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Household cooking fuel choice: Evidence from the Republic of Benin

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Abstract

This paper investigates empirically the choice of cooking fuels and the factors that are associated with the adoption of modern cooking fuels. Exploiting the 2015 Benin Living Standard Measurement Survey data of 19,705 households, a multinomial probit model is estimated to identify the factors that are associated with the adoption of the three categories of cooking fuels (traditional, transition, and modern). Overall, the findings reveal that the most used cooking fuels are traditional in general, that is, firewood (68.28%), followed by transition fuels (27.25%), and modern fuels (4.47%), with disparities across rural and urban areas. The estimation results indicate that having a female household head, having a household head with at least secondary formal education level, per capita expenditures, remittances, access to electricity, and economic shocks are positively associated with the adoption of modern cooking fuels, while not living in the main city of the country hinders their adoption.

KEYWORDS

cooking fuels, cooking stoves, greenhouse gases, mitigation, shocks, technology

JEL CLASSIFICATION

D12; O13; Q41

1 | INTRODUCTION

Traditional cooking stoves are sources of air pollution and lead to negative impacts on health in developing countries (Bensch & Peters, 2015; Choumert-Nkolo, Motel, & Le Roux, 2019; Jeuland et al., 2015; Khandelwal et al., 2017). Indeed, one of the most urgent problems in the developing world is cooking with firewood and other biomass fuels by a large part of the population, as the resulting indoor smoke pollution causes serious health problems, especially for women and children who have the most frequent exposure (Khandelwal et al., 2017). The use of those stoves and fuels leads also to deforestation, environmental degradation, and destruction of habitats of species. Actually, a sustainable ecological system depends on an adequate forest cover, but the uncontrolled and unsustainable deforestation causes severe threat to environmental sustainability (Akinyemi, Efobi, Osabuohien, & Alege, 2019; Jan, 2012; Jebli, Youssef, & Ozturk, 2015; Lufumpa, 2005). One of the major anthropogenic causes of deforestation worldwide is the large dependence of the world population on biomass fuels for domestic energy consumption, and biomass is used in inefficient ways in rural areas, leading to increased demand of households (Jan, 2012; Lufumpa, 2005). In sub-Saharan Africa (SSA), virtually all rural households rely on biomass, mostly firewood for cooking purposes, and firewood collection and use is associated with various negative effects on the living conditions of the poor (Bensch & Peters, 2015). To reduce fuelwood consumption, the use of improved cooking stoves (ICSs) is being promoted due to their potential to address the aforementioned problems (Adrianzén, 2013; Bensch & Peters, 2015).

It is worth noting that the seventh sustainable development goal (SDG) is about ensuring access to affordable, reliable, sustainable, and modern energy for all, showing the importance of sustainability in energy use and also of mitigating actions regarding climate change. In fact, the second largest contribution to global climate change is from black carbon emissions from the use of traditional cook stoves and diesel engines (Ramanathan & Carmichael, 2008). Because of that, there has been a recent push toward the widespread promotion of ICSs in the developing world (Jeuland et al., 2015). In addition, the United Nations (UN) advocates the intensification of the programs encouraging access and use of modern energy sources, especially liquefied petroleum gas (LPG) by households in developing countries (Akinyemi et al., 2019; Rahut, Das, De Groote, & Behera, 2014). Traditional cooking stoves use also has social implications, such as excess time, risk, and strain of fuel harvesting for women and children (Ruiz-Mercado, Masera, Zamora, & Smith, 2011). The International Energy Agency (IEA, 2015) estimated the number of people that rely on the combustion of solid fuels for cooking purposes at 2.7 billion worldwide. The World Health Organization (WHO, 2018) states that in 2016, globally 3.8 million deaths were due to being exposed to indoor or household smoke, almost all in low- and middle-income countries, with about 739,000 deaths in Africa. The adoption of ICSs and modern cooking fuels exerts a positive impact on climate change mitigation (the potential for reducing greenhouse gas [GHG] emissions). Indeed, while biomass is seen as a renewable source if it is sustainably harvested, its utilization may release more GHGs in the atmosphere than LPG stoves (IEA, 2015). Therefore, it is of paramount importance to shift from traditional fuels and stoves to modern fuels (electricity, LPG, natural gas, and biogas) and ICSs.

In the Republic of Benin, the use of ICSs and modern fuels is promoted through projects such as the Projet d'Appui aux Marchés Ruraux de Bois (Support Project to Rural Wood Markets-PAMRB), and Foyers Améliorés au Bénin et au Togo (Efficient Cook Stoves in Benin and in Togo). However, the adoption of ICSs is still low in the country, amounting to 19% (Akouehou et al., 2012). Actually, biomass (fuelwood, charcoal, dung, and agricultural residues) is the most used source for cooking energies in the country. This pattern is similar to that of the developing countries in general. For instance, in developing countries, solid fuels (traditional biomass and coal) are often a source of household energy for cooking, especially in rural areas (Ajayi, 2018; Akpalu, Dasmani, and Aglobitse, 2011; Malla & Timilsina, 2014). Malla and Timilsina (2014, p. 7) state that "In developing regions, biomass-based energy (bioenergy) for cooking is expected to remain significant in next 30 years." So, there is a need for policies to shift from solid to modern fuels. Note that in the Republic of Benin the forest cover was estimated at 4,625,000 ha, about 42% of the land size (DGFRN, 2014; FAO, 2010; MCVDD, 2019), and the last estimations were around 4,311,000 ha in 2015 (MCVDD, 2019). Moreover, the inventories show that the Republic of Benin that was a carbon sink (a net balance of −1,093.61 Gg of CO_2 equivalent) in 1990 has become a net source of GHGs estimated at 681.93 Gg CO_2 equivalent in 1997 and 7,792.37 Gg CO_2 equivalent in 2015 (MCVDD, 2019). This reverse situation is attributable to deforestation, forest degradation for agriculture, wood exploitation, and energy sources for cooking (MCVDD, 2019).

