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Women's Empowerment in Households and the Use of Cleaner Cooking Fuel in Ghana

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Abstract

The study explores the effect of women's empowerment on the use of cleaner cooking fuel in Ghana. Utilising data from the Ghana Living Standards Surveys administered in the years 1998/99, 2005/06, 2012/13 and 2016/17, and employing the ordered probit, OLS and 2SLS-IV regressions, the study finds that households managed by female are more likely to use cleaner types of cooking fuel than male-headed households. Within the sub-sample of female-headed households, both *de jure* (absolute controlled) and *de facto* (partial controlled) female-headed households are more likely to use cleaner types of cooking fuel than their male-headed counterparts. An analysis on household expenditure, reveals that female-headed households prioritise household cooking fuel and food expenditure over expenditure on non-essential (such as alcohol, tobacco, and narcotics), compared to male-headed households. In addition, the level of female empowerment in household matters on how resources are allocated across different types of consumption. Avoiding expenditures on non-essentials (alcohol, tobacco, and narcotics) seems to help in the adoption of cleaner cooking fuel in female-headed households.

Keywords: Women's Empowerment, cleaner cooking fuel, Household Head, Developing countries

JEL: D1, J16, O13

1. Introduction

Women's empowerment is a multifaceted concept, where women are regarded active subjects and agents of social change, rather than passive objects (Chaudhary et al., 2012). A major component of empowering women is their increased involvement in decision-making. In a household setting, the concept of empowerment is to rectify the power imbalance between men

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and women which potentially may improve household welfare. Female headship in household, can be viewed as an indicator of women's empowerment as it increases their decision-making power. Previous literature has highlighted the importance of female headship in households in the improvement of the general welfare of the household (see Guyer, 1980; Blumberg, 1988; Kennedy and Peters, 1992; Duflo and Udry, 2004; Malhotra and Schuler, 2005). In particular, the effect of female household headship on income, food security, and nutrition is evident in various existing studies (see Kennedy and Peters, 1992; Ozawa and Lee, 2006; Mallick and Rafi, 2010; Felker-Kantor and Wood, 2012; Sharaunga Mudhara and Bogale, 2016). However, the effect of female headship on household energy poverty has been given limited empirical attention. Empowering women and eliminating energy poverty are a crucial concern of the Sustainable Development Goals (SDGs) of the United Nations; understanding how women's empowerment influence energy poverty in households is vital to inform policy.

In a developing country context, energy poverty is defined as the lack of access to modern energy services, namely electricity and clean fuels for cooking (International Energy Agency, 2010). It follows the energy ladder hypothesis, households that use advanced forms of cooking fuels (eg. electricity and gas) are said to be energy rich followed by those that use transition fuels (eg. charcoal), and those that use primitive fuels (eg. firewood) are said to be energy poorer households. Almost half of the world's population, including 700 million Africans rely on biomass fuels for cooking. Biomass fuels are typically burned in open fires, often indoors, leading to high levels of household air pollution from smoke. Women and children experience high exposures to smoke in and around the home due to gender-based domestic roles and these exposures have been linked to a range of adverse health outcomes (Gordon, Bruce & Grigg, 2014; WHO, 2014). It might be, expected that, when women are active subjects in decision-making in households, they are more likely to adopt cleaner forms of fuel, thus reducing energy poverty. Not least because women are often more likely to adopt healthier lifestyles than men (Mencher, 1988; Duflo and Udry; 2004).

Despite these important discussions, the literature on how female headship in households influences energy poverty is limited. Although, the gender of household head is commonly used as a control variable in studies examining energy poverty (eg. Dongzagla and Adams, 2022), it is rarely the main focus as a determinant. Some notable exceptions are studies that specifically

addressed the impact of women decision-making within households on the adoption of improved cookstoves, utilising survey data of small groups of people in Ethiopia and Bangladesh (Alem, Hassen and Köhlin 2023; Miller and Mobarak 2013). Compelling empirical evidence is crucial for policymakers to develop targeted interventions aimed at reducing or eliminating energy poverty. This study investigates whether female empowerment within households affects the adoption of cleaner main cooking fuels. It further examines the impact of female empowerment on household expenditures for cooking fuel and food, as well as on non-essential expenditures, using micro-level data, stacked cross-sectional data from four (4) rounds of the Ghana Living Standard Survey (GLSS) administered in the years 1998/99, 2005/06, 2012/13 and 2016/17. In particular, this study investigates whether female-headed households adopt cleaner main cooking fuel compared to their counterpart male-headed households. Identifying the impact of women's empowerment on the adoption of cleaner main cooking fuel from other factors in this type of data is clearly challenging. To do this we consider different dimensions available in the data. In this study, we distinguish between male-headed households, de jure female-headed households, and de facto female-headed households. Women, apart from being legal heads of the household as a result of being single, divorced or widowed (*de jure* heads), often also oversee household decisions in the absence of the man (*de facto* heads). In this case, their decision-making is not entirely autonomous, as it may still be influenced by the husband or the husband's male family members in the house. Previous studies found that although *de jure* female-headed households are more likely to be poorer, they have similar physical assets with full control over them, thus enabling them to make autonomous decisions as their male-headed counterparts. In terms of agricultural production, they achieve similar levels of crop diversification compared to male-headed households (Horrell and Krishnan, 2007). Here we make a distinction between male-headed, partially female-headed (*de facto*) and fully female-headed (*de jure*) households to help identify the impact of women's level of empowerment on the adoption of cleaner forms of cooking fuel.

Female-headed households, according to Rosenhouse (1989), are generally poorer and have less access to credit, and as such less able to smoothen consumption over their lifetime relative to male-headed households. However, previous literature has established that they have positive household management behaviours when they have control over household resources e.g. in terms of food consumption and avoiding expenditure on non-essential items (Mencher, 1988;

Peters and Herrera, 1989; Duflo and Udry, 2004). There are therefore good reasons to expect the adoption of cleaner forms of main cooking fuel in their households despite their lower level of income. Mencher (1988) noted that in absolute terms, the amount of money devoted in male-headed households on sustenance is often greater than that in female-headed households, but in relative terms, as a proportion of income, it is lower than that in female-headed households. Further, Peters and Herrera (1989); Mencher (1988); Duflo and Udry (2004) indicated that, although most female-headed households allocate a larger share of their budgets to food, they spend less on alcoholic beverages than do male-headed households, suggesting better outcomes for all household members in terms of nutrition and health in female-headed households. In light of female heads' expenditure prioritisation, female-headed households are expected to favour the adoption of cleaner forms of cooking fuel when given decision making power in households. To support the hypothesis that female headed households behave differently, we investigate the effect female empowerment in households has on household expenditure on cooking fuel, food and on items that are non-essential to the household sustenance (alcohol, tobacco, and narcotics[2]). Expenditure on non-essential items may restrict a household's capacity to afford and utilize cleaner cooking fuels. Consequently, we explore whether reducing expenditures on non-essential items can facilitate the adoption of cleaner cooking fuels in female-headed households.

After controlling for household and individual characteristics, we found that female-headed households are more likely to use cleaner forms of cooking fuel, such as electricity or gas, compared to male-controlled counterparts. Within the sub-sample of female-headed households, the same patterns are estimated both in *de jure* (absolute controlled) and *de facto* (partial controlled) female-headed households. The analysis on household expenditure offers some insights that may help us explain these findings. Particularly, female-managed households are found to prioritise household cooking fuel and food expenditures over non-essential (alcohol, tobacco, and narcotics) expenditure compared to male-headed households. Moreover, *de jure* female heads allocate even fewer resources to non-essential expenses in comparison to their *de facto* counterparts. This likely stems from the absolute control that *de jure* female heads exert over their households and the management of household resources, in contrast to *de facto* female heads.

[2] The available indicators of household non-essential expenditure in the data.

The results suggest that female-headed households allocate higher budget share for cooking fuel and food than male-headed households, while male-headed households tend to allocate higher budget share for non-essential items than their female-headed counterparts. The results also suggest that avoiding expenditures on non-essential items helps in the adoption of cleaner cooking fuel in female-headed households. Specifically, female-controlled households who spend less on non-essential items tend to use cleaner cooking fuel in their households.

