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# Energy Consumption and the Welfare of Ugandan Households: A Panel Analysis

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**ABSTRACT**

Literature well recognizes the central importance of energy consumption in enhancing household welfare. The policy stance for Ugandan government is to improve the welfare households through implementation of various household energy consumption enhancing initiatives has been visibly robust. Albeit theoretical and empirical and practical recognition of the welfare impact of energy consumption by households, on Uganda regarding household welfare remain unappealing. This study examines the relationship between households' energy consumption and the households' welfare in Uganda. The study adopts a combination of longitudinal and explanatory research designs. Household welfare is measured by the household's level of consumption expenditure per adult equivalent while household energy consumption expenditure is captured the household's monthly total expenditure on all fuels in Uganda Shillings. The study utilizes four waves of panel data from the Uganda National Panel Survey (UNPS); 2019/2020, 2017/2018, 2015/2016 and 2013/2014 obtained from the Uganda Bureau of Statistics (UBOS). The household is taken as a unit of analysis and the household head as a unit of observation. The empirical model is specified in the general framework of the Bergson-Samuelsson Social welfare Model/function (BSSWF) and is estimated by the method of the Two-Stage Least-Squares with Fixed Effects Estimator (2SLS-FE). Results show that when the households' energy consumption levels increase by 1%, Consumption Per Adult Equivalent among the Ugandan households increase by 0.14% other factors constant. Meaning energy consumption levels have the ability to explain households' welfare. Initiatives aimed at improving household energy consumption levels is a pragmatic policy option to increase household welfare in Uganda.

**Keywords:** Energy Consumption, Household Welfare, Uganda
**JEL Classifications:** Q41, I31, C23, D12

## 1. INTRODUCTION

The concept of Household welfare is synonymous with the happiness or well-being of the households (Ahmad and Sadaqat, 2016). People have intrinsic desires for better well-being. Well-being is an important value for people's lives, and is considered as an index of societal progress (Voukelatou et al., 2021). Aspects that influence household welfare inform policies aimed at improving not only household welfare but also overall social welfare (Nguyen and Nguyen, 2019). To attain the primary objective of poverty reduction and promotion of social welfare, it is necessary to understand the effects of specific policies that directly affect household welfare (Glewwe, 1990).

Whereas energy consumption is recognized as welfare enhancing, Household consumption expenditures on energy, affect different aspects of human welfare with critical policy implications (Karumba and Uchapondwa, 2017). Households' energy

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consumption is associated with household welfare spanning from necessities and basics to recreational and luxury consumption (Romero-Jordan et al., 2016). There are economic gains from energy use, accruing from increased productivity in home enterprises and intensification of agricultural activity, (Phoumin et al., 2020). Energy consumption facilitates production and improves household welfare and plays an important role in the growth and development process of an economy, (Mawejje and Mawjje, 2016; Sambodo and Novandra, 2019) reported health benefits from energy consumption associated with reduced malnutrition. Energy services are a necessity good for households, implying an income elasticity of demand for energy as a good that is greater than zero and smaller than unity (Meier et al., 2013). Globally, energy consumption has been formalized by the United Nations among international development goal, Sustainable Development Goal 7, which seeks to ensure access to affordable, reliable, sustainable and modern energy for all.

Uganda, over time, has implemented initiatives aimed at social economic transformation to enhance household welfare through increased energy consumption by expanding household electricity access in all its forms (capacity, availability, reliability and quality) through extension of the national electricity power grid network, promotion of energy efficiency, use of alternative sources of energy, increased investments and exploitation of the abundant renewable energy sources including hydropower and geothermal to increase power generation capacity and expansion of rural electrification programs. Notwithstanding such tremendous effort, Uganda continues to register low welfare results. The per capita electricity consumption for Uganda is only 82 kWh (IEA, 2022), among lower than Sub-Saharan Africa's average estimated at 552 Kwh per capita and much lower the world's average of 2,975 Kwh per capita (Emmanuel and Japheth, 2021; Atuhaire, 2023*).*

Using mixed methods, a study conducted in Nakulabye slum, Kampala, by Yaguma, P., Parikh, P., & Mulugetta, Y. (2022), established that low consumption loads in households make electricity provision financially unviable and that high costs and tariffs constrain access.