The objective of this paper is to analyze the choice of cooking fuels (with an emphasis on modern fuels) and the factors that are associated with the adoption of modern cooking fuels in the Republic of Benin, a West African country, using the 2015 Benin Living Standard Measurement Survey (LSMS). Therefore, the specific objectives are: (a) to analyze the adoption rate of different cooking fuels, emphasizing its disaggregation across rural and urban areas; and (b) to identify the factors that are associated with the adoption of modern cooking fuels. The extent to which shocks constitute bottlenecks for the adoption of non-traditional cooking fuels is also analyzed in this paper. To our knowledge, no paper to date has addressed the subject matter in the context of the Republic of Benin. For Rogers (1983), the adoption of a new idea, even when it has obvious advantages, is often difficult, and because of that there is so much interest in the diffusion of innovations. Moreover, technology adoption is context specific. Likewise, for the design and the implementation of effective policies to improve access to clean cooking it is of paramount importance to understand the key determinants of household cooking energy consumption and cooking stoves (Malla & Timilsina, 2014). Furthermore, in many developing economies particularly SSA and South Asia, access to modern energy services remain a key developmental challenge despite several efforts by national governments and development agencies (Mensah & Adu, 2015). Based on the findings, policy implications are drawn to improve the adoption of modern cooking fuels by the households that will contribute to mitigating GHGs and to reduce health problems related to indoor smoke pollution.

The rest of the paper is structured as follows. Section 2 presents the background related to the paper. Social protection policy in the Republic of Benin is presented in Section 3. The materials and the methods are described in Section 4. Section 5 presents the empirical results as well as their discussion. Section 6 concludes and discusses policy implications.

2 | BACKGROUND

There are basically two sources of energy, namely: (a) traditional biomass (fuelwood, charcoal, and crop residue); and (b) modern fuel types (such as LPG and electricity) (Mensah & Adu, 2015; Rahut et al., 2014). The classification may take into account a third source—transitional fuel—composed of kerosene or petrol, coal lignite, and charcoal. In developing countries, households typically face socio-economic, cultural, and environmental challenges in moving toward the use of cleaner sources of energy (Rahut et al., 2014). It is acknowledged in the literature that ICSs have multiple economic, social, environmental, and health benefits (Jan, 2012). Generally, ICSs perform more efficiently than open fire ones in controlled cooking tests or laboratories, but in real field conditions they have a performance level which departs from that observed in laboratory settings (Adrianzén, 2013). This difference in performance may be due to socio-economic factors such as education, preferences, wealth, area of residence (urban versus rural), and so on (Adrianzén, 2013). Moreover, the term "improved" is non-specific as to technology and performance; this term is frequently applied sloppily by promoters to somewhat different devices in different periods and regions (Ruiz-Mercado et al., 2011).

The adoption of cooking technologies and fuels may be analyzed within the framework of the model of diffusion of innovations (Agarwal, 1983; Dearing, 2009). The diffusion of a technology is the process by which it is communicated by the means of certain channels over time among the members of a society (Rogers, 1983). Moreover, Ruiz-Mercado et al. (2011) proposed a framework which considers the adoption of a new cooking device as a dynamic complex process and a stage in a larger process of technology absorption, cultural adaptation and appropriation of the technology. The diffusion of innovation involves a period of time for individual members of society to obtain information on the innovation through different channels, to assess its usefulness, and finally to decide whether to use it or not (Ruiz-Mercado et al., 2011). From the adopters' point of view, the adoption of new cooking stove results in the modification of cooking practices (Ruiz-Mercado et al., 2011), as it implies switching from traditional to modern cooking stoves, or from traditional to modern cooking fuels.

The adoption of cooking technologies and fuels may also be analyzed by referring to the energy-ladder hypothesis which postulates that as long as their income increases, households not only consume more of the same good but they also shift to more sophisticated, higher-quality goods (Ajayi, 2018; Nansaior, Patanothai, Rambo, & Simaraks, 2011; Ngepah, 2011; Rahut et al., 2014). Thus, the energy-ladder hypothesis assumes that as their income (wealth) increases, households shift from traditional cooking stoves (traditional cooking fuels) to ICSs (modern cooking fuels). Therefore, the concept of energy-ladder is used to describe the way in which households are expected to move to more sophisticated fuels with the improvement in their economic status (Hosier & Dowd, 1987). Nevertheless, as their wealth increases, households instead diversify their energy sources; a process of switching to multiple fuels or fuel stacking (Nansaior et al., 2011). In addition, biomass energy use pattern is dynamic, because it depends on factors such as changes in prices and access to other fuel types (Akpalu et al., 2011).