The remainder of the paper is structured as follows: Section 2 provides a literature review on women's headship in households, the energy ladder and gender differences in expenditure preferences, along with a review of relevant existing evidence. Section 3 discusses the methodology used in this study, including the model and estimation strategies, the data and measurement of variables. This section also includes a summary and descriptive analysis of the data. Section 4 presents the results and analysis of the study. Finally, Section 5 offers conclusions and recommendations.

2. Overview of the Literature

2.1 Women's Empowerment in Households

Women's empowerment involves transforming women from passive objects to active subjects in decision-making processes (Chaudhary, Chani and Pervaiz, 2012). Within the household context, women typically acquire the authority to oversee household decisions upon assuming the role of head of the household. Previous household studies frequently categorise households based on the gender of the head (i.e., male- and female-headed households) to assess the effect of women's decision-making power on various outcome variables. For example, Sharaunga Mudhara and Bogale (2016) try to identify the food security status of 300 primary female-headed households in Msinga, South Africa using the Household Food Insecurity Access Scale (HFIAS). They find that female-headed households with higher levels of economic agency, physical capital empowerment, psychological empowerment and farm financial management skills empowerment were more likely to be food secure. However, in Bangladesh, Mallick and Rafi (2010) find no significant differences in the food security between male- and female-headed households. Duflo and Udry (2004) find in Ivory coast that rainfall shocks associated with high yields of women's crops shift expenditure towards food. In rural Zimbabwe, Horrell and Krishnan (2007) find female-headed households' productivity to be lower only for growing

cotton than male-headed households. Using data from Malawi and Kenya, Kennedy and Peters (1992) find that food security and preschooler good nutritional status are influenced by the interaction of income and the proportion of income controlled by women rather than simply one or the other. On the contrary, Felker-Kantor and Wood (2012) in Brazil find food insecurity to be higher among female-headed households compared to male-headed households, but the presence of adult females to reduces food insecurity. Recently in Ghana, using the seventh round of the Ghana Living Standard Survey (GLSS 7), Essilfie et al (2021) find that women's decision-making were important indicators for improving household food security.

Additionally, female-headed households are further divided into two subgroups, *de jure* and *de facto* female-headed households. *De jure* female-headed households are those where a woman is recognized both legally and customarily as the head of the household. In Ghana, *de jure* households typically include unmarried women and those who are either divorced, separated or widowed. Women in *de jure* households generally have absolute control over the household's income and assets. *De facto* female-headed households are characterised by the temporary absence of an adult male, making a woman the acting head of household. In these households, the absent husbands or other male relatives often still influence basic decision-making and make varying contributions to household incomes. As a result, the female head often does not have complete control of income and assets in the household. This distinction is mirrored in studies from other countries. For example, Kennedy and Peters, 1992 found in both Malawi and Kenya that, *de facto* female-headed (partial female control) households had the lowest income but despite that, preschoolers' nutritional status was significantly better than in the higher income male-headed and *de jure* female-headed (full female control) households.

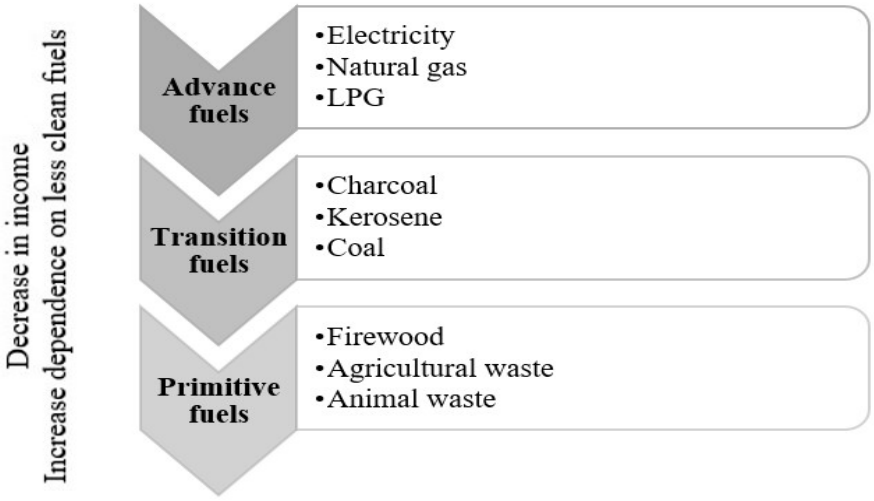
2.2 The Energy Ladder and Differences in Expenditure Among Male and Female Heads

The concept of the energy ladder points out the differences in energy-use patterns between households with different economic status. The energy ladder hypothesis is based on the economic theory of consumer behavior, using more of a particular fuel as income increase (Hosier and Kipondya, 1993). However, households do not only consume more of the same fuel as income increases but they also shift to higher quality and efficiency fuel. The energy ladder hypothesis is underpinned by the assumption that a low standard of living makes households more dependent on biomass fuels (Baland, Bardhan, Das, Mookherjee, Sarkar, 2007). Unlike in

developed countries where energy poverty tends to be defined as when households are unable to provide sufficient heat to their homes (Hills, 2012; Phimister, Vera-Toscano and Roberts, 2015), the concept and its measurement in developing countries is based on the energy ladder hypothesis, households are energy poor if they are unable to use cleaner cooking fuels in their homes. Households that use advanced forms of fuel are said to be energy rich, while those in the transition fuel category are energy poor and those that use primitive fuels are the energy poorer households.

In the energy ladder hypothesis, emphasis is put on the role of income in the determination of fuel use as can be seen in Figure 1 below, movement downwards the ladder is associated with decreasing income.

Figure 1: The energy ladder



Mekonnen and Köhlin (2009) argued that, as households' income increases, their demand for fuel is influenced by the type of appliances they use, and that fuel choice depends on the purpose for which energy is required. They further argued that, in developing countries, households do not change to modern energy sources, instead, they tend to combine fuels as sources of energy. This may include a combination of solid fuels with non-solid fuels. Thus, instead of a step by step move up the ladder as income increases, they choose different fuels available on the menu. Households may choose to combine high-cost and low-cost fuels, depending on their budgets, needs and preferences (World Bank, 2003). This points out the idea of fuel stacking or multiple fuel use as against the energy ladder (fuel switching) (Masera, Saatkamp and Kammen, 2000;

Heltberg, 2005). Therefore, where there is information on household multiple fuel use, composite indices are also used to measure energy poverty.

While the energy ladder model emphasises income as a crucial determinant of household adoption of cleaner cooking fuels, research indicates that the extent of income controlled by women also plays a significant role in this decision, an effect that extends beyond mere income levels (Israel, 2002). Studies highlight notable differences in how male and female heads allocate their earnings, with women typically investing a larger portion of their income into household essentials such as food and fuel (Blumberg, 1988; Kennedy and Peters, 1992).

Mencher (1988) points out that while the absolute amounts contributed by males for household sustenance may sometimes exceed those of females, the proportion of their income dedicated to these needs is consistently lower compared to that of females. Moreover, women are found to spend over 74% of their cash income on enhancing the family's food supply and meeting other household needs, including cooking fuel (Guyer, 1980; Mencher, 1988). Peters and Herrera (1989) observed that in Malawi, most female-headed households allocated a larger share of their budgets to food and spent 25-50% less on alcoholic beverages compared to male-headed households. Even among higher-income female-headed households, a proportionately smaller amount is spent on alcoholic beverages, and overall budget allocations tend to mirror those of male-headed households more closely.

Mencher (1988) also noted that men often reserve a portion of their income for leisure and "status production" activities, such as socialising with friends over food and drinks. Male-headed households also tend to spend a higher proportion of their incomes on other productive assets, such as inputs into cash crop production, including land, hired labor and fertilizers (Kennedy and Peters, 1992). As a result, in male-headed households, the budget for acquiring cleaner and more costly cooking fuels may be constrained by competing demands for leisure and non-essential expenditures (such as alcohol) as well as investments in productive resources like land and hired labour. Thereby potentially undermining investment in such essential household improvements, including the adoption of cleaner cooking technologies.

