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Energy consumption, weather fluctuation, and household composition in the Philippines

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Abstract

Using a discrete/continuous modeling approach, the total energy consumption for a benchmark household is predicted and the consumption with heat index deviation relative to the consumption without is also analyzed. This paper finds that weather fluctuations and household composition are important factors in energy consumption. Based on the prediction exercises, the paper finds that the increase in the consumption of electricity, LPG, and charcoal is mainly driven by the consumption of female-headed female-majority households, female-headed male-majority households, and female-headed balanced households, respectively. While the paper cannot provide concrete evidence on the channels why this is the case, the combined effects of traditional gender roles and headship as sources of strong bargaining power in the household can potentially explain the results.

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1 Introduction

The world has experienced a rapid increase in energy consumption and much of it takes place in Asia[1]. Based on Enerdata's Energy Statistical Yearbook, Asia's energy consumption in 2017 accounts for 42% of the total energy consumption in the world and accounts for 69%, 44%, and 35% of the total coal, electricity, and oil consumption, respectively. Much of these energy consumption can be attributed to China due to its industrialization efforts and sustained economic growth. Indonesia, Thailand and South Korea also contribute to oil consumption while electricity consumption is also increasing in India, Indonesia, South Korea, and Japan.

In the Philippines, the total final energy consumption (TFEC) reached 33.1 MTOE in 2016, an increase of 8.4% from its 2015 level (Department of Energy, n.d.). Among the sectors, transportation accounts for 37% of the TFEC in 2016 and is followed by the residential sector at 27% and industry at 23%. Among the energy sources, the TFEC of petroleum products is the highest at 16.3 MTOE (43% of TFEC) in 2016. That of biomass and electricity is 7.2 MTOE and 6.4 MTOE, respectively.

Focusing on the residential TFEC, the observed increase from 2015 to 2016 is attributed to the increased use of electricity and Liquefied Petroleum Gas (LPG) although biomass (fuelwood, charcoal, and agriwaste) continues to account for the largest portion of the TFEC by energy sources (63%) due to its affordability, abundance, and accessibility especially in rural areas (Department of Energy n.d.). The increase in the use of electricity is attributed to increasing incomes and the government's electrification efforts (Department of Energy n.d.).

There are several trends that will likely affect the energy consumption of Filipino households. First, the population in the Philippines is expected to grow and the number of households is expected to increase to 35.1 million in 2040 (Department of Energy n.d.). Second, the country is at risk to natural disasters like tropical cyclones and storm surge and has experienced extreme shifts in weather patterns and slow-onset extreme climate shifts such as EL Nino and La Nina. The country is the fifth most risk-prone country in the world in the period 1994-2013 (Asian Development Bank 2017) and one of the top ten countries most affected by extreme weather events in terms of fatalities and economic losses (Eckstein et al 2018). Third, energy prices are increasing as a result of various factors such as external shocks in the oil and coal world markets and the increasing demand in the Philippines that is heightened by the changing weather patterns.

Due to the residential sector's potential contribution to energy saving measures, it is important to analyze patterns and drivers of the households' energy consumption and this will inform the measures needed to conserve energy and reduce carbon footprints in the process. In addition, this will inform policies related to the planning of energy supply and the development of other energy sources. In the Philippines, some research on drivers of the households' energy consumption are done, which are centered mostly on income (Terrence and Remedio 1995, Garcia et al 1994), although some also investigate the effects of weather (Bayudan-Dacuycuy 2017).

[1] From 2109 million tonnes oil equivalent (MTOE) in 1990 to 5755 MTOE in 2017.

The current research investigates the effects of dwellers' attributes, with a particular focus on gender. This is an important area of analysis on several grounds. *First*, households use different energy sources for different needs. There is already evidence from the literature that energy consumption is affected not only by income and prices (Halvorsen and Larsen 2001, Schipper et al 1985, Archibald and Gillinghan1980) and dwelling attributes and weather (Junk et al 1987, Meyers and Schipper 1984, Schipper and Ketoff 1983) but also by dwellers' attributes. Druckman and Jackson (2008), for example, find that while household fuel use and carbon emissions are both strongly related to income levels, the type of dwelling, tenure, household composition, and rural/urban location are just as important. Santin et al (2009) find that household characteristics and the behavior of occupants account for the variation in energy demand for space and water heating after controlling for dwelling attributes. Other occupant-related attributes include age (Lenzen et al 2004, O'neill et al 2002), household size (Lenzen et al 2004), education (Junk et al 1987), and ethnic groups (Hackett and Lutzenhiser 1991).

