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The essential elasticity for energy demand: an application of la-aids model in east Malaysia

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Abstract: In Malaysia, the most significant amount of subsidy is distributed on energy. Misallocation of resources may lead to over consumption and incurred unsustainable financial for the country. East Malaysia was chosen as the scope of this study due its difference with Peninsular Malaysia in terms of geographical location, economic activities, affordability, demographic structure and infrastructure. This study estimated the elasticity of demand for energy (petrol, diesel, electricity and LPG) using Linear Approximate Almost Ideal Demand System (LA-AIDS) model. The findings indicated that low income group was price elastic towards the over consumption of petrol, electricity and LPG. Electricity was found as a substitution for LPG and diesel meanwhile diesel was a complementary for petrol. Furthermore, low income groups treated diesel, electricity and LPG as a necessity goods, however, petrol was a luxury good. These robust findings will help the policy maker to effectively distribute energy subsidy without wastage.

Key words: Elasticity; Energy demand; Over consumption; LA-AIDS model; East malaysia

1. Introduction

Traditionally Malaysia focused on primary commodities to sustain economic growth. The primary commodities like rubber, tin, timber and palm oil provided the economic growth in line with the export of oil from 1970. Beginning 1980, Malaysia encountered several period of shock and adjustment. The shock and adjustment resulted in inflation and high deficits. Subsidies given by the government caused the national debt to stand at 53.3 percent of GDP in 2013. According to Ministry of Finance Malaysia (2014), it was estimated to increase as high as 54.8 percent in 2014. It was found that the distribution of energy subsidies for petrol (RON 95), diesel, electricity and LPG occupied 63 percent of total subsidies which was estimated as high as RM26.6 billion in 2013.

Various actions were taken by the government to resolve the problem known as internal shocks. These internal shocks were the result on the attempt to control external shocks. One of the measures taken by the government was to reduce the subsidy on the price of energy. The domestic price for energy increased resulting in cost push inflation. This is because 80 percent of the total energy demand comes from petroleum based products. Secondly, the government financed the energy subsidies from borrowing but not from international reserve. According to Ricardian equivalent theory, borrowing for the sake of financial debt was only a short term solution. It could trade off for current increase in the standard of living by increasing the burden of the future generation. Thus, question arouse whether subsidy should be totally eliminated. The answer would be no because as long as there was government and the existence of democratic political system, subsidy would always exist. However, subsidy should not be distributed in a blanket basis. Therefore, an appropriate system that could target the rightful individual and amount should be established.

Previous studies conducted looked into the changes on energy price towards the macroeconomic variables in Malaysia. The analysis only looked into the macroeconomic impact for the reason of forecasting. These studies were conducted using a time series data. Unfortunately, a robust analysis can only be done if the demand for each type of energy with and without subsidy be analyzed to derive the essential elasticity of demand using a cross sectional data. The cross sectional data that questions the changes in their consumption pattern with subsidy and without subsidy will not only classify respondents based on location and income on who should be given the subsidy but it would also help to estimate the over consumption and its cost for each energy type.

The Linear Approximate Almost Ideal Demand System would be able to provide a comprehensive and idealistic demand system which can derive an accurate estimation on essential elasticity of demand. The LA-AIDS model is linear, flexible and satisfies the axioms of demand theory. The model

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also assumes that individual utility of energy consumption is weakly separable from quantities of all other type of goods purchased by the households. Thus, only this model uses two-stage budgeting process compared to the normal demand function as well as price gap approach used in the previous studies. Thus, with this approach the study was able to derive the essential elasticity of demand by analyzing the budget share of over consumption for each type of energy with and without subsidy at micro level in Sabah and Sarawak using the Linear Approximate Almost Ideal Demand System (LA-AIDS) model.