Whereas increased energy consumption is beneficial to household welfare consumption among households in many developing countries, Uganda inclusive, has presented mixed results (ADB, 2020). This contention is the motivation to this study thus; to investigate the impact of energy consumption on welfare of households in Uganda. (ADB, 2020) argues that the mixed results of energy consumption on household welfare emanate, partly, from the fact that there are still impediments to universal electricity access in developing countries such as high investment and operation costs, technical implementation, limited demand given market conditions, distribution and maintenance issues as well as and regulatory and political concerns. Thus, while there is linkage for energy consumption in improving household welfare, statistics on Uganda regarding welfare variables are scanty and not appealing, justifying the need for this investigation with regard to the linkage between energy consumption and household welfare for the observed poor welfare indicators among households. The purpose of this study is therefore to examine relationship between households' energy consumption and the households' welfare in Uganda.

## 2. A LITERATURE REVIEW

### 2.1. Conceptualization on Household Welfare

Welfare and utility are concepts that are used interchangeably empirical studies (Grootaert et al., 2002). Welfare and utility are related but not identical concepts. Welfare derived from the consumption of goods and services either directly or indirectly because of the characteristics embodied in the good or service. In the collective household theory, individual welfare entails a family welfare function that relates the set of potentially unequal levels of well-being for family members to an aggregate measure for the family as a whole (Chavas et al., 2018). This is a social challenge which involves understanding the linkages among individual behavior, household demand, and the aggregation of unequal well-being. This challenge calls for a refined analysis of the linkages between individual demand behavior and household welfare.

### 2.2. Conceptualization on Household Energy Consumption

Household energy consumption can be understood as the amount of energy resources (such as biofuels, Kerosene, electricity, gas, petroleum, diesel, and solar) that are being spent by households on various electricity appliances used by the households (Danlami et al., 2015). In a wider perspective of energy consumption, the (World Bank, 2019) takes energy consumption to mean "the use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport." On the other hand, (Vasseur et al., 2019) define energy consumption in relation to household behavior on energy use. Energy consumption of households is based on a complex interaction between contextual, economic and social influence in which household energy consumption originates from the need to heat, cool, transportation, and light residential dwellings. (Olayeni, 2012) and (Nkalu et al., 2020) consider energy consumption to compose of energy use in kilograms of oil equivalent. As (Zong et al., 2020) notes, household energy consumption comes from both in-home and out-of-home household activities which may not be independent of each other. (Moore et al., 2020) consider energy consumption as the actual energy use by end users in their survival activities. Due to complexity of delineating in-home and out-of-home energy consumption requirements for the households, the measure of household energy consumption adopted in this study accounts for all related household energy requirements needed to run household basic activities (for instance lighting, cooking, heating, transportation, electrifying home appliances etc.) including indirect energy consumption, for instance the energy used in cottage manufacturing.

### 2.3. The Bergsonian Household Utility Function

In the tradition of collective household models, the efficient allocation of resources within a household is captured by a Bergsonian household utility function involving different welfare

weights applied to each individual. Maximizing this Bergsonian utility function subject to a household budget constraint generates centralized household demands that, in a Pareto efficient household, give the same demands obtainable from a decentralized household program. According to (Samuelson, 1956), the notion of household utility function is quite unclear since households often consist of more than one individual. Consequently, the theory suggests maximization of happiness of a representative agent (e.g. a household head). This is because if one maximizes the happiness of the representative agent such as the household head, one increases overall welfare of the entire household. Thus, the use of a Bergson Samuelson welfare function (BSWF) is an appropriate approach to aggregate household preference. In this case, it is assumed that the household maximizes a "household utility function" depending on total household consumption. Due to the nature of the data utilized in this study for which the unit of analysis is the household and unit of observation is the household head, an assessment of the household welfare metric approaches presented above makes the Bergsonian utility approach to estimating household welfare a more appropriate for this study. Consequently, this study formulates the empirical models in the framework of the theoretical household welfare function suggested by Samuelson.

### 2.4. A Review of Related Empirical Literature

In a related study done on Uganda, (Tuyiragize and Bassi, 2023) launched a study that aimed at identifying classes and patterns of household energy utilization and examining predictive factors of household class membership while focusing on two main indicator variables for energy consumption, that is, cooking and lighting. The study utilized secondary data from the 2019/2020 Uganda National Household Survey (UNHS) on a sample of 2,138 households. The unit of observation was the household head. The study employed latent class analysis modelling and identified four latent household classes, namely: "Solar-firewood," "Electricity-charcoal," "Moderate energy" and "Low energy-user." Results from the study revealed that the main drivers of household energy choice for cooking and lighting were age, education level, housing conditions and wealth status of the household head.