There is also country-level empirical evidence on the role of gender in energy poverty. The study of Sehjpal, Ramji, Soni and Kumar (2014) find in rural India that as women attain more formal employment, the chances of selecting cleaner fuels significantly increase. As well, sociocultural

factors might play a bigger role in the determination of household energy choices aside from income. Further, access to electricity would positively impact energy choices for cooking only after a minimum threshold requirement has been met. Still in India, Malakar, Greig and van de Fliert (2018) emphasized on the role of gender norms on energy-use. They found that using solid fuel for cooking is entangled with structural elements, like practices of traditional income generating, well-known traditions, a sense of belonging and gender norms. Johnson, Gerber and Muhoza (2019) found in rural northern Zambia that a shift to more modern energy services is not gender neutral. Thus, in spite of its community-wide benefits, there was unevenly distributed benefits of a new technology and service between women and men as a result of wider socio-cultural norms and practices. In a field experiment conducted in Bangladesh, Miller and Mobarak (2013) find that women who bear disproportionate cooking costs have stronger preference for health-saving improved stoves. In another experiment in Ethiopia, Alem, Hassen and Köhlin (2023) find that wives, who are responsible for fuelwood collection and cooking are 57% more willing to pay for improved cooking stoves than husbands and 39% more than couples. Also, wives who made the stove purchase decision alone using their own income are 67% willing to pay more than husbands who made the purchase decision alone.

In conclusion, the existing literature does not firmly establish a definitive role of gender in the determinants of energy poverty. However, there is suggestive evidence of a potential link between women's empowerment and reduced energy poverty, primarily through the enhanced household welfare associated with women's control over resources, which includes the use of cleaner cooking fuels. This study primarily focuses on addressing the knowledge gap concerning the impact of women's empowerment on energy poverty, specifically through its influence on the adoption of cleaner main cooking fuels.

3. Methodology

3.1 Main Framework

To fill the gap identified in the above literature, this study aims to investigate whether households managed by females adopt cleaner main cooking fuel compared to their male-headed counterparts in Ghana, focusing on, (i) the aggregate distinction between female- and male-headed households, and (ii) a more detailed decomposition between *de jure* female- and *de facto*

female-headed households and male-headed households. For this, we estimate the following empirical model:

$$fuel_{i,t} = \beta_1 + \beta_2 gendered\_head_{i,t} + \sum_{j=3}^{k} \beta_j X_{ij} + \delta_t + \lambda_{it} \qquad (1)$$

where $fuel_{i,t}$ is an ordered categorical variable (1=firewood, 2=charcoal, 3=electricity/gas) which measures energy poverty of household i in survey round t. $gendered\_head_{i,t}$ is the gender of the head in household i in survey round t and is represented by either aggregating female heads ($femhead_{i,t}$) or distinguishing between *de facto* female heads ($defactofemale_{i,t}$) and *de jure* female heads ($dejurefemhead_{i,t}$). The variable X_{ij} represent a set of controls for characteristics of household heads and household characteristics, including household income and location, the head's age, education level, employment and marital status. $\beta's$ are the parameter vectors and the focus is on β_2s in equation (1). δ_t represents time fixed effects which control for unobserved survey round characteristics, and λ_{it} is the random error term of the equation.

The estimation strategy accounts for multinomial choices and is implemented with the use of multinomial probit (MNP) and logit (MNL) models. Although the MNL has been widely used in empirical literature, it has the well-known limitation associated with the implied "Independence of Irrelevant Alternatives (IIA)" assumption (Ben-Akiva and Lerman, 1985). The implication of the IIA for this study is that, for example, the choice of electricity/gas over firewood as a main cooking fuel should not be affected by the inclusion or exclusion of other alternative fuels (e.g., charcoal) in the choice set. This assumption is, however, very unlikely in the context of fuel use, particularly in developing countries where fuel switching behaviour is predominant among households. In this study, the outcome variable is ordered in line with the energy ladder hypothesis. However, the MNP model will not account for the ordinal nature of the dependent variable. Ordered multiple-choice models are commonly used as a framework for analyzing such responses and hence will be used here.

3.1.1 Underlying Mechanisms

To support the hypothesis that female-headed households behave differently, the study also investigates how household heads prioritise household expenditures. This aims to explore why

female heads may be more inclined towards adopting cleaner forms of cooking fuels than male heads. The analysis is grounded in the Engel curve hypothesis, which posits that household expenditure on a specific good or service varies with household income. This is based on the identifying assumption that the share of the budget allocated to food expenditure reliably indicates welfare differences between households of different demographic compositions. We refer to the works of Deaton (1997) and Lewbel and Pendakur (2008) and consequently estimate the following empirical models using OLS:

$$w(x)_{i,t} = \mu_1 + \mu_2 gendered\_head_{i,t} + \mu_3 size_{i,t} + \sum_{j=4}^{k} \mu_j X_{ij} + \rho_t + \varepsilon_{it} \qquad (2)$$

where $w(x)_{i,t}$ is a household i's Engel curve budget shares given total expenditures x in survey round t, We considered budget shares on (i) cooking fuels (firewood, charcoal, and gas & electricity), (ii) food and (iii) non-essentials (namely, alcohol, tobacco, and narcotics). $gendered\_head_{i,t}$ and X_{ij} are the same as in equation (1) above, and $size_{i,t}$ is the size of household i in survey round t. In addition, $\mu's$ are the parameter vectors, here the focus is on μ_2s in equation (2), and they are all expected to be positive for cooking fuel and food expenditures and negative for non-essential expenditure. ρ_t represents time fixed effects which control for unobserved survey round characteristics, and ε_{it} is the random error term of the equation.

Expenditure on non-essential items may limit the household's ability to afford and use cleaner cooking fuels. Hence, households that want to adopt cleaner forms of cooking fuel that typically have a higher market price, may decide to reduce expenditure on non-essentials and save towards it. We empirically investigate this by exploring whether a lower budget allocation on non-essentials is positively associated with the adoption of cleaner (and more expensive) cooking fuel, and whether there are differences between female and male-headed households.

We therefore augment equation (1) to investigate the following: (i) the effect of female headship in household on energy-poverty, (ii) the effect non-essential spending (in this case, expenditure on alcohol, tobacco, and narcotics) on energy poverty, and particularly (iii) the interaction effect of female headship in household and non-essential spending on energy-poverty. We estimate equation (3) below;

$$fuel_{i,t} = \varphi_1 + \varphi_2 femhead_{i,t} + \varphi_3 nonessenl_{i,t} + \varphi_4(femhead_{i,t} * nonessenl_{i,t}) + \sum_{j=5}^{k} \varphi_j X_{ij} + \omega_t + \pi_{it} \quad (3)$$

where $fuel_{i,t}$ is defined as in equation (1), $femhead_{i,t}$ is the gender of household i head in survey round t, $nonessenl_{i,t}$ measures the budget share allocated on non-essential items (alcohol, tobacco and narcotics), $(femhead_{i,t} * nonessenl_{i,t})$ is the interaction between the head's gender and non-essential expenditure variables, the variable X_{ij} are a set of controls as in equation (1) and (2) above. $\varphi's$ are the parameter vectors, we focus on φ_4 to see the effect of the interaction term (female*non-essential) on the type of main cooking fuel choice. ω_t represents time fixed effects which control for unobserved survey round characteristics, and π_{it} is the random error term of the equation.

We employ the ordered probit technique due to the ordinal nature of the dependent variable (fuel). To account for any potential endogeneity bias, the study also estimates equation (3) using the seemingly unrelated regressions (SUR) with the conditional mixed-process (CMP) technique for ordered probit model proposed by Roodman (2011). This technique allows building recursive multi-equation models similar to the two-stage least squares technique to deal with endogeneity bias in a model (Roodman, 2011; Cupák, Kolev and Brokešová, 2019). In addition, the Two Stage Least Squares-Instrumental Variable (2SLS-IV) estimation technique is employed as a further robustness check. This also enables us to calculate the magnitude of the effect of the interaction term, since it is difficult to evaluate the marginal effect of an interaction term in non-linear models. The use of IV addresses the potential endogeneity in the model due to potential omitted variables such as unobserved individual characteristics that affect both consumption of non-essentials and choice of cooking fuel. If present the endogeneity may lead to biased and inconsistent estimates in the relationship between energy poverty and non-essential spending (Koomson, Villano, Hadley, 2020a; Churchill and Marisetty, 2019).