Household segmentation, based on household size, income, head's age, and household's geographical location, is also an important factor in energy consumption (Hayn et al 2014). Segmentation based on the gender composition of household members may also play a role. For example, women/girls are more likely to stay at home while men/boys are more likely to go out to work or play and these differences can drive a wedge on the patterns of energy choice and consumption. In the Philippines, a large proportion of women is in-charge of food preparation, house cleaning, and child care duties (Bayudan 2006).

Second, weather shocks are known to affect men and women differently and the different effects are the likely result of the different roles each gender play in the society. For example, Charmes (2006) finds that both men/boys and women/girls collect firewood but asserts that majority of women/girls are involved in food preparations. In this case, the type of energy sources used for cooking affects the welfare and productivity of women and children. Using biomass, fuelwood, or charcoal emits particulates that can cause respiratory illnesses. Using charcoal is inefficient and it affects the time that children and women allocate to productive endeavors.

Third, weather is an integral part of our lives and it is certainly relevant in energy consumption. Electricity consumption is lower when it is raining because there is less need for cooling. Fuelwood, charcoal, and biomass (residues from corn, rice, sugarcane, and coconut) consumption may be lower due to supply constraints during rainy season. The LPG consumption may be affected due to damaged infrastructures resulting from landslides and heavy rains. There is evidence that the variability in weather patterns is a result of climate change, the adverse effects of which is documented to hit the Philippines the most.

2 Theoretical framework and empirical strategy

Based on the 2011 Household Energy Consumption Survey (HECS), a survey conducted by the Philippine Statistics Authority, majority of households have zero consumption of energy sources except electricity (figure 1). Given this, a plausible empirical strategy is to use the discrete-continuous approach to model energy choice and energy consumption. In this approach, the first decision is the choice whether to use a specific energy source (energy choice). Conditional on this choice, households will then decide how much of the energy source will be consumed (energy consumption). Variables related to weather are included to analyze their effects on energy choice and energy consumption and this strategy is applied on a cross-sectional dataset.

The use of cross-section data to analyze the effect of climate/weather on various outcomes is widely criticized. Auffhammer and Mansur (2014), for example, argue that estimates exploiting the cross-sectional variation in climate are subject to omitted variables bias. This is the bias resulting from the correlation of the unobservable characteristics of households and climate and is corroborated by Albouy et al (2013) who find that northern households are less tolerant of heat than southern households in the US. This issue is mitigated in the case of the Philippines since the country is located in the tropics and has two seasons only, wet and dry, and households' unobserved characteristics are less likely to be systematically correlated with their geographical location. The use of panel data to understand the dynamics of consumer choices in the face of climate/weather change is preferred in the literature (see for example, Dell et al 2014). Unfortunately, longitudinal household data on energy in the Philippines are not available and this is a limitation of the paper that we acknowledge at the outset.

To motivate the use of the discrete-continuous approach, households are assumed to have the utility function: $u = u(Q,b,z,s,e)$. Q is a vector of energy type, z is a numeraire, b is a vector of characteristics of Q, s is a vector of household characteristics and e is an unobservable component. In the context of discrete-continuous choice modeling, the discrete choice is to decide if Q is zero or not while the continuous choice is to decide how much Q to consume (Vaage 2000).

If household chooses energy f, Hanemann (1984) states that the conditional utility function associated with energy type f is $\bar{u}_f = \bar{u}_f(Q_f, b_f, z, s, \varepsilon)$ subject to $p_f Q_f + z \leq y$ where p_f is the price of energy f, y is income, and the rest is as defined above. Given the available data, f includes electricity, LPG, charcoal, biomass, and fuelwood. Mansur et al (2008) define the conditional indirect utility function as $\bar{v}_f(p_f, b_f, y, s, e) = \bar{u}_f[\bar{Q}_f(p_f, b_f, y, s, e), b_f, z(p_f, b_f, y, s, e), s, e]$. Applying Roy's identity, the conditional demand for energy f is $\bar{Q}_f(p_f, b_f, y, s, e) = -\dfrac{\partial \bar{v}(p_f, b_f, y, s, e)/\partial p_f}{\partial \bar{v}(p_f, b_f, y, s, e)/\partial y}$.

For the empirical implementation, we assume that the conditional indirect utility function for energy type f is $\bar{v}_f^* = x_f \delta_f + e_f$, where x is a vector of observable factors and e is an unobservable shock. $\bar{v}_f^*$ is not observed but v_f is and it is 1 if energy type f is chosen. To model energy choice, we use $\phi(Q_f > 0) = \Pr(Q_f > 0 \mid x) = F(x\delta)$ where δ is a vector of parameters associated with x while F is the cumulative distribution of an independent and identically distributed error term. The modeling strategy in this case is a Probit regression.