(Chen et al., 2017) investigated the welfare impacts brought about by the purchase of a popular home solar system, "D20g" in Uganda. The study estimated the effects of the "D20g" using a prospective individual-level matching approach, which entailed matching purchasers of the system to similar households outside of the marketing area for the "D20g." The study found substantial impacts of energy spending, with treatment households saving approximately 1.40 USD/week, which corresponded to 77% of the comparison group's weekly energy expenditure. Improved self-reported health and safety outcomes were noted, as treatment households reported fewer lower incidence of coughing by 9% points.

(Mawejje and Mawjje, 2016) examined the causal relationship between electricity consumption and sectors as well as aggregate output growth in Uganda using quarterly data spanning from 2005 to 2015. The study focused on the agriculture, industry and services sectors. Vector Error Correction (VECM) technique was used to estimate the long-run relationship and applied Granger causality tests after Vector Autoregression (VAR) to determine the direction of this relationship. Findings indicated long-run unidirectional causality running from electricity consumption to GDP at an aggregate level, while at the sectoral level, results indicated long-run causality running from electricity consumption to industry; a unidirectional short-run causality running from services sector to electricity consumption; and neutrality in the agricultural sector.

(Drazu et al 2015) investigated the patterns of energy consumption for domestic buildings in urban areas of Uganda. This study investigated the range of energy sources employed by households, the level of consumption of energy as well as common appliances and equipment in use. The study used cross sectional data for 79 households collected using questionnaires and assessed the electrical bills, documented electrical equipment used within dwellings as well as the time and duration of electricity use. Analysis was achieved by descriptive statistics. Findings suggested strong demand for energy, largely from solid fuel sources, with most households making use of either firewood or charcoal or both for cooking.

(Yapyeko, 2023) utilized panel data derived from the four rounds of the Uganda National Surveys 2019/2020, 2017/208, 2015/2016 and 2013/2014 to examine the relationship between income inequality and household welfare in Uganda. Using household consumption expenditure and poverty level as proxies for household welfare, while the Gini coefficient was used to measure income inequality. Panel Fixed effects and Panel random effects estimation techniques were employed in the analysis. Results show that income inequality predicted household welfare with households in lower income thresholds being associated with poor household indicators.

(Emmanuel and Japhet, 2021) investigated the impact of rural electrification on Ugandan women's empowerment. Using a panel model approach involving household and community data collected over two waves of Uganda National Panel survey (UNPS) for the periods of 2010/2011 and 2011/2012. Estimation was done by panel fixed effects model. Results showed that Women who lived in electrified households were more likely to have both higher total household incomes and total household asset values. Results further showed that having electricity access was associated with a fewer number of dependents within the household, and that Women who lived in households located urban regions were more likely to use electricity.

(Buyinza and Jakob, 2018), investigated the impact of household electrification on educational outcomes in Uganda. Education outcomes variable was measured as a binary dependent variables taking the value of "1" if a child *i* from household j was enrolled in school at time t, and "0" otherwise. Using a household panel data of the Uganda National Panel Surveys for five waves: 2005/6, 2009/10, 2010/11, 2012/13 and 2015/16. Estimation was achieved by employing a panel probit estimator. Findings indicated that electrification increases school enrolment at all education levels, and that electricity connection to household significantly affected female's education than their male counterparts.

(Njoh et al., 2022) examined the relationship between electricity consumption and improvement in women's welfare in Africa. The main focus was that increased electricity consumption can improve women's welfare, measured in terms of the UNDP Gender Development Index (GDI) and electricity consumption in kilo-Watt hours (kWh) of electricity consumed per capita. The study employed the log linear panel regression techniques. The results confirmed the hypothesis of a positive relationship between electricity consumption and improvement in women's welfare in Africa.

Using the 2015 Cambodia Socio-Economic Survey (CSES) data, (Phoumin et al., 2020) investigated the impacts of electricity consumption on household welfare and impacts of electricity consumption on the environment in Cambodia. Household welfare was measured by two proxies: Household earnings and school performance of the children in the household. Regressions were estimated by the instrumental variable estimation techniques. Findings revealed that accessing and using electricity provided opportunities for income-generating activities for the household and also increased human capital development of the household. Further, that biomass was dominant source of energy supplying 78% of the residential sector among the Cambodian households in the year 2015, that households with access to electricity and with ability to spend on electricity consumption, realized positive household welfare effects through reduction of biomass consumption.