The IV models require the use of instruments that are relevant to the endogenous treatment variable (in our case, expenditure on non-essential items), but exogenous to the outcome variable (main cooking fuel). A key factor that is expected to influence household's expenditure on non-essential items, but not the choice of cooking fuel is the religious affiliation of the head of the household. Specifically in Ghana, religious affiliations, such as Islamic and Christian denominations, influence the consumption of alcohol, tobacco, and narcotics, as these groups

often prohibit or discourage their use. Additionally, the prevalence of a particular religious group in a geographical area can influence the consumption of alcohol, tobacco, and narcotics. For instance, the northern regions of Ghana, which are predominantly Islamic and hold traditional beliefs, contrast with the southern regions where Christian, Atheist, and other faith groups are more prevalent. For the CMP and 2SLS-IV regressions, the study utilises the following instrumental variables: (i) a binary variable denoting the religious denomination of the head, grouping together religious denominations that discourage their consumption against the rest (Muslim or Christian=1, no religion or Traditionalist or other=0), (ii) interaction term between the 'female head' dummy and the religious denomination of the head, and (iii) interaction term between the 'female head' dummy and the percentage of households belonging to each of the five categories (Muslim, Christian, no religion, Traditionalist, and other) in the geographical regions (10 regions).

3.2 Data

This study employs micro level data from four rounds of the Ghana living standards survey (GLSS) based on wider coverage of households and availability of observations. These survey rounds included the GLSS 4 administered in 1998/1999, GLSS 5 in 2005/2006, GLSS 6 in 2012/2013 and GLSS 7 in 2016/2017 and are pulled together to form a repeated cross-section data. The GLSS is a nationally representative household survey, the sampling frame for the survey is the population living in private households in Ghana. The above sample frame is divided into primary and secondary sampling units. The primary sampling unit is the census Enumerated Areas (EAs) that are formed within the then ten administrative regions of Ghana based on proportional allocation using the population in each of the regions. The second sampling unit on the other hand is the households living in each of the EAs.

For the fourth round of the GLSS, the two-stage sampling resulted in the selection of 300 EAs at the first stage and a fixed number of 20 households from each EA. Out of the total of 6,000 households selected, 5,998 were successfully covered in the survey representing 99.7 percent coverage. Similarly, in the fifth round of the GLSS, a two-stage stratified random sampling approach was adopted, where in the first stage 580 EAs were considered, while in the second stage, 15 households per EA was considered. The combined outcome of the two-stage sampling resulted in a total of 8,700 households nationwide. In the end, however, 8,687 households were

successfully interviewed representing a 99.85 percent response rate for the GLSS5 sample. The sixth round followed a similar sampling approach and 1,200 EAs were considered in the first stage and 15 households from each primary sample unit, leading to a total of 18,000 households. Out of this, 16,772 were successfully interviewed comprising a response rate of 93.2 percent. The seventh round of the GLSS, like the previous rounds was proposed to study about 15,000 households in 1,000 EAs. At the end 14,009 households were successfully interviewed constituting 93.4 percent of the total households. Table 1 shows the waves and corresponding sample administered.

Table 1: Household sample administered per GLSS wave

Wave	Year	Sample administered
GLSS 4	1998/1999	5,998 (99.7%)
GLSS 5	2005/2006	8,687 (99.85 %)
GLSS 6	2012/2013	16,772 (93.2%)
GLSS 7	2016/2017	14,009 (93.4%)

3.3 Variable measurement

It is important to note that the dataset does not contain information on whether households use a combination of different fuels. Instead, the survey specifically asks, "What is the main cooking fuel of the household". Based on responses to this question, we constructed the main cooking fuel variable for our analysis (1 if the household uses firewood as a main cooking fuel, 2 if charcoal and 3 if electricity or gas). This incorporates the concept of energy ladder by making a distinction between the various types of cooking fuel that can be ranked from primitive (e.g. firewood), to transition (e.g. charcoal), and finally advanced fuels (gas/electricity). This is assumed to be more advantageous over the alternative of modelling multiple fuel use because we are able to clearly see the preference of women in decision making in the choice set. The responses also included kerosene, crop residue, dung cake, saw dust and others, but these cases were excluded from the analysis due to insignificant numbers reported. This is a self-reported measure which is widely accepted and can provide accurate and efficient assessments of objective states (Cleary, 1997).

Household head gender (Female head) is measured as a binary variable. To further assess whether female heads having absolute control relative to partial control over the household matters, we sub-divided the aggregate female-headed households into two binary variables, *de jure* (absolute household controllers) and *de facto* (partial household controllers) female-headed households. Therefore, three binary variables are constructed: '*de jure*-female', '*de facto*-female' and 'male head' variables. Household expenditure on (i) cooking fuels (firewood, charcoal, gas and electricity), (ii) food and (iii) alcohol, tobacco and narcotics are expressed as a share of total household expenditures. Expenditures on cooking fuel are available only in the latest two waves of the data (GLSS 6 and 7), therefore the corresponding part of the analysis is limited to these

two waves. Household expenditure on alcohol, tobacco and narcotics are used as indicators of non-essential expenditures, as these were the only relevant variables in the data that the study could utilise for this analysis. Also, to control for other factors that may influence household energy-poverty and expenditures, we include as covariates: (i) the log of equivalized household income , (ii) the household size, (iii) the age of the household head in years, (iv) controls for marital status of the head (never married, married, cohabitating, divorce and widowed), (v) indicators for educational level of the head (no education, primary, middle, secondary and tertiary), (vi) employment status of the head, and finally, (vii) whether the household is in an urban or rural area.

3.4 Descriptive Statistics

Table 2 summarises the mean values of the variables discussed in Section 3.3, highlighting demographic disparities across household types. Marital status varies significantly, with male heads having higher percentages in the "never married", "married and cohabitating" categories, while female heads predominantly fall into the "divorced" and "widowed" categories. Educational attainment also shows significant differences. A larger proportion of female heads who have no education compared to their male counterparts who had no education. Female heads again are the highest in the primary category compared to male heads and are more likely to have only primary education. In contrast, male heads have a higher representation at both secondary and tertiary education, with approximately 15% and 14% respectively, compared to about 11% and 8% respectively for female heads.

Within female-headed households, about 17% of *de facto* heads have no education, slightly higher than the 16% observed for *de jure* heads. When examining education levels, *de facto* heads record about 20% primary, 45% middle, 9% secondary and 9% tertiary education. In contrast, *de jure* heads show slightly different educational outcomes, about 23%, 42%, 12% and 8% respectively. Female heads on average are older than their male counterparts, whiles within female-heads, *de jure* heads have the highest average age. This is consistent with extant literature that *de jure* heads are mostly older. In terms of household size, male-headed households tend to be larger than female-headed households overall. Within female-headed households, *de jure* female-headed households have the smallest household size. Geographically, male-headed households are more prevalent in rural areas than female-headed households overall. However,

within the sub-set of female-headed households, *de facto* female households in the rural areas are slightly above their *de jure* counterparts.

Regarding employment, income and expenditures, approximately 67% of male-headed households are employed, compared to about 54% for their female-headed counterparts. This disparity partly accounts for the income differences favouring male-headed households, with an average of GHC 319.12 equalized income. Among the female-headed sub-group, similar patterns emerge. About 55% of *de facto* heads are employed against about 53% of *de jure* heads, with average income difference of about GH₵295.00. Expenditure patterns between male-headed and aggregate female-headed households reflect these income disparities. Male-headed households spend an average of GH₵954,586.00 more than female-headed households. In terms of budget allocation, female-headed households dedicate roughly 0.9% more of their budget to cooking fuel and 3% more to food, while spending about 1.3% less on alcohol, tobacco, and narcotics compared to male-headed households. These differences have been statistically verified to be significant at the 1% level, as indicated in Table 2. Within the female-headed sub-sample, in absolute terms, de facto heads spend a total average of GH₵854,037.00 more than de jure heads. However, *de jure* heads devote slightly higher budget shares on cooking fuel, food and on alcohol, tobacco and narcotics than *de facto* heads.