2. Literature review

The literature review of the impact of subsidies on energy demand based on the method of analysis such as multiple regression analysis, time series analysis and advance econometric analysis were discussed. Based on the multiple regression analysis, Hughes (1985) used a cross sectional survey to examine the relationship between energy consumption with income, household size, fuel prices and number of fuel appliances in urban Kenya. The findings ascertained that electricity demand was negatively related to its own price while positive effect was found on income and household size. However, household income was insignificant in explaining the changes of LPG consumption. This was supported by the study conducted by Reddy (1995) and Miah et al. (2011). Meanwhile Nwachukwu and Chike (2011) found that fuel subsidy possessed a positive effect on fuel demand while fuel price responded negatively.

Moreover, Filippini and Pachauri (2004) estimated the price elasticities and income elasticities of electricity demand using the disaggregated level survey data in urban India. The findings claimed that income played an important role in explaining electricity demand while price was inelastic towards electricity demand. Olivia and Gibson (2006) estimated the function of budget share of energy consumption with total expenditure, unobserved prices and household characteristics. The unit values were used as proxy for actual market prices of energy. The findings revealed that lubricant oil, LPG and gasoline were found to have high expenditure elasticity. The own-price elasticity of energy types were ascending from LPG, lubricant oil, kerosene and electricity respectively. The high estimated elasticity for electricity indicated that subsidies would cause the substitution among these energy sources.

On the other hand, time series analysis was carried out to focus on the macroeconomic variables. Ramanathan (1999) used a two-step co-integration model to estimate the price elasticity and income elasticity for gasoline demand in India. The findings concluded that the gasoline demand was more responsive to the change in income compared to the changes of price. The income and price elasticities were more significant in the long run compared to short run elasticities. The findings were supported by Alves and Silveira Bueno (2003) who further discovered that gasoline and alcohol were substitute goods using cross price elasticity. On the contrary, Inglesi and Pouris (2009) found that price possessed high impact on electricity demand in South Africa. The economic growth with 4 percent in long run meanwhile 6 percent in short run. The electricity demand was decreased by 31 percent in long run meanwhile a fall of 18 percent in short run. Akinboade et al. (2008) studied the influence of income and own price on gasoline demand in South Africa using bounds test approach. The results found the stable relationship among gasoline demand, price and income in the long run. However, gasoline demand was claimed to be inelastic towards both income and price.

In relevant, energy was known as the basis for economic growth while economic growth could not continue without adequate energy consumption. Therefore, Zhang (2011) used a modified Granger causality test proposed by Toda and Yamamoto (1995) to examine the relationship between energy consumption and economic growth in Russia in terms of the quantitative proportional relation, interactive directions and comparison with other BRIC countries. The findings indicated that energy consumption had a time-varying long run relationship with economic growth in Russia. In the comparison of BRIC countries, Russia encountered the worst consistency of energy consumption and economic growth. Moreover, both Russia and Brazil had significant bi-directional causality mean while China had only unidirectional causality running from energy consumption to economic growth. For India, energy consumption and economic growth did not have any causality.

In addition, Charap et al. (2013) analyzed a panel of cross-country data to explore the responsiveness of energy consumption towards the explanatory variables like technology, environmental regulations, real income and energy price. The findings indicated that the price elasticity of energy demand did not vary significantly among advanced and non-advanced countries. However, the income elasticity of energy demand for advanced countries was lower than the non-advanced countries. In addition, the short run price elasticity of energy demand was found smaller than long run elasticity which implied the loss of consumer welfare in short run was higher than long run. The countries with large subsidies were also found to have significant long term benefits from the reform of energy subsidies.

The recent study conducted by Arzaghi and Squalli (2015) was to estimate the price and income elasticity of demand for gasoline using panel data for 32 countries from year 1998 to 2010. A log-linear gasoline demand was established as a function of logarithm for real price of gasoline, real GDP per capita, weather, land per capita and urbanization level. The lagged consumption was added in order to estimate the long run elasticity. The findings revealed that gasoline was price and income inelastic

in both short run and long run. However, the long run price and income elasticity were much larger than short run elasticity estimation. This was similar to the study of Eltony (1994) and Bhattacharyya and Blake (2009) who also compared both price and income elasticity of gasoline demand in the short run and long run.