A study by (Litaaba-Akila et al., 2023) assessed the effects of energy poverty on household welfare in Togo. It is related to the current study because energy poverty is highly associated with energy consumption. It used cross sectional secondary data from the 2018 Harmonized Household Living Conditions Survey of Togo. Household welfare was measured as a binary subjective variable and employed logistic regression to estimate the empirical model. Findings affirmed that energy poverty reduced household welfare. More specifically, estimates from the study indicated that a 1% increase in energy poverty was associated with a 0.27% decrease in welfare.

Study by (Mduduzi, B. & Talent, Z. (2018) established significant determinants of household welfare by education of the household head, dependency ratio, gender of the household head, employment status and marital status in south Africa. Van Hove and Johnson (2021) established significant differences in household energy access and consumption in refugee camps of Northern Uganda, where electricity use was mainly for energy needs e.g. lighting and phone charging.

## 3. MATERIALS AND METHODS

The study followed a quantitative approach, adopting a triangulation and the longitudinal research designs. Panel data of the Uganda National Panel Surveys (UNPSs) for four waves: 2019/2020, 2017/2018, 2015/2016 and 2013/2014 from the Uganda Bureau of Statistics (UBOS) was used.

UBOS collects data using a two -stage sampling design from the wave population, where balanced a panel population was included in the study. The four waves have been preferred because they provide a credible panel dimension in which individuals are followed up over a substantial period of time and give a fairly large longitudinal sample size on the individuals on whom data has been collected. The unit of analysis in this study is a household and unit of observation is the household head. The unit of observation is appropriate for this study because it is consistent with the theoretical model that, which anchors this study. The study analyzed a total sample of 9,959 of the household heads that were consistently followed over the four waves of the UNPS considered for analysis in this study.

This study employed the Bergson-Samuelsson Social Welfare Function (BSSWF) as the main theoretical anchor. This theory posts that the maximization of happiness of a representative agent such as a household head will eventually maximize the household happiness. In more generalized form, but there are numerous sets of sufficient conditions under which such a consumer will exist (Leary et al., 2020; Dow and Werlang, 1985). The key assumptions of BSSWF are that preferences are identical and homothetic and that income distribution is fixed among members of the household. Thus, when the utility of the representative agent increase, the household members' welfare increases generally. This theoretical assumption works well in households of typical developing economies like Uganda, where household heads are typically the bread winners as well as sole decision makers.

### 3.1. The Econometric Model Estimation

To measure the change in household welfare due energy consumption, this study follows the econometric modelling approach adopted, among others, by (Widodo, 2006; Tilakaratna, 2006; Grace, 2020), and specified a model of the form:

$$Y_{1,it} = \alpha_{10} + \alpha_{11} X_{1,it} + \sum_{j=1}^{m} \alpha_{1j} Z_{it} + \varepsilon_{1t} \quad (1)$$

Where, ($Y$) represents the adopted proxy variable for household welfare (which is the dependent variable under investigation); ($X_1$) represents energy consumption which is the key independent variable under investigation; (Z) represents a vector of control variables and ($\varepsilon_{i,t}$) is the residual element at time (t).

Let $Y_{it} \Gamma + X_{1it} \beta = Z_{it} \delta$, equation (1) can then be re-written as:

$$y_{it} = Z_{it} \delta + \mu_i + v_{it} \quad (2)$$

Where $\delta$ is a K by 1 vector of coefficients, such that K = $m$ + $k$. Assume that there will be a 1 by $k$ vector of observations on the $k$ instruments in $X_{2it}$, the order condition in the IV estimation of the panel model is satisfied if $k \geq m$.

Considering theoretical rudiments of Instrumental variables models described in equations (1) – (2), the empirical model estimation that addresses objective one of this study is specified ad follows:

The empirical model for empirical estimation was specified as a Log-linear equation as follows:

$$Log\left(consexp_adulteq\right)_{it} = \delta_0 + \delta_1 log(hhenergycons)_{it} + \delta_2\, hhelectraccess_{it} + \delta_3\, hhsize_{it} + \delta_4\, hhresidence_{it} + \delta_5\, hhdepratio_{it} + \delta_6\, hhhgender_{it} + \delta_7\, hhhincome_{it} + \delta_8\, hhlbrforce_{it} + \sum_{i=1}^{q-1}\theta_i\, hhheduc_{it} + \sum_{j=1}^{q-1}\theta_j hhhemploysector_{it} + \sum_{k=1}^{q-1}\theta_k hhadultcomp_{it} + \varepsilon_{1t} \quad (3)$$