Despite the higher income level in male-headed households, there is significant difference in the adoption of cleaner forms of cooking fuels, with female headed households being more likely to adopt such forms of cooking fuel. In particular, 58% of male-headed households use firewood and about 26% use charcoal as their main cooking fuel. In contrast, female-headed households show a 48% usage of firewood and about 37% usage of charcoal. Additionally, about 16% of male-headed households use electricity or gas compared to approximately 15% in female-headed households. Similarly, within the female-headed sub-group, about 15% of *de facto* heads use electricity or gas compared to about 14% in *de jure* headed households. Both subgroups of female-headed households exhibit an equal usage of firewood at about 48%. However, *de jure*

headed households have a marginally higher usage of charcoal at about 38%, compared to 37% in *de facto* headed households[3].

[3]The correlation between the independent variables is generally low (< 0.50). The low correlations between the variables suggests less collinearity among them which will not cause estimation issues.

Table 2: Descriptive Statistics

	Total	Male	Female	T-test Difference	*De facto* Female	*De jure* Female	T-test Difference
Heads	1.00	0.702	0.298	0.404***	0.088	0.209	-0.121***
Marital Status							
Never married	0.106	0.107	0.102	0.005	---	0.144	
Married	0.568	0.715	0.220	0.495***	74.01	---	
Cohabitating	0.096	0.104	0.077	0.027*	25.99	---	
Divorce	0.114	0.051	0.264	-0.213***	---	0.376	
Widowed	0.116	0.023	0.338	-0.315***	---	0.480	
Education Level	2.953	3.037	2.723	0.3135***	2.721	2.724	-0.003
No education	0.128	0.114	0.166	-0.052**	0.175	0.162	0.013
Primary	0.180	0.167	0.216	-0.049*	0.198	0.225	-0.027*
Middle	0.428	0.427	0.428	-0.001	0.448	0.419	0.029*
Secondary	0.139	0.151	0.107	0.044*	0.091	0.116	-0.025*
Tertiary	0.125	0.140	0.082	0.058***	0.089	0.079	0.010
Age	45.867	44.591	48.878	-4.29***	42.146	51.718	-9.572***
Household Size	4.235	4.594	3.388	1.206***	3.892	3.175	0.717***
Rural	0.576	0.604	0.510	0.094***	0.515	0.508	0.007
Employed	0.630	0.669	0.537	0.132***	0.554	0.530	0.024*
Equalized Income	1682.31	1777.3	1458.18	319.12***	1665.556	1370.485	295.07***
Expenditures							
Total	4050307	4334461	3379875	954586.3***	3980133	3126096	854,037***
Cooking fuel (wood,char, gas, elec.)(% of total)	0.036	0.033	0.042	-0.009***	0.041	0.042	-0.001*
Food (% of total)	0.505	0.496	0.526	-0.030***	0.512	0.532	-0.020*
Alco/Toba/Narc(% of total)	0.014	0.018	0.005	0.013***	0.004	0.005	-0.001
Main cooking fuel	1.602	1.575	1.663	-0.087***	1.674	1.658	0.016*
Wood	0.55	0.580	0.482	0.098***	0.480	0.483	-0.003
Charcoal	0.298	0.265	0.373	-0.108***	0.366	0.376	-0.010
Electricity/Gas	0.152	0.1553	0.145	0.010	0.154	0.141	0.013*

'---' means not applicable (***de jure*** households include unmarried, divorced/separated and widowed women. ***de facto*** consist of only married/cohabitating women).

*** p<0.01 (Here, a simple t-test is performed by household head gender and revealed significant differences in the variables including income and expenditures)[4].

[4] This will be useful in our analysis, particularly the difference in income and expenditures.

4. Empirical Results

4.1 Empirical Estimations and Discussions

This section analyses the nexus between women's empowerment in households and energy-poverty in Ghana. Specifically, the aim is to assess the effect of female headship on household choice of main cooking fuel (firewood, charcoal and electricity or gas). Equation (1) is estimated using ordered probit model and the results are presented in Table 3 . The paper accounts for the respective households' income level, size, and location, as well as the household head's age, education level, marital status and employment status. To further analyse whether the degree of women's empowerment in the household matters, we present estimates of the ordered probit model in Table 4 that compare *de jure* (absolute control) and *de facto* (partial control) female heads to male heads. In each table, the estimated coefficients are reported in the first column, with the corresponding marginal effects presented in the remaining columns. All regressions include year and region fixed effects and use robust standard errors.

Table 3: Estimates of equation (1) using ordered probit

	Ordered Probit	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
Female Head	0.171***	-0.042***	0.011***	0.031***
	(0.020)	(0.005)	(0.001)	(0.004)
Observations	28,552	28,552	28,552	28,552
Other controls	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes

Notes: Robust standard errors are reported in parentheses. Statistical significance is denoted with *** p<0.01, ** p<0.05, * p<0.1. Other controls include head's age, education level, marital status and employment status; household's size, income and location. Full estimates are provided in Appendix I.

The results in Table 3 suggest that, compared to male-headed households, female-headed households are more likely to use cleaner main cooking fuel . Particularly, female-headed households are about 4.2 percentage points less likely to use firewood as their main cooking fuel compared to their male-headed counterparts (Table 3, column 2). However, they are about 1.1 percentage points more likely to use charcoal as their main cooking fuel than male-headed ones (Table 3, column 3). Similarly, female-headed households are about 3.1 percentage points more likely to use electricity or gas as their main cooking fuel than male-headed ones (Table 3, column 4).

The findings highlight the commitment of female-headed households to adopting cleaner main cooking fuel. A key question remains: Does the level of empowerment in the household matter? Table 4 explores this by comparing the cooking fuel choices of *de jure* female-headed households, where the woman has full legal and customary control, against *de facto* female-headed households, where a woman leads due to the man's absence and has partial control, and male-headed households. The results in Table 4 suggest that female heads having absolute control over the household matter, even though the equality tests at the bottom of Table 4 suggest insignificant differences between *de jure* and *de facto* female-headed households. .

Table 4: Estimates of equation (1) using ordered probit

	Ordered Probit	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
De facto female	0.156***	-0.038***	0.010***	0.028***
	(0.027)	(0.007)	(0.002)	(0.005)
De jure female	0.190***	-0.046***	0.012***	0.034***
	(0.030)	(0.007)	(0.002)	(0.005)
Observations	28,552	28,552	28,552	28,552
Other controls	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
De facto female = De jure female : chi sqr =0.74 (p value=0.3907)		0.74 (0.3908)	0.74 (0.3910)	0.74 (0.3907)

Notes: Robust standard errors are reported in parentheses. Statistical significance is denoted with *** p<0.01, ** p<0.05, * p<0.1. Other controls include head's age, education level, marital status and employment status; household's size, income and location. Full estimates are provided in Appendix II.

The estimates suggest that both *de jure* and *de facto* female-headed households are more likely to use cleaner main cooking fuel in their households than their male-headed households. Specifically, *de jure* female-headed households are about 4.6 percentage points less likely to use firewood as their main cooking fuel, and *de facto* female-headed households are about 3.8 percentage points less likely to use it, compared to male-headed households (column 2). On the contrary, *de jure* female-headed households are about 1.2 percentage points more likely to use charcoal as their main cooking fuel, and *de facto* female-headed households are about 1 percentage point more likely to use it, compared to male-headed households (column 3). Similar estimates are reported in column 4 in the case of electricity/gas, *de jure* female-headed households are about 3.4 percentage points more likely to use electricity/gas as their main cooking fuel, and *de facto* female-headed households are about 2.8 percentage points more likely to use it, compared to male-headed households.

The results suggest that *de jure* female-headed households, despite having the lowest level of income (as shown in Table 2) are potentially the least likely of the three categories of households to use uncleaned main cooking fuel in their households, compared to charcoal and electricity/gas. This is probably because of the absolute control they have over their households compared to their *de facto* female-headed counterparts. To conclude, the above findings indicate that the choice of cleaner cooking fuel in households depends largely on whether the household is controlled by female, and potentially the amount of control they have over the household. These findings provide empirical support to the argument that women fully spend over 74% of their cash income on supplements to the family food supply and household needs including cooking fuel (Guyer, 1980; Mencher, 1988). It also supports the work of Miller and Mobarak (2013); Alem et al (2023) who find women to more willing to pay for improved cookstoves.