Furthermore, there were various types of advance econometric approaches used to analyze the energy demand. Carter et al. (2009) estimated the aggregated electricity consumption with income and price using Heckman two-step approach in Barbados. Households who used solar water heating had higher price elasticity than those who utilized air conditioning and electric water heating. The income elasticity was found to be insignificant to the demand of appliances. There was only little influence on electricity demand as a change in electricity price. Besides, Lay et al. (2012) and Nlom and Karimov (2014) also studied the probability of using cleaner energy using Probit regression model. The findings showed a positive effect between household income, educational level, firewood price and location on the probability of cleaner energy consumption. On the other hand, electricity price, kerosene price, household size as well as age and gender of household head were negatively related to the usage of cleaner energy.

However, the previous studies indicated that only Linear Approximate Almost Ideal Demand System (LA-AIDS) model could be used to derive the essential elasticities for energy demand. Chambwera and Folmer (2007) integrated two-stage budgeting approach using LA-AIDS model to analyze energy demand in Harare. The findings indicated that electrified households preferred to use electricity while the priority for firewood by non-electrified households as total energy expenditure increased. Besides, electrified households with larger household size would use electricity as substitution for kerosene. An increase in educational level of household head would increase the budget share of electricity for electrified households. On the other hand, the own price possessed negative effect on the budget share of electricity, firewood and kerosene.

The LA-AIDS model was also employed by Gundimeda and Kohlin (2008) to estimate the elasticities of different categories of fuel in India. The findings revealed that energy consumption was not only influenced by the growth of population and income, but also other factors such as geographical area, forest cover, and occupation. The negative sign for expenditure elasticity indicated that domestic fuel was a necessary good. The Marshallian own-price elasticities showed that all energy types were responded negatively to a change in its own price. Fuelwood was found to be price elastic which supported the conventional wisdom. On the other hand, the Hicksian cross price elasticities pointed that the greatest impact on fuelwood demand came from LPG for lower income households in rural area.

Moreover, similar method was developed by Ngui et al. (2011) to study the price and fuel expenditure elasticities of demand to determine the factors affect the energy demand in Kenya. The findings indicated that the budget share of electricity was positively influenced by the charcoal and LPG price meanwhile negatively caused by the price of kerosene and fuel wood. The households preferred to use more electricity when the charcoal and LPG prices increased since they were substitute items. Besides, the Marshallian own price elasticities revealed that MSP, AGO and lubricants were price elastic while kerosene, electricity, LPG, charcoal and fuel wood were price inelastic. The different signs of Marshallian and Hicksian cross price elasticities for electricity, LPG and charcoal versus fuel wood as well as kerosene and fuel wood versus LPG stated that the income effect outweighed the substitution effect. On the other hand, the expenditure elasticities indicated that only kerosene and lubricants were luxury goods while electricity, LPG, charcoal, fuel wood, MSP and AGO were found to be normal goods.

Last but not least, Guta (2012) applied the integration of LA-AIDS model and multinomial logit model (MLM) to analyze the energy use of households. The findings of LA-AIDS model indicated that traditional energy was an inferior good while normal good for modern energy. MLM showed that rural households with low income preferred to use modern energy rather than traditional type when their total expenditures increased. Besides, the positive coefficient for education implied that households headed with higher educational level were more likely to choose modern energy.