In equation (2), *Log*(*consexp_adulteq*) represents logarithm of consumption expenditure per adult equivalent, *Log*(*hhenergycons*) represents logarithm of household's energy consumption, *hhelecaccess*represents household's access to electricity, *hhsize* represents household size, *hhresidence* represents household residence, *hhdepratio* represents dependency ratio, *hhhgender* represents gender o the household head, *hhheduc* represents education level of the household head, *hhhemploysector* represents sector of employment of the household head, *hhadultcomp* represents household composition, *hhlbrforce* represents household labour force, *hhhincome* represents total income of the household head and $\epsilon$ represents the residual element, ($\Sigma$) sign is used on categorical regressors that have more than two categories and $(q-1)$ represents the maximum number of included categories of the categorical regressors.

In equation (3), the regressors: "*hhelecacces*" and "*hhenergycon*" are the endogenously determined explanatory variables which are to be instrumentized. The endogeneity of "*hhelecacces*" is assumed to originate from measurement errors (i.e. the binary measure of electricity access is likely to be a poor proxy measure of electricity access) while the endogeneity of "*hhenergycons*" is assumed to originate from simultaneity with the dependent variable.

### 3.2. Selection of the Estimation Technique

There is empirical evidence that welfare and electricity are simultaneously determined. This creates endogeneity concerns arising from electricity related explanatory variables that are included in the welfare model the energy consumption explanatory variable. The Two-Stage Least-Squares Fixed Effects Estimator (2SLS-FE) and the Two-Stage Least-Squares Random Effects Estimator (2SLS-RE) to address endogeneity issues. Implementation of the Hausman specification test (Hausman, 1978) the 2SLS-FE was a preferred estimator for the empirical model:

The model variables, variable notations, variable definition and units of measurement, expected signs of the coefficients on the independent variables and data sources for each variable are all summarized in [Table 1] as follows;

**Table 1: Operationalization of the model variables**

| Variable Name | Notation | Variable type | Variable definition and units of measurement | Expected sign | Data source |
|---|---|---|---|---|---|
| Dependent variable | | | | | |
| Consumption expenditure per adult equivalent | *consexp_ adulteq* | Quantitative and continuous | Household per capita expenditure per month, adult equivalent (UGX) | NA | UNPSs (UBOS |
| Independent variables | | | | | |
| Energy consumption | *hhenergycons* | Quantitative and continuous | Household's monthly total expenditure on all fuels (UGX) | + | UNPSs (UBOS |
| Household size | *hhsize* | Quantitative and discrete | Number of persons lining in the household (Count) | - | UNPSs (UBOS |
| Location of household residence | *hhresidence* | Dummy | 0=Rural<br>1=Urban<br>Ref: Rural | +/− | UNPSs (UBOS |
| Dependency ratio | *depratio* | Quantitative and continuous | Ratio of non-employed to employed household members (ratio) | + | UNPSs (UBOS |
| Gender of the household head | *hhhgender* | Dummy | 0=Female<br>1=Male<br>Ref: Female | +/− | UNPSs (UBOS |
| Education attainment of the household head | *hhheduc* | Categorical | 0=No education<br>1=Primary Education<br>2=Secondary Education<br>3=TVET Education<br>4=University Education+Ref: No Education | +/− | UNPSs (UBOS |
| Sector of employment of the household head | *hhhemploysector* | Categorical | 0=Agriculture<br>1=Industry<br>2=Services<br>Ref: Agriculture | +/− | UNPSs (UBOS |
| Household adult composition | *hhcomposition* | Categorical | 0=Only female adults<br>1=Only Male adults<br>2=Female and Male adults<br>Ref: Only female adults | +/− | UNPSs (UBOS) |

Source: Author's compilation

**Table 2: Descriptive statistics on consumption expenditure per adult equivalent (in UGX per month) of the households in the sample**

| Statistic | Obs | Mean Value | Minimum value | Maximum value | CV |
|---|---|---|---|---|---|
| Wave 5: 2013/2014 | 2,449 | 65,371 | 6,367 | 4,036,518 | 1.526 |
| Wave 6: 2015/2016 | 2,632 | 109,298 | 8,713 | 5,820,494 | 1.495 |
| Wave 7: 2018/2019 | 2,444 | 113,405 | 5,484 | 10,500,100 | 2.279 |
| Wave 8: 2019/2020 | 2,418 | 138,067 | 9,010 | 2,047,018 | 1.142 |
| Overall | 9,943 | 106, 485 | 5,484 | 10,500,100 | 1.697 |