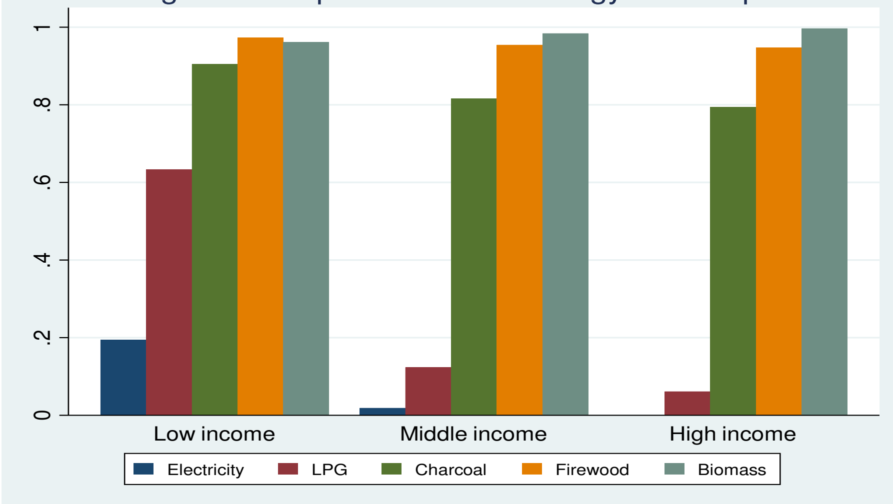

Figure 1: Proportion of zero energy consumption

The conditional demand for energy type *f* is then modeled as $\phi(Q_f \mid Q_f > 0, x) = g(x\gamma) + u_f$ where γ is a vector of parameters associated with the vector of explanatory variables *x*, u is an unobservable shock, *g* is the density function for $Q_f \mid Q_f > 0$. The modeling strategy adopted is a Generalized Linear Model (GLM).

Further, *x* is assumed to be a vector of demand shifters, $x = x(S, p_f, d)$, where *S* is weather shock, p_f is a vector of energy prices, and *d* is a vector of sociodemographic attributes. Following Mansur et al (2008), the welfare impacts of variability in weather on households' energy choice can be interpreted as the change in income necessary to keep the utility constant given weather variability. In the present context, this is $\Delta w = E(Q_f \mid x)_{S_1} - E(Q_f \mid x)_{S_0}$ where s_1 is the scenario with weather fluctuations and s_0 is the no shock scenario. Consumption-based measure of welfare is based on Samuelson's (1974) money metric utility, which measures levels of living by the money required to sustain them. The starting point is the standard utility maximization problem where households choose goods to maximize utility subject to a budget constraint. Deaton and Zaidi (2002) discuss that the "consumer preferences over goods are thought of as a system of indifference curves that can be labeled by taking a set of reference prices and calculating the amount of money needed to reach a utility level. The exact calculation of money metric utility requires information on preferences, which can be approximated from the cost function. By the known Shepard's Lemma, the derivative of this cost function with respect to prices is the quantity consumed." Building up on this, the literature has used household consumption as an indicator of household welfare (see for example, Skoufias et al 2012, Skoufias and Coady 2007, Thomas et al 2002, Deaton 1997).

Recognizing the varied factors affecting energy choices, van der Kroon et al (2013) develop a framework to explain energy choices and this framework revolves around three categories: *external environment* like climate and geographic location, *decision context* like government policies, and *household opportunity set* like socioeconomic attributes and culture/tradition. In this framework, the household opportunity set is often given a gender dimension. Decision context is related to the functioning of consumer markets. This set includes prices, reliability of supply, number of distributors, and transaction costs related to distance to markets. Closely related to the decision context is the external environment, which includes geographical location that largely determines access to consumer markets. These three categories are represented in the models as far as the data can accommodate.

Following the literature on double hurdle models, the energy choice equation for energy source *f* is:

$$\begin{aligned}\Pr(Q_f > 0) &= \beta_1 headsex + \beta_2 headage + \beta_3 headcoll + \beta_4 headjob + \beta_5 tothhmem + \beta_6 q\_bedroom \\ &+ \beta_7 q\_batthroom + \beta_8 q\_storey + \beta_9 urban + \beta_{10} heat\_elec + \beta_{11} heat\_lpg + \beta_{12} heat\_charcoal \\ &+ \beta_{13} heat\_others + \beta_{14} f1 + \beta_{15} f2 + \beta_{16} HID + \beta_{17} HIDsq + e\end{aligned} \tag{1}$$

and the conditional energy consumption equation for energy source *f* is:

$$\begin{aligned}E(Q_f \mid Q_f > 0) &= \beta_1 headsex + \beta_2 headage + \beta_3 headcoll + \beta_4 headjob + \beta_5 tothhmem + \beta_6 q\_bedroom \\ &+ \beta_7 q\_batthroom + \beta_8 q\_storey + \beta_9 urban + \beta_{10} heat\_elec + \beta_{11} heat\_lpg + \beta_{12} heat\_charcoal \\ &+ \beta_{13} heat\_others + \beta_{14} f1 + \beta_{15} f2 + \beta_{16} HID + \beta_{17} HIDsq + \beta_{18} income \\ &+ \beta_{18} p\_elec + \beta_{19} p\_lpg + \beta_{20} p\_charocal + \beta_{21} p\_others + u\end{aligned} \tag{2}$$

where *headsex*, *headage*, *headcoll*, and *headjob* refer to the household head's sex age, college education or greater, and whether the head has a job, respectively. The variables *tothhmem*, *q_bedroom*, *q_bathroom*, *q_storey*, and *urban* refer to the total household members, number of bedrooms, bathrooms and floors/storey, and urban dummy, respectively. The variables *heat_elec*, *heat_lpg*, *heat_charcoal*, *and heat_organic sources* are dummy variables to represent the use of electricity, LPG, charcoal, and organic sources for heating water.

HECS has detailed data on the household's use of electricity for lighting, cooking, ironing, laundry, and to power the radio, television, refrigerator, air conditioner, fan, pump, and other appliances. Detailed data are also available on the household's use of electricity, LPG, and organic sources for heating water. To aggregate such information, an index is constructed using the score generated by the principal component analysis (PCA)[2]. Positive scores generated by the PCA are associated with higher electricity usage. Based on the Kaiser criterion, two factors (referred to as *f1* and *f2*) are retained since these factors have eigenvalues greater than one. The overall Kaiser-Meyer-Olkin measure of sampling adequacy is 0.89, which indicates that the detailed data on the household's electricity use contain enough similar information to warrant the use of the PCA.

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[2] The PCA is a technique used to reduce the dimension of the data by creating uncorrelated indices or components, where each component is a linear weighted combination of the initial variables. The variance of each of the component is generated such that the first component contains the largest variation in the original data; the second explains additional but less variation and so on. For technical details, see Filmer and Pritchett (2001). An application of PCA is on household assets to create an indicator for socioeconomic status in the absence of income and expenditure data such as those found in Filmer and Pritchett (2001).

The variables *p_elec*, *p_lpg*, *p_charcoal*, and *p_organic sources* denote the price of electricity, LPG, charcoal, and organic sources, respectively. The variable *HID* is the difference between the current heat index from its normal values, the computation of which is discussed in section 3.

Equations (1) and (2) are simultaneously estimated using the *twopm* routine in Stata[3] following the empirical strategy outlined above and using three household types based on the gender composition of household members: male-majority, female-majority, and balanced. Male-majority households refer to households whose male members are at least 60% of the total household size. Female-majority households are analogous to the definition of male-majority. Balanced households are households with male and female members consisting 41%-59% of the total household size. The sample includes all households in the HECS, which are headed by persons 20-85 years old.

3 Data sources

This paper uses the 2011 HECS collected by the Philippine Statistics Authority and the weather data collected by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) through weather stations spread across the Philippines. We use dry bulb temperature (in degree Celsius, ºC) and relative humidity (in %) data to come up with a proxy for weather variability. The mapping of weather information with the HECS dataset follows Bayudan-Dacuycuy (2017).

Relative humidity can interact with temperature to form the heat index, which is a human discomfort index that measures the temperature that the human body perceives or feels. Since the climate in the Philippines is characterized by high temperature, high humidity, and abundant rainfall, the heat index appears to be an ideal weather variable that can be linked to consumption patterns of energy. Prolonged activity under the hot sun when the heat index is high can have severe consequences such as fatigue, heat cramps, heat exhaustion, and heat stroke. Hence, people may be cautious to go out when the heat index is high and this can have significant implications on households' energy choice and energy consumption.

The heat index (HI) is computed using the average of relative humidity and temperature collected by PAGASA in 2011[4]. Data on normal values, or the 30-year average, are used as long-

[3] Technical details of the estimator can be found in Belotti et al (2015). An alternative strategy is to use the Heckman selection model. Belotti et al (2015), however, argue that the zeros in the Heckman selection model are censored values of the positive outcome (e.g. wages that are not reported or top-coded) while the zeros in the 2-part model are true zeros. In this paper, consumption is computed using three sets of information (frequency of purchase, number of months, quantity). If these sets of information are consistently missing, then it is plausible that households have really nothing to report and we take this to mean as zero consumption.