4.2 Differences in Household Expenditure in Gendered-Headed Households

To deepen our understanding of the findings reported above, where female-headed households are more likely to use cleaner cooking fuel in their households compared to their male-headed counterparts, this section investigates how household heads prioritise household expenditures. The analysis is framed on the Engel curve hypothesis and equation (2) is estimated to explore the allocation patterns. The outcome variables considered are the budget shares allocated to (i) cooking fuel, (ii) food and (iii) alcohol, tobacco and narcotics. The primary independent variables of interest are the aggregate female heads variable and also the *de jure*- and *de facto* female-heads binary variables. Thus, the analysis assesses the differences in budget prioritisation between female- and male-headed households regarding essential expenditures (cooking fuel and food) and non-essential expenditures (alcohol, tobacco, and narcotics). It compares not only aggregate female-headed with male-headed households but also breaks down the comparison between *de jure*- and *de facto*-female heads and their male counterparts. Equation (2) is estimated separately for each budget share, based Ordinary Least Squares (OLS), and the findings are reported in Table 5.

Table 5: Estimates of equation (2) using OLS

Depend. Variables:	**Cooking fuel expenditure (Wood, charcoal, gas, elect.)/ Total expenditure**		**Food expenditure/ Total expenditure**		**Non-essential expenditure (Alcohol, Narcotics, Tobacco) expenditure/ Total expenditure**	
Ind. Variables	(1)	(2)	(3)	(4)	(5)	(6)
Female Head	0.007***		0.002		-0.015***	
	(0.001)		(0.002)		(0.001)	
De facto female		0.005***		0.007**		-0.009***
		(0.001)		(0.003)		(0.0005)
De jure female		0.009***		-0.003		-0.022***
		(0.001)		(0.004)		(0.001)
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,728	19,728	28,552	28,552	21,000	21,000
R-squared	0.118	0.118	0.126	0.126	0.117	0.121
De facto female = De jure female:	Chi sqr=5.59 (p-value= 0.018)		Chi sqr=3.73 (p-value=0.0534)		Chi sqr=97.29 (p-value=0.0000)	

Notes: Robust standard errors are reported in parentheses. Statistical significance is denoted with *** p<0.01, ** p<0.05, * p<0.1. A coefficient equality test is performed and Chi square values, with p-values in parentheses, are reported. Other controls include head's age, education level, marital status and employment status; household's size, income and location. Full estimates are provided in Appendix III.

The results from Table 5 reveal distinct budget allocation patterns across different household types. Column (1) shows that, at 1% significance level, female-headed households allocate approximately 0.7 percentage point increase of the budget to cooking fuel, than male-headed households. Further breakdown in column (2) indicates that *de facto* female-headed households allocate about 0.5 percentage points more, and *de jure* headed-households allocate about 0.9 percentage points more to cooking fuel than male-headed households. Column (3) highlights that there is no statistically significant difference in the allocation of budget share for food among female- and male-headed households, despite the significantly high food expenditure in absolute terms[5] in male-headed households compared to their female-headed counterparts. This provides empirical support for the assertion of Mencher (1988) that while males might spend more money on household sustenance in absolute terms, the proportion of their income spent is not necessarily higher than that of females. In terms of food expenditure within female-headed households, column (4) of Table 5 shows that *de facto* female-headed households allocate a

[5] A simple t-test of food expenditure, in absolute terms by household head gender indicates a significantly high expenditure on food by male-headed households compared to their female-headed counterparts.

significantly higher budget share, about 0.7 percentage points higher, to food than male-headed households. Conversely, no significant difference in food budget allocation was observed between *de jure* female-headed and male-headed households.

In relation to household expenditure on non-essentials such as alcohol, tobacco and narcotics, female-headed households are found to allocate a smaller share of their budget than male-headed households. Specifically, column (5) of Table 5 shows a decrease of about 1.5 percentage point in the budget share allocated to alcohol, tobacco, and narcotics in female-headed households relative to male-headed households. Within the female-headed sub-group, column (6), both *de facto* and *de jure* female-headed households allocate lower share of their budget for alcohol, tobacco, and narcotics than their male-headed counterparts, about 0.9 percentage point and about 2.2 percentage points decrease respectively. Furthermore, the results of the coefficient equality test, presented at the bottom of Table 5, indicate that the coefficients for *de facto* and *de jure* female heads are significantly different in columns (2), (4), and (6), confirming that *de jure* female heads allocate even less to non-essential expenditures compared to their *de facto* counterparts. Overall, these findings underscore that female-headed households, particularly those headed by *de jure* females, prioritise essential expenditures such as cooking fuel and food over non-essentials like alcohol, tobacco, and narcotics more than male-headed households in Ghana.

Finally, the study investigates the relationship between non-essential expenditure and the adoption of cleaner main cooking fuel, by estimating equation (3) above. Equation (3) classifies fuel into three categories (1=firewood, 2=charcoal, 3=electricity/gas) as dependent variable. The key explanatory variable of interest is the interaction term ‘female*nonessential’. A negative and significant coefficient for the interaction term would indicate that lower spending on non-essential items such as alcohol, tobacco, and narcotics facilitates the use of cleaner cooking fuels, aligning with the hypothesis that female heads of households engage in more household-sustaining behaviours than male heads.

Table 6 presents estimates of equation (3) using ordered probit-IV (CMP) and 2SLS-IV estimation techniques [6]. To address potential endogeneity concerns (CMP and 2SLS-IV regressions), the study uses religious denomination of the household head as an instrumental variable. This choice is based on the assumption that religious denomination influences expenditures on non-essentials but is unlikely to directly affect the choice of cooking fuel.

The choice is instrumental variables is supported both by the weak IV test and the overidentification test. Specifically, the overall F-statistic reported at 35.645 indicates strong correlation between the chosen instrumental variables and the suspected endogenous regressors ('non-essential expenditure' and 'female*non-essential expenditure'), surpassing the Stock-Yogo (2005) critical values, which rejects the null hypothesis of weak instruments. Furthermore, the Hansen J test provides supporting evidence for the exogeneity of the overidentifying restrictions.

Table 6: Estimates of equation (3) using Ordered probit, CMP and 2SLS-IV

Dependent Variable: Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)		
Independent Variables	**O. Probit-IV (CMP)**	**2SLS-IV**
Non-essential exp. (% of total)	**-9.6864*** **	**-8.5985*** **
	(2.096)	**(1.945)**
Female head*(Non-essential)	**-26.8870***	**-18.236*** **
	(14.411)	**(6.132)**
Female head	**0.1536** **	**0.0027**
	(0.078)	**(0.033)**
Underid test		62.966(0.00)
Hansen J (overid)		0.085(0.77)
Endogeneity test		32.581(0.00)
F-stat		35.645
Year Effects	Yes	Yes
Region Effects	No	No
Other controls	Yes	Yes
Observations	19,766	19,766
R-squared		0.328

Notes: Robust standard errors are reported in parentheses. Statistical significance is denoted with *** p<0.01, ** p<0.05, * p<0.1. For the under identification, Hansen J. (overidentification) and endogeneity tests, test values, with p-values in parentheses, are reported. Other controls include head's age, education level, marital status and employment status; household's size, income and location. Full estimates are provided in Appendix VI.

[6] Full estimates are provided in Appendix IV, along with ordered-probit estimates that do not account for potential endogeneity.

From Table 6, the results indicate that increased budget shares allocated to non-essentials (alcohol, tobacco, and narcotics), lead to a decreased use cleaner forms of cooking fuels. In particular, the 2SLS-IV estimates show that a one percentage point increase in the budget share for non-essentials in male-headed households is associated with an 8.6 percent reduction in the likelihood of adopting cleaner cooking fuels, a result that is significant at the 1% level. This result supports our conjecture that households dedicating more resources to non-essentials may compromise on essential and healthier alternatives.

Moreover, the results emphasize the distinct behaviour of female-headed households in relation to cleaner cooking fuel adoption. Specifically, the coefficients of the interaction term 'female head*non-essential' in the CMP and 2SLS-IV regressions are negative and significant at 10% and 1% level respectively. This suggests that the negative impact of non-essential expenditure on the choice of cleaner cooking fuels is more pronounced in female-headed households. All else equal, the 2SLS-IV results suggest that a percentage point increase in the budget share for non-essentials in female-controlled households tends to further decrease the likelihood of adopting cleaner main cooking fuels by about 26.8 percent, compared to male-controlled households. These findings confirm the view that female-headed households in Ghana, when prioritising less on non-essentials, are more likely to adopt cleaner cooking fuels.