Many papers have analyzed the factors associated with the adoption of ICSs and/or of cooking fuels, especially in developing countries (e.g., Choumert-Nkolo et al., 2019; Jan, 2012; Jeuland et al., 2015; Malla & Timilsina, 2014). The factors hypothesized to be associated with the adoption of ICSs and/or modern cooking fuels, in the economics literature, include socio-economic characteristics (such as age and education of the household head, family size, household income, number of children under 5, access to credit, total landholding, active household members, biomass collection, household uses/own toilet), behavioral and cultural factors (like household preferences, food tastes, cooking practices, and cultural beliefs), and other external factors (such as availability of fuels, physical environmental, and government policies). We assume that shocks may also be associated with the adoption of ICSs and/or modern cooking fuels. Actually, shocks may push households into a poverty trap (Carter & Barrett, 2006), and because of the fact that the economic and poverty status may depend on shocks, these can influence the adoption of modern cooking fuels.

3 | SOCIAL PROTECTION POLICY IN THE REPUBLIC OF BENIN

Social protection had been ineffective in the country until 2013. In 2013, the analysis of the social protection system revealed that the social protection mechanisms put in place had proven to be ineffective (République du Bénin, 2013). First, traditional social protection mechanisms failed to provide adequate protection in a context of modernization, urbanization, and vulnerability to covariant shocks. Indeed, these shocks require more formal and effective mechanisms with the government playing an important role. Second, the modern protection mechanism developed by the

Government appeared to be very limited. In fact, only 6.4% of the economically active population have subscribed to the social security systems. Overall, only 8.4% of the population is covered by health insurance. However, the Government had taken a certain number of measures including free cesarean sections, free care for children under 5, free school fees and the establishment of the universal health insurance plan (Régime d'Assurance Maladie Universelle [RAMU]).

Despite these efforts, a large part of the population remained deprived of access to basic social services, economic opportunities and does not effectively enjoy their economic and social rights. In this regard, the Holistic Social Protection Policy (Politique Holistique de Protection Sociale [PHPS]) has been developed in 2013 and adopted in 2014 with a view to providing an appropriate response to these challenges (Ministère du Plan et du Développement [MPD], 2016; République du Bénin, 2013). This social protection policy is generally oriented toward reducing the vulnerability of the population to economic and social risks. Specifically, the PHPS will intensify measures in favor of the most vulnerable groups, strengthen the social insurance system, and improve the legislative and regulatory framework for social protection in Benin. The priorities of this policy can be summarized as follows: (a) promotion of social transfers; (b) strengthening social action services; (c) consolidation of the legislative and regulatory framework; (d) strengthening of contributory schemes; and (e) the extension of social insurance. It constitutes a set of basic social security guarantees defined at national level which provide protection aimed at preventing or reducing poverty, vulnerability, and social exclusion (MPD, 2016). It is a minimum package of measures to protect and promote the most vulnerable households and people to meet the priority needs identified in the risk and vulnerability profile. Nevertheless, the current government redesigned the RAMU and it became the Insurance for the Strengthening of Human Capital (Assurance pour le Renforcement du Capital Humain [ARCH]).

4 | MATERIALS AND METHODS

4.1 | Model specification

This paper adopts the basic framework for the analysis of discrete choice based on random utility theory, following the existing literature (e.g., Chen, Heerink, & van den Berg, 2006; Karimu, 2015; Mensah & Adu, 2015). Thus, the choice of cooking fuels by households is modeled as a selection among a set of available fuels. Based on the random utility theory, this study assumes that the indirect utility of the household i associated with cooking fuel j (U_j^i) can be expressed as a function of its price (p_j) and non-price attributes (X_j), and household characteristics (Z^i):

$$U_j^i = V^i(p_j, X_j, Z^i) + \mu_j^i \tag{1}$$

where $V^i(.)$ is the deterministic part of the utility function of household i, and μ_j^i is a stochastic disturbance term. A household i aiming to maximize utility, will choose cooking fuel j among the set of K available alternatives, if and only if:

$$U_j^i > U_k^i, j \neq k \tag{2}$$

In this framework, household cooking fuel choice can be conceptualized as a categorical variable (comprising the cooking fuels from among which the households select the main). Therefore, this variable is composed of K categories. Due to the nature of the dependent variable (categorical), a multinomial logit model or a multinomial probit model can be applied (Wooldridge, 2002). However, with the former there is the necessity to test the hypothesis of the Independence of Irrelevant Alternatives (IIA), which states that the relative probabilities of choosing between two alternatives is not affected by the existence of additional alternatives. Nevertheless, this hypothesis is unlikely to hold in the case of cooking fuel choice, as it is very likely that the presence of transition fuels may influence the likelihood of choosing between traditional and modern fuels (Jeuland et al., 2015; Karimu, 2015; Mensah & Adu, 2015). Given that, a multinomial probit is preferred to a multinomial logit as the former relaxes the IIA hypothesis.