[4] The temperature data are converted into Fahrenheit using $T_{(^0F)} = T_{(^0C)} * 9/5 + 32$. The heat index is then generated using the following formula from the National Weather Service-National Oceanic and Atmospheric Administration website:

run proxy. HI deviation (HID) is then generated by taking the difference between the 2011 HI and the normal HI. This represents the variability of weather from its long-run average and is potentially related to climate change, which manifests in altered patterns of weather parameters such as wild swings in rain and snow, melting glaciers, and rising temperatures resulting in drying out of some areas and in increased precipitation in others. The current HI is below (above) the normal HI when HID<0 (HID>0).

To recognize the nonlinear effects of the HID, HID squared is also used as an additional weather-related variable. Squaring the deviation puts more weight on observations that are very far from the long-run average. This may prove useful in providing a more complete characterization of the empirical effects of weather variables on energy choice and energy consumption.

4 Discussion of results

Based on the Probit-GLM estimates[5], the total energy consumption is predicted. To do this, the prediction is done for a benchmark household[6]: household head has a job (=1), use of electricity to heat water (=1), use of LPG to heat water (=1), and use of LPG to cook foods (=1). All continuous dependent variables take their mean values. Given these characteristics, total consumption of electricity, LPG, and charcoal are predicted given different values of heat index deviations. Positive (negative) values of HID mean that the heat index is higher (lower) than normal. Further, predictions on consumption are done for three household types (balanced, male-majority and female-majority) and for the following head sex-location configurations: female-headed in rural areas, male-headed in rural areas, female-headed in urban areas, and male-headed in urban areas.

To analyze the welfare change resulting from HI fluctuations, the difference between the total consumption when $HI = i \quad (i \neq 0)$ and $HI = 0$ is computed. The consumption differences (henceforth referred to as *relative consumption*) for electricity, LPG, and charcoal are presented in figures 2-4.

Relative to HID<0, figure 2 shows that the electricity consumption changes more when HID>0. Comparison across the three household types shows that balanced and female-majority

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$$\begin{aligned} HI = {} & 42.379 + 2.04901523*T + 10.14333127*R - 0.22475541*TR - 6.83783*(10\text{^}(-3))*Tsq \\ & -5.481717*(10\text{^}(-2))*Rsq + 1.22874*(10\text{^}(-3))*TsqR \\ & + 8.5282*(10\text{^}(-4))*TRsq - 1.99*(10\text{^}(-6))*TsqRsq \end{aligned}$$

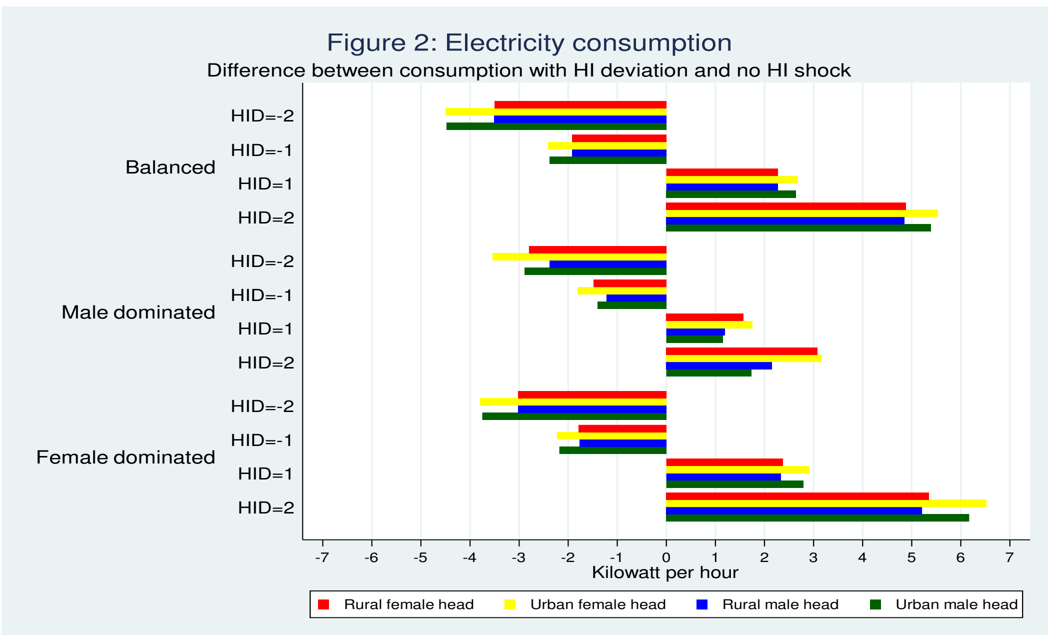
where T is temperature in Fahrenheit, Tsq is squared temperature, R is relative humidity in percentage, and Rsq is squared relative humidity. The formula to compute HI requires that relative humidity be in degree Fahrenheit. Once computed, we converted the HI into degree Celsius, since this is the measurement unit used in the Philippines.