2.1. Previous studies in Malaysia

In Malaysia, previous studies attempted to analyze energy demand using macroeconomics variables with time series data. The study conducted by Ang (2008) using a trivariate VAR model to determine the integration between output, pollutant emissions and energy consumption. The bi-directional causality between output growth and energy consumption was found in the long run. Meanwhile there was non-causality between output and pollutant emissions in both short run and long run. Besides, Lean and Smyth (2010) employed the modified of Granger causality test to examine the relationship between aggregate output, electricity consumption, exports, capital stock and labor force in Malaysia. The findings claimed that Granger causality running from all other variables to aggregate output, electricity consumption and capital stock in long run. The bidirectional Granger causality was found between aggregate output and electricity consumption and between aggregate output and capital stock. Meanwhile there was only unidirectional Granger causality from capital stock to labor force. Moreover, Tang and Tan (2013) found a bi-directional Granger causality between electricity consumption, economic growth, energy prices and technology in both long run and short run.

The Granger causality test was also utilized by Chandran et al. (2010) to investigate the nexus of

electricity consumption and GDP in Malaysia. The finding of Engle-Granger cointegration showed that there was a positive relationship between GDP and energy consumption in long run. However, it became insignificant when price index was added as dependent variables. Meanwhile the short run relationship was found between energy consumption and price index. After that, Lean and Smyth (2014) examined the relationship between disaggregated energy consumption by fuel type and economic growth from 1980 to 2011. The findings indicated that there was a cointegration between GDP, capital, labor and energy consumption. The ARDL tests indicated the largest long run elasticity went to diesel. The energy consumption like diesel, motor petrol, fuel oil, LPG and kerosene was positively related to GDP in short run. Meanwhile motor petrol was claimed as an important factor in stimulating economic growth for short term in Malaysia. Furthermore, Begum et al. (2015) also used ARDL bounds test to investigate the impact of energy consumption, GDP and population on CO_2 emissions in Malaysia. GDP was negatively related to CO_2 emissions from 1970 to 1980 while positive impact was found during the period of 1980 to 2009. In long run, energy consumption and GDP were found to be positively related to CO_2 emissions while no significant impact incurred by population growth.

3. Methodology

The survey research design using cross sectional data was conducted in this study. The research instrument used was a questionnaire with open-ended questions. The energy usage in terms of quantity for each energy type consumed with subsidy and without subsidy was also recorded. The respondents were chosen using two-stage cluster sampling method. Sabah state was divided into West Coast Division, Interior Division, Kudat Division, Sandakan Division and Tawau Division. Meanwhile Sarawak state was divided into South Region, Central Region and North Region. The regions and divisions were further distinguished into urban and rural areas. Due to large sample size in each cluster, it was further divided into sub-districts. The sub-districts were chosen randomly using simple random sampling method. Finally, the respondents were also selected randomly from each sub-district in urban and rural areas. Based on the formula developed by Cochran (1963), Kish (1965) and Sudman (1976), a total sample size of 1,026 households were selected where 508 households from Sabah and 518 households from Sarawak. The data was collected using a structured face to face interview.

3.1. Model estimation

To fulfill the objectives of this study, the model demand for each energy type based on the Linear Approximate Almost Ideal Demand System (LA-AIDS) model was used to estimate the elasticities of energy consumed in Sabah and Sarawak. The model was estimated using EViews software. A two-stage budgeting process was used to allocate the budget for energy in this study (Blundell, 1988; Baker *et al.*, 1989). At the first stage, the linear relationship in Engel curve in this study was established between the budget share of energy expenditure (w_e) and the logarithm of total household expenditure (X) together with demographic variables.

$$w_e = \delta_0 + \sum_k \delta_k \, d_k + \beta_e \ln X \qquad (1)$$

Where w_e= total energy expenditure / total household expenditure. The expenditure elasticity of the energy demand for an average household was

$$e_{ex} = 1 + \frac{\beta_e}{w_e} \qquad (2)$$

By applying the Shephard's lemma and substituting in the indirect utility function as well as incorporating with stone price index to ensure the demand system was linear, the expenditure share of the i^{th} energy group can be written as

$$w_i = \eta_{i0} + \sum_l \eta_{il} \, N_l + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln \left(\frac{y}{p^s}\right) \qquad (3)$$

where p_i was price of ith commodity, y was total energy expenditure defined by $y = \sum_i p_i q_i$ where q_i was quantity demanded for i^{th} energy group and p^s was stone price index estimated by $\ln(p^s) = \sum_i \overline{w}_i \ln p_i$, N was demographic variables.