To model household fuel choices, two alternatives exist in the literature. The first is to rely on the actual fuels used, and the second is to group them into three categories following the energy-ladder hypothesis, such as traditional fuels, transition fuels, and modern fuels (Choumert-Nkolo et al., 2019; Karimu, 2015). The original dependent variable available in the data set contain many modalities corresponding to the cooking fuels used by the households. These fuels for cooking are: (a) electricity; (b) LPG; (c) natural gas; (d) biogas; (e) kerosene or petrol; (f) coal lignite; (g) charcoal; (h) firewood; (i) straw/branches/herbs; (j) crop residues; (k) animal waste; and (l) others. Therefore, we group these eleven fuel types in three categories, as suggested by the energy-ladder hypothesis. Thus, traditional fuels are composed of firewood, straw/branches/herbs, crop residues, animal waste, and others. Transition fuels include kerosene or petrol, coal lignite, and charcoal, and modern fuels comprise electricity, LPG, natural gas, and biogas.

4.2 | Data and variables

The data source for this paper is the Benin LSMS of 2015 (Enquête Modulaire Intégrée sur les Conditions de Vie des Ménages 2015 [EMICoV-2015]) collected by Benin statistical services (Institut National de la Statistique et de l'Analyse Economique [INSAE]) between March and June 2015. The data set contains information relative to the main cooking fuels used by the households, and the shocks they have faced, which renders possible this research. The original dataset includes 21,402 households grouped into 920 clusters (from the fourth census) across the country. After cleaning (elimination of households with missing data, and those that did not cook any meal), the used database contains 19,705 observations. The dependent variable is the categorical variable capturing the type of fuels used by the households for cooking purposes. In light of the literature on adoption of modern cooking fuels (e.g., Chen et al., 2006; Choumert-Nkolo et al., 2019; Jan, 2012; Jeuland et al., 2015; Malla & Timilsina, 2014; Mensah & Adu, 2015), the independent variables included in the estimations are presented in Table 1. As the data set does not contain prices of cooking fuels, these are not included in the estimations. Nevertheless, a variable capturing per capita income, access to electricity, and department of residence are included in the econometric analyses. The inclusion of department of residence captures within country regional availability of energy sources (Chen et al., 2006).

5 | EMPIRICAL RESULTS AND DISCUSSION

Before presenting the estimation results, summary statistics are presented. Table 2 reports the summary statistics on the adoption of the original fuels as well as of the three categories aforementioned. Traditional fuels were used at the time of the survey by 68.28% of households, with disparities among rural and urban areas. It is observed that 45.52% of the households relied on traditional cooking fuels in urban areas, whereas 89.04% used them in rural areas. Among this category of fuels, firewood was the most used regardless of the area of residence. Transition fuels were used by 27.25% of the household in the country; 46.30% and 9.88% in urban and rural areas, respectively. Thus, transition cooking fuels use is slightly higher than traditional ones in urban areas. The adoption of modern fuels is still low in the country (4.47%). In urban settings, modern cooking fuel adoption rate is about 8.17%, while it amounts to 1.09% in rural areas.

The summary statistics of the explanatory variables used in the estimations are presented in Table 3. A quarter of the households of the sample were headed by females. The average household head age at the time of the survey was 43 years. At least 60% of the household heads did not have any formal education level, and only 5% have university level. Three quarters of the household heads were married or were living together with their partners. The average household size at the time of the interviews was four persons. Formal credit access is low in the country as shown by the access rate of 4%. About one-third of the households had access to electricity. In terms of remittances, 2% of the households of the sample have received, during the 12 months prior to the survey, money from their relatives. The average expenditures per capita amounted to CFA F 301,335.8 (about $509.49), with heterogeneities among households. Households used to face several types of shocks. For instance, 24% of the households reported to have been subject to biophysical shocks (floods, heavy rainfalls, droughts, late onsets, etc.), 19% to economic shocks (rise in prices, joblessness, income reduction, etc.), 13% to social shocks (diseases, accident, death of a household member, etc.), and 1% to other shocks. These statistics show that 52% of the households are from rural settings.

The choice of cooking fuels is estimated as aforementioned using the multinomial probit model, with the reference category being traditional cooking fuels. Table 4 reports the marginal effects (the estimated coefficients are available upon request). The model is overall significant as $Prob > \chi^2 = 0.00$. Shocks are found to be associated with the choice of cooking fuels. Households that have been affected by social shocks are less likely to adopt traditional fuels compared to those that were not subject to any shock. In addition, the likelihood to adopt transition fuels increases with being affected by social shocks. The households that encountered economic shocks are more likely to choose traditional and modern fuels relative to their counterparts that have not been affected by any shock. The findings also indicate that economic shocks decrease the likelihood of adopting transition fuels relative to no shocks. Actually, shocks may push