Source: Author's compilation from analysis of raw data. Consumption expenditure per adult equivalent is measured in 2009/10 prices per month)

**Take 3: Descriptive statistics on "energy consumption expenditure" (UGX per month) by households in the sample**

| Statistic | Obs | Mean value | Minimum value | Maximum value | CV |
|---|---|---|---|---|---|
| Wave 5: 2013/2014 | 2,449 | 9,677 | 0 | 255,600 | 1.766 |
| Wave 6: 2015/2016 | 2,648 | 8,766 | 0 | 425,000 | 1.950 |
| Wave 7: 2018/2019 | 2,444 | 9,185 | 0 | 800,000 | 3.066 |
| Wave 8: 2019/2020 | 2,418 | 9,123 | 0 | 225,000 | 2.106 |
| Overall | 9,959 | 9,178 | 0 | 800,000 | 2.269 |

Source: Author's compilation from analysis of raw data. Energy consumption expenditure is measured in UGX per month)

## 4. FINDINGS AND DISCUSSION

### 4.1. Descriptive Statistics on the Study Variables

The descriptive statistics are displayed on the adopted household welfare indicator as well as on the main independent variable under investigation in this study. The descriptive statistics of interest are the number of observations, the mean values, minimum values, maximum values and the coefficient of variation.

Table 2 shows the summary of the descriptive statistics of interest on consumption expenditure per adult equivalent which has been used as an indicator of household welfare in this study while Table 3 shows the summary of the descriptive statistics of interest on energy consumption which is the key independent variable under investigation.

Analysis of the descriptive statistics displayed in Table 2 indicate that the mean values on consumption expenditure per adult equivalent of the households has been following an upward trend from the 2013/2014 UNPS all through to 2019/2020 UNPS. This result suggests that, on average, households have been experiencing improving welfare over the four waves, as indicated by increasing average consumption expenditure per adult over the same time period. Table 2 further show that over times, the overall mean consumption expenditure per adult equivalent of the was UGX 106,485 per month with the minimum monthly consumption expenditure per adult equivalent of UGX 5,484 and the maximum monthly consumption expenditure per adult equivalent of UGX 10,500,100. Further analysis of raw data reveals that both the minimum and the maximum monthly consumption expenditure per adult equivalent were recorded during the 2018/2019 UNPS. The coefficient of variation (CV) estimates indicated in Table 2 exceeded one, indicating larger sizes of the standard deviations in consumption expenditure per adult equivalent relative to their mean values suggesting somewhat greater dispersion in the household consumption expenditure per adult equivalent around the mean values across the four waves of the sample studied.

Statistics in Table 3 indicate that over the four-wave period of the sample, the mean monthly energy consumption expenditure by Ugandan households was UGX 9,178. Wave by wave, statistics in Table 3 show that the mean monthly energy consumption expenditure was highest during the 2013/2014 UNPS recorded at UGX 9,677 and the lowest mean energy monthly consumption expenditure was recorded at UGX 8,766 during the 205/2016 UNPS. Household monthly energy consumption expenditure ranged from a minimum on Ug. Shs 0 to a maximum of Ug. Shs

**Table 4: Multicollinearity test results: The VIF estimates**

| Logarithm of household consumption expenditure per adult equivalent | | |
|---|---|---|
| **Independent variable** | **VIF** | **1/VIF** |
| Logarithm of energy consumption | 1.23 | 0.8104 |
| Access to electricity | | |
| HH has access | 1.27 | 0.7880 |
| Ref: HH has no access | | |
| Household size | 2.46 | 0.4062 |
| Location of household residence | | |
| HH is in Urban | 1.35 | 0.7406 |
| Ref: HH is in rural | | |
| Dependency ratio | 1.26 | 0.7928 |
| Gender of the household head | | |
| HHH is male | 1.87 | 0.5346 |
| Ref: HHH is female | | |
| Education level of the household head | | |
| Some Primary Education | 2.64 | 0.3793 |
| Completed Primary Education | 2.06 | 0.4866 |
| Some Secondary Education | 2.17 | 0.4614 |
| Completed secondary education | 1.61 | 0.6208 |
| Post-secondary education | 2.03 | 0.4925 |
| Ref: No formal Education | | |
| Sector of employment f the household head | | |
| Industry | 1.12 | 0.8954 |
| Services | 1.10 | 0.9112 |
| Ref: Agriculture | | |
| Household Adult Composition | | |
| Only Male Adults | 1.88 | 0.5332 |
| Female and Male Adults | 2.43 | 0.4116 |
| Ref: Only female adults | | |
| Household Labour force | 2.28 | 0.4380 |
| Total income of the household head | 1.22 | 0.8219 |
| Mean VIF=1.76 | | |