At this second stage, corner solution was found when some households did not consume certain energy groups at current prices and income levels (Angulo et al., 2001). To solve this problem, a two-step estimation procedure based on Amemiya-Tobin approach was used to account for these non-consuming households (Heien and Wessells, 1990). The first decision that household would consume a specific energy was estimated using probit regression. The maximum likelihood estimates from Probit regression were used to compute the Inverse Mill's Ratio (MRH_i) for each household and each energy group. The second decision was estimated by incorporating the Inverse Mill's Ratio as an instrumental variable to the demand Eq. (3) given by

$$w_i = \eta_{i0} + \sum_l \eta_{il} \, N_l + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln \left(\frac{y}{p^s}\right) + \xi_i \, \lambda_{ih} + \varepsilon_i \qquad (4)$$

Where ε_i was an error term

Heien and Wessells (1990) claimed that the model will not add up if all n equations were specified as Eq. (4). This was due to adding up restriction requires $\xi_i \, \lambda_{ih} = 0$ which was impossible since λ_{ih} assume any value. However, this adding up constraint was preserved by dropping one equation. The budget share of kerosene over consumption was omitted since lack of over consumption found in the category. The complete demand function with the allocation of budget was estimated using Seemingly Unrelated Regression (SUR) technique together with homogeneity and symmetry restrictions maintained which proposed by Zellner (1962). Finally, the LA-AIDS model for the budget share of each type of energy was given as

$$w_{iS} = \eta_{i0S} + \gamma_{iS} \ln p_{iS} + \gamma_{jS} \ln p_{jS} + \beta_{iS} \ln\left(\frac{Y_S}{p^s}\right) + \eta_{iSAG} \ln AG + \eta_{iSHS} \ln HS + \eta_{iSEDU} \ln EDU + \eta_{iSG} D_G + \eta_{iSL} D_L + \xi_{iS}\,\lambda - \sum_{i=1}^{n-1} \xi_{iS}\,\lambda + \varepsilon_{iS} \quad (5)$$

where w_{iS} is budget share of over consumption of ith energy type per household, p_{iS} is energy price for ith energy type, p_{jS} is energy price for different energy type, $\frac{Y_S}{p^s}$ is total energy expenditure per household divided by the Stone price index, AG is age of the household head, HS is number of persons living together per household, EDU is years of schooling of the household head, D_G is dummy variable for gender of household head, D_L is dummy variable for regions, η_{i0S} is constant term of budget share of over consumption and ε_{iS} is error term of budget share of over consumption.

The elasticity derivation for LA-AIDS models were widely investigated and well documented. According to Buse (1994) and Greene and Alston (1990), taking the derivative of Eq. (5) with respect to $\ln Y$, the expenditure elasticity e_{if} could be obtained as follows:

$$e_{if} = 1 + \left(\frac{1}{w_i}\right)\left(\frac{\delta w_i}{\delta \ln Y}\right) = 1 + \left(\frac{\beta_i}{w_i}\right) \quad (6)$$

The Hicksian compensated price elasticities that derived for the LA-AIDS model at the point of normalization is expressed as follows:

$$e_{ij} = e_{ii} + e_{if} w_j = -\delta_{ij} + \left(\frac{\gamma_{ij}}{\overline{w}_i}\right) + \overline{w}_j \quad (7)$$

where δ_{ij} was the Kronecker delta that is unity ($\delta_{ij} = 1$) if $i = j$, and zero otherwise.