5 The estimates are not presented due to space constraint but are available upon request.

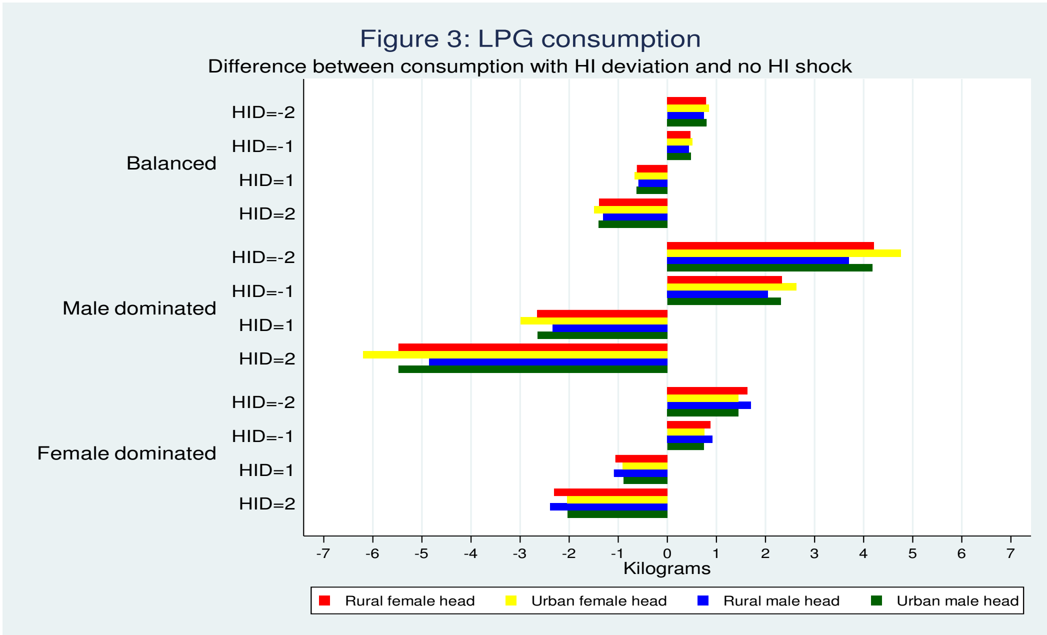
6 The marginal effects will likely vary over different values of HID. To investigate this, we evaluated the marginal effects at different points in the domain of HID. Only HID=1 and HID=-1are presented in the interest of space. But the marginal effects using profiles with other HI values below or above the normal are also computed and are available from the author upon request.

households have higher relative consumption than male-majority households. Results indicate that in the event of a 1 ºC HI fluctuation above the normal value, the electricity consumption of balanced and female-majority households is higher (than the no shock consumption) by around 3 kilowatt-hours (kWh) and by around 5-7 kWh in the event of a 2 ºC HI fluctuation above the normal value. The electricity consumption of male-majority households is higher by around 1.5 kWh.

In the event of a 1 ºC HI fluctuation below the normal value, the electricity consumption of balanced and female-majority households is lower (than the no shock consumption) by around 2 kWh while in the event of a 2 ºC HI fluctuation below the normal value, is lower by around 3.5-4.5 kWh. Comparison within balanced and female-majority households shows that the relative consumption of those in urban areas (both male- and female-headed) is higher than the relative consumption of those in rural places. However, for male-majority households, the relative consumption of female-headed households (both in urban and rural) is higher than the relative consumption of their male counterparts.