Source: Generated by the author from data analysis

800,000, indicating that in all the UNPSs, the minimum household monthly energy consumption expenditure was UGX 0 suggesting that there were households who, in a given month, spent nothing on energy (zero total expenditure on all fuels) to fulfil their household energy needs. This could be attributed households with access to alternative energy sources at a free cost from their environment such as crop residues and firewood for cooking. At the same time there are households who depend on natural resources such as sunlight as a sole source of lighting, yet there are other households who do not need energy for such activities like ironing, energy for powering electronics such as radios, televisions and refrigerators. In a nutshell, zero monthly energy consumption expenditure suggest that there are Ugandan households who have subsistence energy access for their energy needs. Further analysis of statistics in Table 3 shows that the coefficient of variation on household's monthly energy consumption expenditure is greater than one in each of the waves considered in this study, which suggests large variability in the household's monthly energy consumption expenditure relative to their mean monthly energy consumption expenditures.

### 4.2. Multicollinearity Checks in the Empirical Model

Having multivariable linear regressions for empirical estimation, becomes pertinent to conduct multicollinearity to assess the degree of linear relationships among the explanatory variables. The study assesses the level of multicollinearity in the empirical models by estimating the variance inflation factors (VIFs) for each explanatory variable, (Kim, 2019; Jongh et al., 2015). This study bases on the threshold mean VIF of 10 such that mean VIF >10 would indicate severe multicollinearity which would call for redress in the model. The estimates of the VIFs are conducted in each empirical model is as summarized in Table 4.

Table 4 indicates all the individual explanatory variables in the model have a VIF estimate <10. In addition, the mean VIF (mean VIF=1.76) is also <10. This indicates low levels of linear relationships among the explanatory variables in the empirical model. Suggesting that there is no high multicollinearity among the explanatory variables in the empirical model that would affect the efficiency of the model to be used in estimations.

**Table 5: Regression estimates of the empirical model**

| Dependent variable: Logarithm of household consumption expenditure per adult equivalent | | | | | | |
|---|---|---|---|---|---|---|
| **Independent variable** | **Model 1: 2SLS-FE** | | | **Model 2: 2SLS-RE** | | |
| | **Coefficient** | **Standard error** | **P-value** | **Coefficient** | **Standard error** | **P-value** |
| Logarithm of energy consumption | 0.1415*** | 0.05261 | 0.007 | 0.1716*** | 0.03157 | 0.000 |
| Access to electricity | | | | | | |
| HH has access | 0.4723*** | 0.07919 | 0.000 | 0.7007*** | 0.07623 | 0.000 |
| Ref: HH has no access | | | | | | |
| Household size | −0.0588** | 0.01002 | 0.000 | −0.0363** | 0.01189 | 0.002 |
| Logarithm of HH income | 0.0843* | 0.04499 | 0.061 | 0.0467 | 0.03984 | 0.241 |
| Location of HH residence | | | | | | |
| HH is in Urban | −0.1896 | 0.1249 | 0.129 | −0.2594** | 0.08932 | 0.004 |
| Ref: HH is in Rural | | | | | | |
| Dependency ratio | −0.0643* | 0.04674 | 0.096 | −0.0141 | 0.02119 | 0.506 |
| Gender of the HHH | | | | | | |
| HHH is male | 0.0022 | 0.0788 | 0.978 | 0.0167 | 0.06989 | 0.811 |
| Ref: HHH is female | | | | | | |
| Education level of the HHH | | | | | | |
| Some Primary Education | 0.1151 | 0.09237 | 0.213 | 0.1582* | 0.09340 | 0.090 |
| Completed Primary Education | 0.1954** | 0.09901 | 0.048 | 0.2018* | 0.10517 | 0.055 |
| Some Secondary Education | 0.3011*** | 0.09598 | 0.002 | 0.2908*** | 0.10271 | 0.005 |
| Completed secondary education | 0.3118** | 0.13942 | 0.025 | 0.2749** | 0.12839 | 0.032 |
| Post-secondary education | 0.5945*** | 0.10281 | 0.000 | 0.5889*** | 0.11127 | 0.000 |
| Ref: No formal Education | | | | | | |
| Sector of employment of the HHH | | | | | | |
| Industry | 0.1022 | 0.06354 | 0.108 | 0.0288 | 0.07416 | 0.698 |
| Services | 0.1503 | 0.06382 | 0.019 | 0.1449** | 0.06197 | 0.019 |
| Ref: Agriculture | | | | | | |
| HH Adult Composition | | | | | | |
| Only Male Adults | 0.2930** | 0.13124 | 0.026 | 0.3606** | 0.14779 | 0.015 |
| Female and Male Adults | −0.0289 | 0.08829 | 0.744 | −0.0382 | 0.10280 | 0.710 |
| Ref: Only female adults | | | | | | |
| HH Labour force | 0.0600*** | 0.01610 | 0.000 | 0.05057*** | 0.01825 | 0.006 |
| | | R-squared: Within=0.6888 Between=0.8007 Overall=0.6191 | | | R-squared: Within=0.6336 Between=0.8662 Overall=0.6056 | |
| | | | Hausman specification test Ho: The RE model is well specifies Chi-square statistic=169.60 (P=0.000) | | | |