TABLE 1 Definition of variables

Variables	Description	Unit
Fuels	Cooking fuels types	1 = traditional fuels
		2 = transition fuels
		3 = modern fuels
Sex	Sex of household head	1 = Male and 0 = Female
Education	Education of household head	
None	The household head has no formal education	0 = No and 1 = Yes
Primary	The household head has primary education	0 = No and 1 = Yes
Secondary	The household head has secondary education	0 = No and 1 = Yes
University	The household head has university education	0 = No and 1 = Yes
Household size	Number of individuals in the household	Number of persons
Age	Age of household head	Years
Marital status	Marital status of the household	
Married	Married or living together with partners	0 = No and 1 = Yes
Divorced	Divorced/separated	0 = No and 1 = Yes
Widowed	Widowed	0 = No and 1 = Yes
Single	Never married or never lived with somebody	0 = No and 1 = Yes
Credit	Have obtained credit	0 = No and 1 = Yes
Expenditures	Per capita expenditures	CFA F[a]
Electricity	Access to electricity	0 = No and 1 = Yes
Remittances	Have received remittances during the last 12 months	0 = No and 1 = Yes
Shocks	Types of shocks that affected the household	
Social	Social shocks	0 = No and 1 = Yes
Economic	Economic shocks	0 = No and 1 = Yes
Biophysical	Biophysical shocks	0 = No and 1 = Yes
Others	Other shocks	0 = No and 1 = Yes
None	No shock	0 = No and 1 = Yes
Residence	Area of residence	1 = rural and 0 = urban
Department	Department of residence	
Alibori	The household lives in Alibori	0 = No and 1 = Yes
Atacora	The household lives in Atacora	0 = No and 1 = Yes
Atlantique	The household lives in Atlantique	0 = No and 1 = Yes
Borgou	The household lives in Borgou	0 = No and 1 = Yes
Collines	The household lives in Collines	0 = No and 1 = Yes
Couffo	The household lives in Couffo	0 = No and 1 = Yes
Donga	The household lives in Donga	0 = No and 1 = Yes
Littoral	The household lives in Littoral	0 = No and 1 = Yes
Mono	The household lives in Mono	0 = No and 1 = Yes
Oueme	The household lives in Oueme	0 = No and 1 = Yes

TABLE 1 (Continued)

Variables	Description	Unit
Plateau	The household lives in Plateau	0 = No and 1 = Yes
Zou	The household lives in Zou	0 = No and 1 = Yes

[a]The currency of the West African Economic and Monetary Union. On average, $1 = CFA F 591.45 in 2015.

TABLE 2 Cooking fuels used by the households

	Percent		
Cooking fuels	**Urban**	**Rural**	**Total**
Modern fuels	8.17	1.09	4.47
Electricity	0.16	0.04	0.10
LPG	4.78	0.88	2.74
Natural gas	2.57	0.16	1.31
Biogas	0.66	0.01	0.32
Transition fuels	46.30	9.88	27.25
Kerosene or petrol	0.54	0.13	0.32
Coal lignite	0.37	0.12	0.24
Charcoal	45.39	9.63	26.69
Traditional fuels	45.52	89.04	68.28
Firewood	44.77	86.12	66.39
Straw/branches/herbs	0.24	1.63	0.97
Crop residues	0.14	1.21	0.70
Animal waste	0.02	0.05	0.04
Others	0.35	0.03	0.18
Total	100	100	100

households into a poverty trap (Carter & Barrett, 2006), and prevent them from relying on transition and modern fuels. Therefore, mitigating the effect of shocks on livelihoods should be beneficial for the adoption of non-traditional cooking fuels, ceteris paribus.

The odds of choosing particular cooking fuels is significantly associated with the gender of the household heads. Female-headed households are less likely to choose traditional fuels relative to their male-headed counterparts and they are more likely to choose transition and modern fuels compared to the male-headed households. These findings suggest that females are more aware than males about the need to give up traditional cooking fuels. As women are most of the time responsible for cooking, when they have the lead in the households, they shift from traditional to transition and/or to modern fuels. The results are consistent with those of Rahut et al. (2014), Karimu (2015), and Mensah and Adu (2015). Formal education level of the household head appears to be important in the choice of cooking fuels. The econometric findings indicate that households whose heads have at least primary education level are less likely to opt for traditional fuels. Having a household head with at least primary education level favors the choice of transition cooking fuels relative to being headed by someone with no formal education level. As for modern cooking fuels, the choice is positively influenced by having a household head with a least secondary education level compared to being headed by someone with no formal education level, whereas primary education level is negatively associated with the adoption of modern fuels. Thus, formal education is of paramount importance in adopting transition and modern cooking fuels, and these findings are in line with those found in the literature (e.g., Jeuland et al., 2015; Karimu, 2015; Mensah & Adu, 2015). So, formal education enables the population to raise their awareness on the negative effects of traditional cooking fuels on health.

TABLE 3 Summary statistics of the explanatory variables

Variables	Average/proportion	Std. dev.	Minimum	Maximum
Sex (Female)	0.25	0.43	0	1
Education				
None	0.61	0.49	0	1
Primary	0.17	0.38	0	1
Secondary	0.17	0.38	0	1
University	0.05	0.21	0	1
Household size	4.48	2.65	1	35
Age	43.28	14.97	14	98
Marital status				
Married or living together	0.75	0.43	0	1
Divorced/separated	0.08	0.27	0	1
Widowed	0.11	0.31	0	1
Never being married or never lived with somebody	0.06	0.24	0	1
Credit	0.04	0.19	0	1
Expenditures	301,335.8	396,694.4	3,500	6,841,761
Remittances	0.02	0.15	0	1
Electricity	0.32	0.47	0	1
Shocks				
Social shocks	0.13	0.33	0	1
Economic shocks	0.19	0.39	0	1
Biophysical shocks	0.24	0.43	0	1
Other shocks	0.01	0.09	0	1
None	0.44	0.50	0	1
Residence (rural)	0.52	0.50	0	1
Department				
Alibori	0.07	0.25	0	1
Atacora	0.10	0.30	0	1
Atlantique	0.08	0.27	0	1
Borgou	0.11	0.31	0	1
Collines	0.07	0.25	0	1
Couffo	0.07	0.26	0	1
Donga	0.05	0.22	0	1
Littoral	0.09	0.29	0	1
Mono	0.07	0.26	0	1
Oueme	0.12	0.33	0	1
Plateau	0.06	0.24	0	1
Zou	0.11	0.31	0	1