5. Summary, Conclusion and Policy Implications

Women's empowerment, particularly their participation in decision-making, has attracted the attention of researchers as an active area of research since 1980s, yet its influence on energy poverty is limited. In developing countries, energy poverty is estimated to have an adverse impact on health, with these effects being more pronounced among women, largely due to gender-based domestic roles. Therefore, if women are more empowered and participate more actively in the household decision making, they may favour the adoption of cleaner forms of household cooking fuel, thus contributing to the reduction of energy poverty. Also, empowering women and eliminating energy poverty are central to the United Nation's Millennium Development Goals, and understanding how women's empowerment influence energy poverty in households is vital to inform relevant policy initiatives. Hence, the relationship between women's empowerment in households and energy poverty in developing countries should be of perennial interest. However, the relevant literature and empirical evidence is rather limited.

To fill this literature gap, this study explores the link between women's empowerment and the use of cleaner cooking fuel in developing countries, with a focus on Ghana. Utilising micro level data from Ghana and employing various identification strategies, the study provided an in-depth analysis of how female empowerment within households leads to greater adoption of cleaner cooking fuel in Ghana. It examines whether households that are fully or partially controlled by females adopt cleaner main cooking fuel compared to their counterparts male controlled households. The study also investigates the influence of female empowerment in households on household food and on non-essential (alcohol, tobacco and narcotics) expenditure. Furthermore, it explores possible trade-offs between expenditures on non-essentials and investment in a cleaner form of cooking fuel, to ascertain whether resources typically used for non-essential consumption are, at least partly, redirected towards adopting cleaner cooking fuel. This enabled us to shed light and understand better how male- and female-headed households allocate their budget, the level of income they may devote on household sustenance, part of which also includes the choice of cooking fuel, and the relative trade-offs such decisions entail.

The results indicated that households controlled by female are more likely to adopt cleaner forms of main cooking fuel than their male-controlled counterparts. In particular, both *de jure* (fully empowered) and *de facto* (partially empowered) female-headed households are more likely to use cleaner forms of cooking fuels than their male-controlled counterparts. The results also suggest that female-controlled households prioritize expenditure on household cooking fuel and food over non-essential expenditure on alcohol, tobacco and narcotics, compared to male controlled households. Furthermore, *de jure* female heads allocate even less to non-essential expenditures compared to their *de facto* counterparts. This is probably because of the absolute control *de jure* female heads have over their households and the allocation of household resources, compared to *de facto* female heads. Finally, the analysis reveals possible trade-offs between non-essential expenditure and investment in cleaner cooking fuel. In summary, the results suggest that female-headed households may focus more on improving household welfare, than male-headed-households, as they spend less on non-essentials and tend to use cleaner cooking fuel in their households.

The study concludes that empowering women in households, thus making them active subjects in household decision making, may potentially help in the adoption of cleaner cooking fuel in

Ghana. The findings reveal a direct link between women's empowerment and the likelihood of adopting cleaner energy sources. Large-scale blanket social interventions may not be very effective in the fight against energy poverty in Ghana, and by extension in other developing countries with similar characteristics. Instead, policy initiatives that focus on empowering women in households and enhancing their role in household decision making may prove to be more successful in reducing energy poverty. However, implementing such policies in Ghana, and similar settings, faces considerable challenges due to deep-rooted socio-cultural and religious norms that traditionally position men as the primary decision-makers. Policymakers must navigate these complexities sensitively and strategically, perhaps by integrating gender empowerment goals with broader community education and gradual normative changes that emphasise the benefits of shared decision-making within households.

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Appendices

Appendix I: Estimates of equation (1) using ordered probit

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)				
Independent Variables	**Ordered Probit**	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
Female Head	0.171***	-0.042***	0.011***	0.031***
	(0.020)	(0.005)	(0.001)	(0.004)
Age	0.016***	-0.004***	0.001***	0.003***
	(0.004)	(0.001)	(0.0002)	(0.001)
Age squared	-0.0002***	0.0001***	-0.00002***	-0.00004***
	(0.00004)	(9.18e-06)	(2.40e-06)	(6.81e-06)
(Never married)				
2.ind_married	0.005	-0.001	0.0003	0.001
	(0.030)	(0.007)	(0.002)	(0.006)
3.ind_cohabitating	-0.186***	0.045***	-0.012***	-0.033***
	(0.032)	(0.008)	(0.002)	(0.006)
4.ind_divorce	-0.167***	0.041***	-0.011***	-0.030***
	(0.034)	(0.008)	(0.002)	(0.006)
5.ind_widowed	-0.103**	0.025**	-0.007**	-0.019**
	(0.042)	(0.010)	(0.003)	(0.008)
(No education)				
2.ind_edu_primary	0.124***	-0.033***	0.015***	0.018***
	(0.028)	(0.008)	(0.004)	(0.004)
3.ind_edu_middle	0.417***	-0.112***	0.044***	0.067***
	(0.027)	(0.007)	(0.003)	(0.004)
4.ind_edu_secondary	0.849***	-0.224***	0.068***	0.156***
	(0.032)	(0.009)	(0.003)	(0.006)
5.ind_edu_tertiary	1.370***	-0.345***	0.062***	0.283***
	(0.034)	(0.008)	(0.003)	(0.007)
Log of income	0.022	-0.005	0.001	0.004
	(0.014)	(0.003)	(0.001)	(0.003)
Household size	-0.099***	0.024***	-0.006***	-0.018***
	(0.006)	(0.001)	(0.0004)	(0.001)
(Unemployed)				
Employed	0.283***	-0.069***	0.018***	0.051***
	(0.023)	(0.006)	(0.002)	(0.004)
(Urban)				
Rural	-1.331***	0.325***	-0.084***	-0.241***
	(0.018)	(0.003)	(0.001)	(0.003)
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
Observations	28,552	28,552	28,552	28,552

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Appendix II: Estimates of equation (1) using ordered probit

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)				
Independent Variables	**Ordered Probit**	**Marginal Effects (dy/dx)**		
		Firewood	**Charcoal**	**Elec/Gas**
	(1)	(2)	(3)	(4)
De facto female	0.156***	-0.038***	0.010***	0.028***
	(0.027)	(0.007)	(0.002)	(0.005)
De jure female	0.190***	-0.046***	0.012***	0.034***
	(0.030)	(0.007)	(0.002)	(0.005)
Age	0.016***	-0.004***	0.001***	0.003***
	(0.004)	(0.001)	(0.0002)	(0.001)
Age squared	-0.0002***	0.0001***	-0.00002***	-0.00004***
	(0.00004)	(9.19e-06)	(2.40e-06)	(6.81e-06)
(Never married)				
2.ind_married	0.016	-0.004	0.001	0.003
	(0.033)	(0.008)	(0.002)	(0.006)
3.ind_cohabitating	-0.174***	0.043***	-0.012***	-0.031***
	(0.035)	(0.009)	(0.002)	(0.006)
4.ind_divorce	-0.173***	0.042***	-0.011***	-0.031***
	(0.035)	(0.009)	(0.002)	(0.006)
5.ind_widowed	-0.111***	0.027***	-0.007***	-0.020***
	(0.042)	(0.010)	(0.003)	(0.008)
(No education)				
2.ind_edu_primary	0.124***	-0.033***	0.015***	0.018***
	(0.028)	(0.008)	(0.004)	(0.004)
3.ind_edu_middle	0.417***	-0.111***	0.044***	0.067***
	(0.027)	(0.007)	(0.003)	(0.004)
4.ind_edu_secondary	0.848***	-0.224***	0.068***	0.156***
	(0.032)	(0.009)	(0.003)	(0.006)
5.ind_edu_tertiary	1.370***	-0.345***	0.062***	0.283***
	(0.034)	(0.008)	(0.003)	(0.007)
Log of income	0.021	-0.005	0.001	0.004
	(0.014)	(0.003)	(0.001)	(0.003)
Household size	-0.099***	0.024***	-0.006***	-0.018***
	(0.006)	(0.001)	(0.0004)	(0.001)
(Unemployed)				
Employed	0.283***	-0.069***	0.018***	0.051***
	(0.023)	(0.006)	(0.002)	(0.004)
(Urban)				
Rural	-1.331***	0.325***	-0.084***	-0.241***
	(0.018)	(0.003)	(0.001)	(0.003)
Year Effects	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes
Observations	28,552	28,552	28,552	28,552
De facto female = De jure female			chi sqr =0.74 (p value=0.3907)	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. For the coefficient equality test, we presented chi square values with p-values in parenthesis.

