concluded that the results of this research are robust.

5. Discussions

This study seeks to analyze the impact of credit on clean energy consumption using survey data from four regions in Ghana. The study focused on rural households because they are less likely to consume clean energy due to inadequate income or capital. The energy theory ladder explains that with an increase in income through credit supply, the rural household may gradually switch from dirty fuels such as fuelwood, charcoal and animal dung to

Table 4

Estimated result of robustness checks.

Source: Survey results, 2018.

Variables	Model 1	Model 2
Credit	0.0014*** (0.0001)	0.0027*** (0.0004)
Control variables	Yes	Yes
Regional dummies	Yes	Yes
Instrumental variables	Yes	Yes
Wald X^2 or F statistics	13.48***	16.56***
Observation	572	572

***Represents statistical significance at 1% alpha levels.

All numbers in parentheses are robust standard errors. The reference region is Savannah.

more efficient and clean energy. The results of this study compared to prior studies are as follows. First, we investigated the impact of credit on the rural household probability to consume clean cooking energy. The study revealed that household probability of consuming clean cooking energy consumption could be promoted should households receive credit. Second, we examined how the intensity of clean cooking energy consumption is affected by credit. At this stage, annual expenditures on clean cooking energy were used to measure the intensity level. The study concluded that those who received credit are more likely to increase their expenditures on clean cooking energy. This implies that credit plays a major role in a clean cooking energy consumption pattern. Moreover, the analysis revealed that the effect of credit is more pronounced for households in the Eastern region. This finding agrees with the studies of [Ma et al. \(2019\)](#), [Edwards and Langpap \(2015\)](#).

Credit accessibility and its impact on household consumption have become a common phenomenon in the world. As other researchers are of the view that credit does not improve welfare ([Coleman, 1999](#); [Adams and VonPischke, 1992](#)), on the other hand, some research studies ([Dong et al., 2012](#); [Asante-Addo et al., 2017](#)) have concluded that credit improves household welfare. In this study, we also find that credit is a crucial determinant of rural household consumption patterns. That is, giving out credit to support rural households will encourage their ability to invest in off-farm employment and also increase their farm productivity ([Lin et al., 2019](#)) which in turn affects their income and household consumption.

Also, several limitations can be remedied by future researchers. For example, this study only focused on rural households; other researchers can focus on urban households and examine whether this study's conclusion confirms that of the urban area households study. Furthermore, in Ghana, it is difficult to have access to clean energy such as LPG stations in rural communities. Still, the story may be different in other countries where there might be several LPG stations in rural areas. A comparative study is also recommended to be carried out by future researchers.

6. Conclusion and policy implications

While the impact of credit on household food consumption and farm productivity in developing countries has been analyzed widely, much less, if any, is known about how credit influences rural household probability to consume clean cooking energy and clean cooking energy expenditures. We addressed this research gap by using household survey data from four regions (Savannah, Eastern, Central, and Bono East) in Ghana. Data collected were analyzed with the aid of descriptive analysis. The IV-Probit and IV-Tobit models were also employed to address the endogeneity issues of credit accessibility. This study consisted of 572 rural households.

The empirical results depicted that credit is an essential instrument to help rural households to choose and spend on clean cooking energy. In addition, the IV-Probit concluded that whiles other variables such as household head level of education, if a household has a member residing in the city and if a household head has off-farm employment significantly and positively affect household's probability to consume clean cooking energy consumption, household size showed a significant and a negative impact. The variable age showed an inverted U-shape for consuming clean fuels. Furthermore, the IV-Tobit reported that clean cooking energy consumption expenditures are positively and negatively affected by the household head level of education, if a household has a member residing in the city and if a household head has off-farm employment. Household size had a negative impact on clean cooking energy expenditures.

From the above results, this study offered several implications. First, the results have revealed that designing policies to encourage rural household participation in the rural credit market is essential. This is because of the role of credit on clean energy consumption. Thus, the more rural households secure credit from financial institutions, the more they are likely to switch from dirty energy to clean energy consumption. Second, household heads with some level of education were more likely to consume clean energy. Therefore, to improve rural household's understanding of the consequences behind the use of dirty fuel and the benefit derived from clean energy consumption, policymakers' should focus on organizing energy consumption education programs in rural areas. Precisely, to educate people on the health effects of indoor smoke. Third, although the results reported that credit improves clean energy consumption, [Fig. 2](#) illustrated that the majority of the rural households still depend on dirty fuels for their cooking. This implies that credit does not completely eradicate the use of unclean cooking fuels in rural households, but it somewhat alleviates dirty cooking fuel consumption. Thus, shifting from dirty fuel to clean fuel is a gradual process. Policymakers should, therefore, target increasing dirty cooking fuel usage efficiency, for example, encouraging rural households to use less smoke dirty fuel products such as efficient cooking stoves and well-processed fuelwood. Again to ensure fuelwood sustainability as a cooking fuel for rural household dwellers since the energy transition toward clean cooking fuel may be slow, tree planting programs should be included in policymakers' decisions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Martinson Ankrah Twumasi: Writing - original draft, Investigation, Writing - review & editing, Conceptualization, Methodology, Software, Formal analysis. **Yuansheng Jiang:** Supervision, Funding acquisition, Writing - review & editing. **Bismark Ameyaw:** Data curation, Writing - review & editing, Methodology. **Frank Osei Danquah:** Methodology, Writing - review & editing. **Monica Owusu Acheampong:** Writing - review & editing, Visualization, Investigation.

Acknowledgment

We gratefully acknowledge the financial supports from the Soft Science Program of Sichuan Department of Sci-technology (Grant No. 18RKX0773) and Sichuan Agriculture University, College of Economics. The authors also extend enormous gratitude to the anonymous reviewers, editors and the chief editors, of the journal, Nelson Fumo (PhD), for their helpful review and critical comments.

Table A.1

Determinants of the amount of credit received (Tobit model).

Source: Survey results, February–April 2018.

Variables	Coefficient	Marginal effect
Education	618.1769 (162.5567)	597.6305 (157.1103)***
Urban	28.6673 (70.5591)	27.7145 (68.2232)
Off-farm employment	−14.9541 (158.5619)	−14.4572 (153.2930)**
Chronic disease	−16.9223 (24.7163)	−16.3599 (23.8871)*
Gender	60.4911 (72.2029)	58.4805 (69.7712)
Age	5.7544 (17.7640)	5.5631 (17.1666)
Age2	−0.0412 (0.2015)	−0.0398 (0.1947)
Household size	47.0663 (11.7403)	45.5020 (11.4085)***
Distance	27.0369 (20.1879)	26.1383 (19.4998)
Brong Ahafo	111.1943 (113.9157)	107.4986 (110.1333)
Central	192.9848 (109.6274)	186.5705 (106.0816)**
Eastern	−72.8230 (101.493)	−70.4026 (98.1035)
Asset ownership	693.7878 (70.3313)	670.7282 (68.0411)***
Social network	271.4967 (71.0577)	262.4729 (68.9341)***
Constant	325.4322 (400.3087)	–
Observations	572	
Prob > F	0.0000	
Log pseudolikelihood	−4616.0296	
F statistics	19.27	
Pseudo R2	0.0221	

*Represent significant levels at 10%.

**Represent significant levels at 5%.

***Represent significant levels at 1%.

The reference region is Savannah.

Appendix

See Table A.1.

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