TABLE 4 Marginal effects for the choice of traditional, transition, and modern fuels

	Traditional fuels	Transition fuels	Modern fuels
Sex (Female)	−0.03***	0.02***	3.26e−03*
	(0.01)	(0.01)	(3.20e−03)
Education (Reference: None)			
Primary	−0.10***	0.10***	−8.44e−03***
	(0.01)	(0.01)	(2.84e−03)
Secondary	−0.16***	0.13***	0.03***
	(0.01)	(0.01)	(3.67e−03)
University	−0.26***	0.10***	0.16***
	(0.02)	(0.02)	(0.01)
Household size	0.01***	−0.01***	8.97e−04
	(1.11e−03)	(1.19e−03)	(6.02e−04)
Age	1.71e−04	−1.78e−04	−1.53e−04
	(1.68e−04)	(1.82e−04)	(1.06e−04)
Marital status (Reference: Married or living together)			
Divorced/separated	−0.01	0.01	−1.10e−03
	(0.01)	(0.01)	(4.36e−03)
Widowed	7.61e−04	4.92e−04	−1.25e−03
	(7.99e−03)	(8.53e−03)	(4.58e−03)
Never being married or never lived with somebody	−0.02**	0.01	0.01
	(0.01)	(0.01)	(0.01)
Credit	−0.02**	0.02*	2.51e−03
	(0.01)	(0.01)	(6.25e−03)
Expenditures	−4.97e−08***	2.06e−08**	2.91e−08***
	(9.16e−09)	(8.62e−09)	(2.41e−09)
Remittances	−0.02	−0.02	0.03***
	(0.02)	(0.02)	(0.01)
Electricity	−0.19***	0.17***	0.02***
	(4.40e−03)	(5.13e−03)	(2.67e−03)
Shocks (Reference: None)			
Social shocks	−0.02***	0.02***	3.92e−03
	(0.01)	(0.01)	(4.59e−03)
Economic shocks	0.02***	−0.04***	0.01**
	(0.01)	(0.01)	(5.68e−03)
Biophysical shocks	0.01	−0.01	1.75e−05
	(0.02)	(0.02)	(0.01)
Other shocks	−0.01	0.01	6.81e−04
	(0.01)	(0.01)	(4.26e−03)
Residence (rural)	0.11***	−0.13***	0.01
	(5.88e−03)	(6.48e−03)	(4.09e−03)

(Continues)

TABLE 4 (Continued)

	Traditional fuels	Transition fuels	Modern fuels
Department (Reference: Littoral)			
Alibori	0.40***	−0.32***	−0.08***
	(0.02)	(0.02)	(0.01)
Atacora	0.39***	−0.30***	−0.09***
	(0.02)	(0.02)	(0.01)
Atlantique	0.25***	−0.16***	−0.09***
	(0.02)	(0.02)	(0.01)
Borgou	0.37***	−0.26***	−0.11***
	(0.02)	(0.02)	(0.01)
Collines	0.31***	−0.21***	−0.11***
	(0.02)	(0.02)	(0.01)
Couffo	0.48***	−0.37***	−0.11***
	(0.02)	(0.02)	(0.01)
Donga	0.34***	−0.24***	−0.11***
	(0.02)	(0.02)	(0.01)
Mono	0.39***	−0.28***	−0.11***
	(0.02)	(0.02)	(0.01)
Oueme	0.21***	−0.12***	−0.09***
	(0.02)	(0.02)	(0.01)
Plateau	0.38***	−0.27***	−0.11***
	(0.02)	(0.02)	(0.01)
Zou	0.30***	−0.20***	−0.11***
	(0.02)	(0.02)	(0.01)
Observations	19,705		

Note: Standard errors are in parentheses. The marginal effects are obtained after estimating a multinomial probit model.
*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

The marital status of the household head is to some extent associated with cooking fuel choice. Actually, the econometric analyses reveal that single household heads have less likelihood to choose traditional fuels compared to their counterparts that are married or live together with their partners. The probability of choosing traditional cooking fuels increases with household size. However, the likelihood of choosing transition fuels decreases with the size of the household. This finding is to some extent in line with that of Mensah and Adu (2015). This suggests that large families are more likely to adopt traditional fuels, and less likely to take on transition fuels, as they have more mouths to feed, so they cannot afford the cost of transition fuels.