Appendix III: Estimates of equation (2) using OLS

Depend. Variables:	**Cooking fuel expenditure (Wood, charcoal, gas, elect.)/ Total expenditure**		**Food expenditure/ Total expenditure**		**(Alcohol, Naccotics,Tobacco.) expenditure/ Total expenditure**	
Ind. Variables	(1)	(2)	(3)	(4)	(5)	(6)
Female Head	0.007***		0.002		-0.015***	
	(0.001)		(0.002)		(0.001)	
De facto female		0.005***		0.007**		-0.009***
		(0.001)		(0.003)		(0.0005)
De jure female		0.009***		-0.003		-0.022***
		(0.001)		(0.004)		(0.001)
Age	-0.0004**	-0.0004**	-0.005***	-0.005***	0.001***	0.001***
	(0.0002)	(0.0002)	(0.0004)	(0.0004)	(0.0001)	(0.0001)
Age squared	4.63e-06***	4.66e-06***	0.00005***	0.00005***	-8.56e-06***	-8.68e-06***
	(1.67e-06)	(1.67e-06)	(4.55e-06)	(4.55e-06)	(1.13e-06)	(1.13e-06)
(Never married)						
2.ind_married	0.005***	0.006***	0.002	-0.001	-0.004***	-0.007***
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)
3.ind_cohabitating	0.003*	0.004***	0.014***	0.011**	0.0005	-0.003***
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)
4.ind_divorce	0.002	0.001	0.014***	0.016***	0.006***	0.008***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.001)	(0.001)
5.ind_widowed	0.004**	0.003	0.009*	0.012**	0.002	0.005***
	(0.002)	(0.002)	(0.005)	(0.005)	(0.001)	(0.001)
(No education)						
2.ind_edu_primary	0.003*	0.003*	-0.004	-0.004	-0.005***	-0.005***
	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.001)
3.ind_edu_middle	0.006***	0.006***	-0.029***	-0.029***	-0.008***	-0.008***
	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.001)
4.ind_edu_secondary	0.008***	0.008***	-0.068***	-0.068***	-0.011***	-0.010***
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)
5.ind_edu_tertiary	0.005***	0.005***	-0.111***	-0.111***	-0.013***	-0.013***
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)
Log of income	0.001	0.001	-0.009***	-0.008***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.0004)	(0.0004)
Household size	-0.002***	-0.002***	-0.007***	-0.007***	-0.001***	-0.001***
	(0.0002)	(0.0002)	(0.001)	(0.001)	(0.0001)	(0.0001)
Employed	0.003**	0.003**	-0.010***	-0.010***	-0.001	-0.001
	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.001)
Rural	-0.018***	-0.018***	0.038***	0.038***	0.005***	0.005***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.0005)	(0.0005)
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,728	19,728	28,552	28,552	21,000	21,000
R-squared	0.118	0.118	0.126	0.126	0.117	0.121
De facto female = De jure female:	Chi sqr=5.59 (p-value= 0.018)		Chi sqr=3.73 (p-value=0.0534)		Chi sqr=97.29 (p-value=0.0000)	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. For the coefficient equality test, we presented chi square values with p-values in parenthesis

Appendix IV: Estimates of equation (3) using Ordered probit, CMP and 2SLS instrumental variables (IV)

Dependent Variable: Ordered Fuel (Firewood=1, Charcoal=2, Elec/Gas=3)					
Independent Variables	**Ordered Probit**	**O. Probit-IV (CMP)**	2SLS-IV stage 1		**stage 2**
			Fem*(Nonessenl)	Non-essential	
Non-essential	**-2.257*** **	**-9.6864*** **			**-8.5985*** **
	(0.337)	**(2.096)**			**(1.945)**
Fem*(Non-essential)	**0.098**	**-26.8870***			**-18.236*** **
	(1.271)	**(14.411)**			**(6.132)**
Female Head	**0.144*** **	**0.1536** **	0.0124***	-0.0276***	**0.0027**
	(0.025)	**(0.078)**	(0.002)	(0.002)	**(0.033)**
Age	**0.010** **	**0.0169*** **	0.0001***	0.0009***	**0.0155*** **
	(0.004)	**(0.004)**	(0.000)	(0.00001)	**(0.003)**
Age squared	**-0.0002*** **	**-0.0002*** **	-0.000001***	-0.000001***	**-0.0002*** **
	(0.00004)	**(0.000)**	(0.000001)	(0.000001)	**(0.00001)**
(Never married)					
2.ind_married	**0.006**	**-0.1127*** **	0.000001	-0.0019**	**-0.0923*** **
	(0.036)	**(0.031)**	(0.000001)	(0.001)	**(0.019)**
3.ind_cohabitating	**-0.137*** **	**-0.1645*** **	0.0003	0.0006	**-0.1077*** **
	(0.040)	**(0.036)**	(0.00001)	(0.001)	**(0.021)**
4.ind_divorce	**-0.152*** **	**-0.1995*** **	-0.0003	0.0065***	**-0.0909*** **
	(0.041)	**(0.038)**	(0.00001)	(0.001)	**(0.025)**
5.ind_widowed	**-0.085** **	**-0.1631*** **	0.0011**	0.0035***	**-0.0663** **
	(0.048)	**(0.043)**	(0.00001)	(0.001)	**(0.029)**
(No education)					
2.ind_edu_primary	**0.027**	**0.0639** **	-0.0012***	-0.0064***	**-0.0494** **
	(0.039)	**(0.036)**	(0.00001)	(0.001)	**(0.024)**
3.ind_edu_middle	**0.400*** **	**0.3925*** **	-0.0011***	-0.0091***	**0.1033*** **
	(0.035)	**(0.042)**	(0.00001)	(0.001)	**(0.026)**
4.ind_edu_secondary	**0.825*** **	**0.7659*** **	-0.0011***	-0.0105***	**0.3309*** **
	(0.040)	**(0.067)**	(0.00001)	(0.001)	**(0.031)**
5.ind_edu_tertiary	**1.527*** **	**1.3044*** **	-0.0010***	-0.0122***	**0.6145*** **
	(0.045)	**(0.104)**	(0.00001)	(0.001)	**(0.033)**
Log of income	**-0.016**	**0.1630*** **	-0.0004***	-0.0069***	**0.0161**
	(0.017)	**(0.016)**	(0.00001)	(0.00001)	**(0.016)**
Household size	**-0.099 *** **	**-0.1342*** **	0.0001*	0.0003*	**-0.0601*** **
	(0.007)	**(0.011)**	(0.00001)	(0.00001)	**(0.003)**
(Unemployed)					
Employed	**0.319*** **	**0.2953*** **	0.0002	-0.0008	**0.1667*** **
	(0.029)	**(0.033)**	(0.00001)	(0.001)	**(0.015)**
(Urban)					
Rural	**-1.268*** **	**-1.1300*** **	0.0002**	0.0047***	**-0.6720*** **
	(0.021)	**(0.084)**	(0.00001)	(0.00001)	**(0.015)**
Religion dummy			0.0001	-0.0115***	
			(0.00001)	(0.001)	
Femhead*religion dummy			-0.0049***	0.0115***	
			(0.002)	(0.002)	
Femhead*religion%			-0.0004***	0.0002**	
			(0.00001)	(0.00001)	
Underid test					62.966(0.00)

Hansen J (overid)					0.085(0.77)
Endogeneity test					32.581(0.00)
F-stat			41.23	28.44	35.645
Year Effects	Yes	Yes			Yes
Region Effects	Yes	No			No
Observations	19,766	19,766			19,766
R-squared					0.328

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. For the under identification, Hansen J. (overidentification), endogeneity and F-stat tests, we report the test values with p-values in parenthesis.