Source: Compiled by the author from empirical regressions. ***P<0.01; **P<0.05; *P<0.1

### 4.3. Regression Estimates

To control for endogeneity bias arising from potential endogenous explanatory variables in the empirical model, the model is estimated by two variants of the instrumental variable estimators: the two-stage least-squares fixed effects estimator (2SLS-FE) and the two-stage least-squares random effects estimator (2SLS-RE). The regression estimates are summarized in Table 5.

### 4.4. Selection of the Preferred Model Estimates

Under the null hypothesis that the 2SLE-RE is a preferred model, the estimated Chi-square statistic from the Hausman test rejects this null hypothesis at 5 percent level of significance (Chi-square = 169.6, P = 0.000). This result suggests that the 2SL-FE is the most appropriate model to estimates the empirical model for the study. The study therefore bases on the 2SL-FE estimates for further interpretation of the regression estimates, discussion of the findings and deriving of the policy recommendations.

### 4.5. Findings on the Causal Effect of Energy Consumption on Household Welfare

The regression estimates from the preferred 2SLS-FE model as summarized in Table 5 indicate that the estimated partial slope coefficient on the energy consumption variable is positive and statistically significant at all the conventional testing levels (Coefficient = 0.1415; P = 0.000).

Results show that when the households' energy consumption levels increase by 1%, its give rise to 0.14% increase in the Consumption Per Adult Equivalent among the Ugandan households, other factors constant.

Result suggests that energy consumption levels explain variations in the levels of consumption Expenditure Per Adult Equivalent, and hence household welfare, among households in Uganda. This is consistent with (Mawejje and Mawjje, 2016; Phoumin et al., 2020) and from improved health (Sambodo and Novandra, 2019) about the positive influence of energy consumption on household welfare and from consumption of luxury and recreational goods (Romero-Jordan et al., 2016).

Additionally, the improved household welfare arising from increased energy consumption levels among households may be associated with use of electricity channels like improved usage of lighting systems in households, increased utilization of media like radios and televisions, improved smartness of individuals due increased use of energy for ironing clothing and from improved cooking options in the households. Consistent with the results from this study, the positive influence of energy consumption on household welfare has been reported by (Njoh et al., 2022; Phoumin et al., 2020; Litaaba-Akila et al., 2023).

### 4.6. Further Findings of Interest from the Model Estimates

Table 5 further indicate that by using household consumption expenditure per adult equivalent as an indicator of household welfare, welfare reduces for households with larger household sizes; the households with formal education level experience a higher welfare relative to households with no formal education as post-secondary education level exerts the largest positive marginal effect on household welfare; the households with only male adults experience a higher welfare relative to households with only female adults and that larger household labour force (14-64 years) has the ability to influence a better welfare among the households in Uganda.

## 5. CONCLUSION AND POLICY IMPLICATIONS

While using household consumption expenditure per adult equivalent as an indicator of household welfare, this study aimed at investigating the effect of energy consumption levels on consumption expenditure per adult equivalent among households. Results show that energy consumption levels by households have positive and significant positive and significant joint effect on consumption expenditure per adult equivalent households in Uganda. Findings suggest that energy consumption levels positively impact on the welfare of the households in Uganda. Further findings reveal that household welfare increasing factors are such factors such as smaller household sizes, having some formal education, household's composition with only male adults and larger household labour force.

Findings from this study suggest that household consumption expenditures per adult equivalent (and hence household welfare) can be enhanced if government continues its campaigns of ensuring and supporting the household-income enhancing programs which could empower the households increase their energy consumption levels and hence enjoying better welfare.

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