Access to credit is related to the adoption of cooking fuels. Indeed, the probability of adopting traditional fuels decreases with access to formal credit, while that of transition fuels increases with this access. The households that have received remittances are more likely to choose modern cooking fuels relative to their counterparts that did not. Moreover, the likelihood to choose cooking fuels is affected by access to electricity. Actually, the findings indicate that households with access to electricity are less likely to adopt traditional cooking fuels compared to their counterparts without access to electricity. Conversely, households that have access to electricity are more likely to choose transition and modern cooking fuels relative to those that do not have access to it. This suggests that access to electricity increases the odds of adopting transition and modern cooking fuels to the detriment of traditional fuels. Therefore, well-developed infrastructures enable households to use transition and modern cooking fuels as found by Karimu (2015). Wealth is associated to the adoption of cooking fuels. Indeed, the probability of choosing traditional fuels decreases with per capita expenditures, used as a proxy of per capita income. However, the likelihood of adopting transition and modern cooking fuels increases with per capita expenditures (the marginal effect of transition fuels is greater than that of modern fuels). Thus, traditional fuels constitute inferior goods for the households, while transition and modern fuels are normal goods. This finding is not in line with that of Karimu (2015) regarding transition fuels. For instance, Karimu (2015) found that income increases the probability of adopting modern fuels, and decreases that for transition and solid fuels. Therefore, poverty reduction strategies will in this case be beneficial to the adoption of transition and modern cooking fuels. However, the finding is in line with Choumert-Nkolo et al. (2019). This result suggests that cooking fuel use decisions of Beninese households conform partially with the transition from traditional to modern fuels as income increases. This transition is mostly characterized by a move away from the use of traditional fuels toward transition fuels.

Geographical location is also found to be associated to cooking fuel choices. Indeed, households living in rural areas are found to be more likely to choose traditional fuels compared to those from urban areas. Conversely, rural households are less likely to adopt transition cooking fuels relative to urban households. These results are consistent with those of Mensah and Adu (2015), and point out what is already observed from the summary statistics. In rural areas, it is easy to find traditional fuel compared with urban areas. The findings indicate also that the adoption of cooking fuels depends on the departments. Households living in the 11 other departments are more likely to adopt traditional fuels compared with those from the Littoral department (the Littoral department encompasses the main city of the country, which is Cotonou). Moreover, households from the Littoral department are more likely to choose transition and modern cooking fuels compared to those living in the 11 other departments. Therefore, the adoption of cooking fuels is associated to regional availability of the fuels.

6 | CONCLUSION AND POLICY IMPLICATIONS

This paper analyzes household choice of cooking fuels (traditional, transition, and modern) and the factors associated with the adoption of modern cooking fuels in the Republic of Benin. Actually, one of the most urgent problems in the developing world is cooking with traditional fuels (firewood and other biomass fuels) leading to serious health problems, especially for women and children who have the most frequent exposure (Khandelwal et al., 2017). To achieve this goal, this paper exploits data from a nationwide survey, the Benin 2015 LSMS. The findings reveal that the main cooking fuels used are traditional in general, and especially firewood (68.28%), followed by transition fuels (27.25%), and modern fuels (4.47%). Moreover, the findings depict disparities across rural and urban areas. In urban areas, the adoption rates of traditional, transition, and modern fuels amount to 45.52%, 46.30%, and 8.17%, respectively, whereas they are about 89.04%, 9.88%, and 1.09%, respectively, in rural areas. The estimation results indicate that having a female household head, having a household head with at least secondary education level, per capita expenditures, remittances, access to electricity, and economic shocks constitute catalysts in the adoption of modern cooking fuels, while having a household head with primary education level, and not living in the Littoral department hinder their adoption. As for transition cooking fuels, their choices are positively associated with having a female head, formal education level of the household head, access to formal credit, per capita expenditures, access to electricity, and social shocks. However, the adoption of transition cooking fuels are hindered by household size, economic shocks, living in rural areas, and not living in the Littoral department. Furthermore, the results show that factors such as household size, economic shocks, living in rural areas, and not living in the Littoral department are positively associated with the use of traditional cooking fuels. Nonetheless, traditional fuels use are found to be hindered by being headed by a female, having a household with at least primary education level, having a single as household head, access to formal credit, per capita expenditures, access to electricity, and social shocks. These findings point to the fact that improving access to electricity and increase in incomes are insufficient conditions for a transition toward modern cooking fuels, as in the case of Choumert-Nkolo et al. (2019).

To improve the use of modern cooking fuels, policies must target male-headed households to sensitize them on the need to give up traditional fuels to preserve the environment and to avoid health-related problems. As wealth is beneficial for the adoption of transition and modern fuels, and detrimental for traditional fuels, the promotion of modern fuels may pass through subsidies (of LPG, natural gas, and biogas prices) in the short and medium runs.

Moreover, poverty reduction intensification and effective social protection will be beneficial to the adoption of modern cooking fuels. Furthermore, policy can target reducing the vulnerability and building the resilience of households to shocks, as shocks constitute in some extent bottlenecks for the adoption of transition cooking fuels. Improving access to formal education, and to electricity should also be reinforced. Given that cooking fuel prices are not included in the analyses due to their unavailability, future research should take them into account to shed light on the link between them and use of modern cooking fuels.

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REFERENCES

Adrianzén, M. A. (2013). Improved cooking stoves and firewood consumption: Quasi-experimental evidence from the Northern Peruvian Andes. *Ecological Economics*, *89*, 135–143.

Agarwal, B. (1983). Diffusion of rural innovations: Some analytical issues and the case of wood-burning stoves. *World Development*, *11*(4), 359–376.

Ajayi, I. P. (2018). Urban household energy demand in Southwest Nigeria. *African Development Review*, *30*(4), 410–422.

Akinyemi, O., Efobi, U., Osabuohien, E., & Alege, P. (2019). Regional integration and energy sustainability in Africa: Exploring the challenges and prospects for ECOWAS. *African Development Review*, *31*(4), 517–528.