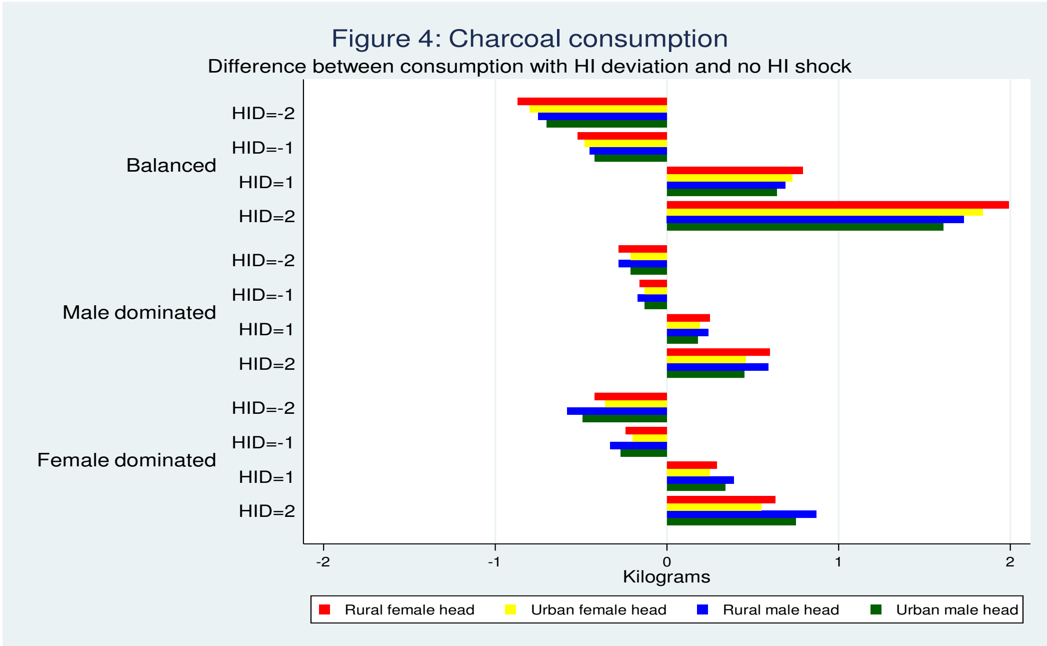


In contrast to the results above, the LPG consumption (shown in figure 3) changes more when HID<0. Comparison across the three household types shows that male-majority households have a relative consumption that is substantially higher than that of the balanced and female-majority households. Results indicate that in the event of a 1 ºC HI fluctuation above the normal value, the LPG consumption of male-majority households is lower (than the no shock consumption) by around 2-3 kilograms (kg) and by around 5-6 kg in the event of a 2 ºC HI fluctuation above the normal value. The LPG consumption of balanced and female-majority households is lower and is within the 1.5-2.5 kg interval for both HI fluctuation scenarios.



In the event of a 1 ºC HI fluctuation below the normal value, the LPG consumption of male-majority households is higher (than the no shock consumption) by around 2 kg and by around 4-5 kg in the event of a 2 ºC HI fluctuation below the normal value. The LPG consumption of balanced and female-majority households is within the 0.5-2 kg interval for both HI fluctuation scenarios. Comparison within male-majority households shows that those headed by female in urban areas have relative consumption that is higher than the other sex-location configurations. However, the relative consumption in balanced households is relatively similar across sex-location configurations.

Similar to results on electricity consumption, the charcoal consumption (shown in figure 4) changes more when HID>0. Comparison across the three household types shows that balanced households have relative consumption that is substantially higher than the relative consumption of male- and female-majority households. Results indicate that in the event of a 1 ºC HI fluctuation above the normal value, the consumption of balanced households is higher (than the no shock consumption) by around 0.5 kg and by around 1.5-2 kg in the event of a 2 ºC HI fluctuation above the normal value. The charcoal consumption of male- and female-majority households is higher by around 0.25-0.75 kg in both HI fluctuations scenarios.



In the event of a 1 ºC HI fluctuation below the normal value, the charcoal consumption of balanced households is lower (than the no shock consumption) by around 0.5 kg and by around 0.75 kg in the event of a 2 ºC HI fluctuation below the normal value. The charcoal consumption of male- and female-majority households is lower and is within the 0.25-0.5 kg interval for both HI fluctuation scenarios. Comparison within balanced households shows that those headed by female, both in urban and rural areas, have relative consumption that is higher than the consumption of their male counterparts. A similar observation is noted within male-majority households, except that the magnitude is substantially lower. Within female-majority households, male-headed households in urban and rural areas have relative consumption that is higher than the consumption of their female counterparts.

Table I: Predicted change in monthly fuel consumption, by HI fluctuations from the normal value

	HI Above normal		**HI Below normal**	
	1 ºC	2 ºC	1 ºC	2 ºC
Electricity (kWh)	33402 to 42678	68392 to 88360	-28561 to -37549	-51798 to -68908
LPG (kg)	-22421 to -27890	-48043 to -59164	18968 to 23849	34580 to 42942
Charcoal (kg)	6217 to 8308	15168 to 20104	-4357 to -5923	-7376 to -10045

Note: Figures are computed using the relative consumption figures for balanced, male-majority and female-majority households and using the base scenario. From HECS 2011, there are 5795 balanced households, 5928 male-majority households, and 5764 female-majority households.
Sample computation for electricity minimum value:
Balanced :N1=5795*femrurbaseelec, N2=5795*femurbbaseelec, N3=5795*malerurbaseelec, N4=5795*maleurbbaseelec
Male-majority :N1=5928*femrurbaseelec, N2=5928*femurbbaseelec, N3=5928*malerurbaseelec, N4=5928*maleurbbaseelec
Female-majority :N1=5764*femrurbaseelec, N2=5764*femurbbaseelec, N3=5764*malerurbaseelec , N4=5764*maleurbbaseelec
where femrurbaseelec, femurbbaseelec, malerurbaseelec, and maleurbbaseelec are the relative consumption differences associated with the sex-location configurations. Get x=minimum(N1, N2, N3, N4) for each of the HID values and sex-location configurations and then get the sum of x for different household types and HID values, ai=sum(x) for HID=i, i=-2, -1, 1, 2.