Akouehou, G. S., Segnon, A., Duclos, L., Hounsounou, L. C., Goussanou, C. A., Gbozo, E., & Mensah, A. G. (2012). *Fiche technique: Foyers améliorés recommandés pour des usages domestiques de bois au Bénin*. Cotonou: Projet d'Appui aux Marchés Ruraux de Bois (PAMRB).

Akpalu, W., Dasmani, I., & Aglobitse, P. B. (2011). Demand for cooking fuels in a developing country: To what extent do taste and preferences matter? *Energy Policy*, *39*, 6525–6531.

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

Carter, R. M., & Barrett, B. C. (2006). The economics of poverty traps and persistent poverty: An asset-based approach. *The Journal of Development Studies*, *42*(2), 178–199.

Chen, L., Heerink, N., & van den Berg, M. (2006). Energy consumption in rural China: A household model for three villages in Jiangxi Province. *Ecological Economics*, *58*, 407–420.

Choumert-Nkolo, J., Motel, P. C., & Le Roux, L. (2019). Stacking up the ladder: A panel data analysis of Tanzanian household energy choices. *World Development*, *115*, 222–235.

Dearing, J. W. (2009). Applying diffusion of innovation theory to intervention development. *Research on Social Work Practice*, *19*(5), 503–518.

DGFRN. (2014). *Stratégie Nationale et plan d'actions de valorisation des Produits Forestiers Non Ligneux (PFNL) prioritaires du Bénin: cas des fruitiers sauvages*. Cotonou: Projet d'Appui à la Promotion des Produits Forestiers Non Ligneux (PAP-PFNL), DGFRN/MECGCCRPRNF.

FAO (Food and Agriculture Organization). (2010). Evaluation des ressources forestières mondiales 2010*:* Rapport national Bénin. Rome: Author.

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis. *Resources and Energy*, *9*(4), 347–361.

International Energy Agency (IEA). (2015). *Energy and climate change: World energy outlook special report*. Paris: Author.

Jan, I. (2012). What makes people adopt improved cookstoves? Empirical evidence from rural northwest Pakistan. *Renewable and Sustainable Energy Reviews*, *16*(5), 3200–3205.

Jebli, B. M., Youssef, B. S., & Ozturk, I. (2015). The role of renewable energy consumption and trade: Environmental Kuznets curve analysis for Sub-Saharan Africa countries. *African Development Review*, *27*(3), 288–300.

Jeuland, M. A., Bhojvaid, V., Kar, A., Lewis, J. J., Patange, O., Pattanayak, S. K., Ramanathan, N., & Ramanathan, V. (2015). Preferences for improved cook stoves: Evidence from rural villages in north India. *Energy Economics*, *52*, 287–298.

Karimu, A. (2015). Cooking fuel preferences among Ghanaian households: An empirical analysis. *Energy for Sustainable Development*, *27*, 10–17.

Khandelwal, M., Hill, M. E., Jr., Greenough, P., Anthony, J., Quill, M., Linderman, M., & Udaykumar, H. S. (2017). Why have improved cook-stove initiatives in India failed? *World Development*, *92*, 13–27.

Lufumpa, L. C. (2005). The poverty-environment nexus in Africa. *African Development Review*, *17*(3), 366–381.

Malla, S., & Timilsina, G. R. (2014). *Household cooking fuel choice and adoption of improved cookstoves in developing countries*. Washington, DC: The World Bank.

MCVDD. (2019). *Troisième Communication Nationale du Bénin à la Convention Cadre des Nations Unies sur les Changements Climatiques*. Cotonou.

Mensah, J. T., & Adu, G. (2015). An empirical analysis of household energy choice in Ghana. *Renewable and Sustainable Energy Reviews*, *51*, 1402–1411.

Ministère du Plan et du Développement (MPD). (2016). *Plan d'Action de la Politique Holistique de Protection Sociale 2014-2018*. Cotonou: Author.

Nansaior, A., Patanothai, A., Rambo, T. A., & Simaraks, S. (2011). Climbing the energy ladder or diversifying energy sources? The continuing importance of household use of biomass energy in urbanizing communities in Northeast Thailand. *Biomass and Bioenergy*, *35*, 4180–4188.

Ngepah, N. (2011). Exploring the impact of energy sources on production, inequality and poverty in simultaneous equations models for South Africa. *African Development Review*, *23*(3), 335–351.

Rahut, D. B., Das, S., De Groote, H., & Behera, B. (2014). Determinants of household energy use in Bhutan. *Energy*, *69*, 661–672.

Ramanathan, V., & Carmichael, G. (2008). Global and regional climate changes due to black carbon. *Nature Geoscience*, *1*, 221–227.

Rogers, E. M. (1983). Diffusion of innovations (3rd ed.). New York: The Free Press.

Ruiz-Mercado, I., Masera, O., Zamora, H., & Smith, K. R. (2011). Adoption and sustained use of improved cookstoves. *Energy Policy*, *39*, 7557–7566.

République du Bénin. (2013). *Politique Holistique de Protection Sociale au Bénin*. Cotonou: Author.

World Health Organization (WHO). (2018). *Burden of disease from household air pollution for 2016*. Geneva: Author.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. Cambridge: The MIT Press.

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