Predicted changes in the monthly energy consumption are presented in table I. The electricity consumption increases by around 33000-43000 kWh and 68000-88000 kWh when the heat index is 1 and 2 ºC above the normal value, respectively. The charcoal consumption increases by around 6000-8000 kg and around 15000-20000 kg for heat index that is 1 and 2 ºC above the normal value, respectively. On the other hand, the LPG consumption decreases by around 22000-28000 kg and by around 48000-59000 kg for heat index that is 1 and 2 ºC above the normal value, respectively. The LPG consumption increases by around 35000 kg and by 47000-53000 kg for heat index 1 and 2 ºC below the normal value, respectively.

Since different household types are affected differently by socioeconomic factors, household composition also plays a role in the prediction exercise. Based on our computations, the maximum value of the predicted change in electricity consumption for a 2 ºC fluctuation (presented in table I) is mainly driven by the high relative consumption of female-majority households with female heads in urban areas. On the other hand, the maximum value of the predicted change in LPG consumption is mainly driven by the high relative consumption of male-majority households with female heads in urban areas. The maximum value of the predicted change in charcoal consumption is mainly driven by the high relative consumption of balanced households with female heads in rural areas, however.

5 Summary and conclusions

Results show that weather fluctuation is important in energy consumption. Fluctuations above the normal heat index will likely affect the frequency of the usage of appliances, which is mostly powered by electricity. Households use electricity based on routines established overtime. When faced with shocks, these routines and the associated energy consumption will adjust. For example, instead of using electric fan on certain hours, households will shift to the use of air conditioning units all day in the face of persistent above normal heat index.

The charcoal consumption is predicted to increase although its increase is not as much. Charcoal can be viewed as a supplementary to electricity consumption since its usage is limited to cooking foods and heating water and may not adequately address the immediate physical needs to attenuate heat. When HI is above normal, the increase in electricity consumption and the complementarity of electricity and charcoal can potentially explain the decrease in the consumption LPG, an energy source that is mainly used for cooking.

Based on the prediction exercises, the maximum value of the change in energy consumption is driven by the household composition. In particular, the consumption of electricity, LPG, and charcoal is mainly driven by the consumption of female-headed female-majority households, female-headed male-majority households, and female-headed balanced households, respectively. Consistent with the literature on gender differences in energy/caloric needs, these results indicate that men and women use energy sources with varying intensities. Women/girls are more likely to stay at home while men/boys are more likely to go out to work or play. In the event of an immediate need for bodily comfort arising from above normal weather fluctuations, the higher electricity consumption of female-majority households is, therefore, not surprising.

Women are argued to be more affected by climate change due to the social roles they played (see for example, Chikulo 2014). While this paper cannot provide concrete evidence on the channels why this is the case, we allude to the combined effects of traditional gender roles and headship as a source of strong bargaining power in the household as plausible reasons why female-headed households seem to be most affected by weather variabilities. Women are possibly more attuned to the needs of their household members and being the head gives them traction to address these needs. In addition, women in female-headed households are likely to have more decision-making power relative to women in male-headed households. While not related to energy consumption, there are studies that provide evidence on the positive effects of female headship on various children's outcomes (see for example, Chudgar 2011) and the positive effects can spillover to energy consumption that has welfare effects as well. Consistent with the literature, the demand for cleaner and safer energy sources moves positively with income and this relationship is again the highest for rural female-headed households.

Variabilities in weather shape the household's energy choice and energy consumption and the government has to continue to find cheaper alternative sources to boost the generation of electricity, the energy type used by the majority of households in the Philippines. While substantial studies on energy choice and energy consumption in developing countries have been done, there are very few researches in the Philippines that analyze such topic through a gender lens and within the context of fluctuations in weather indicators, even fewer. This paper has provided a systematic evidence on how the energy choice and energy consumption of different households change with weather variabilities and it has done so by looking at the different household compositions based on gender and headship. Future research can use other factors, such as household activities assigned at the individual level, to refine the gender dimension on energy choice and energy consumption. Efforts to collect longitudinal data will greatly improve the research in this area. Using extreme weather events should be explored as well.

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