The integrated expenditure elasticites of demand for each energy type were obtained through the multiplication of the elasticities in the first stage Eq. (2) with the elasticities in the second stage Eq. (6) as follows:

$$e_{iY} = e_{ex} * e_{if} \quad (8)$$

4. Empirical findings

4.1. Descriptive statistics

Table 1 showed that mean statistics for explanatory variables based on income groups and location in Sabah and Sarawak respectively. The largest mean for budget share of over consumption in Sabah went to electricity which was ranged from 0.41 to 0.73. Meanwhile households in Sarawak possessed the largest mean for budget share of petrol over consumption from 0.22 to 0.47. Besides, the mean for budget share of LPG over consumption was found to be the smallest amount in both Sabah and Sarawak which were estimated from 0.05 to 0.12 and 0.07 to 0.28 respectively. On the other hand, total energy expenditure was found to be higher as households' income increased. In addition, higher income group was also claimed to have larger household size and higher educational level. The age of household head in the study was ranged from 39 to 45 years old. Meanwhile most of the households were headed by a male in both Sabah and Sarawak.

Table 1: Mean statistics for explanatory variables

	Sabah						Sarawak					
	Urban			Rural			Urban			Rural		
Income Group	Low	Middle	High	Low	Middle	High	Low	Middle	High	Low	Middle	High
Variable												
Budget share of petrol	0.12 (0.09)	0.21 (0.13)	0.11 (0.15)	0.08 (0.07)	0.20 (0.14)	0.19 (0.27)	0.47 (0.36)	0.43 (0.36)	0.33 (0.37)	0.42 (0.29)	0.39 (0.35)	0.22 (0.24)
Budget share of diesel	0.04 (0.01)	0.11 (0.06)	0.20 (0.29)	0.04 (0.01)	0.10 (0.08)	0.12 (0.22)	0.13 (0.06)	0.18 (0.11)	0.28 (0.37)	0.05 (0.03)	0.41 (0.23)	0.38 (0.37)
Budget share of electricity	0.73 (0.14)	0.62 (0.28)	0.41 (0.35)	0.73 (0.16)	0.59 (0.29)	0.41 (0.36)	0.14 (0.16)	0.19 (0.13)	0.09 (0.11)	0.16 (0.09)	0.28 (0.20)	0.26 (0.33)
Budget share of LPG	0.11 (0.09)	0.07 (0.04)	0.05 (0.06)	0.12 (0.11)	0.13 (0.09)	0.12 (0.26)	0.24 (0.28)	0.12 (0.09)	0.07 (0.12)	0.28 (0.25)	0.09 (0.09)	0.17 (0.20)
Total energy expenditure	2.17 (0.21)	2.44 (0.17)	2.66 (0.15)	2.14 (0.24)	2.36 (0.19)	2.62 (0.15)	1.71 (0.23)	2.04 (0.21)	2.44 (0.22)	1.79 (0.20)	2.09 (0.19)	2.59 (0.14)
Age	39.54 (12.4)	39.09 (8.86)	41.76 (9.83)	43.64 (10.3)	40.77 (8.83)	41.37 (9.82)	39 (13.3)	38.37 (8.19)	43.79 (8.20)	39.13 (10.6)	41 (9.01)	42.73 (7.86)
Household size	4 (1.51)	4.94 (1.79)	5.29 (1.83)	4.97 (1.85)	5.70 (2.06)	5.83 (1.98)	3.64 (1.57)	4.83 (1.57)	5.91 (1.43)	4.61 (1.62)	5.88 (1.65)	7 (2.22)
Educational level	8.57 (4.13)	12.40 (2.68)	14.37 (3.58)	6.71 (3.88)	11.85 (2.74)	14 (2.29)	8.49 (3.75)	12.27 (3.31)	13.86 (3.49)	6.86 (3.58)	11.10 (3.86)	13.63 (3.24)
Gender	0.71 (0.46)	0.61 (0.49)	0.76 (0.43)	0.78 (0.41)	0.66 (0.48)	0.63 (0.49)	0.59 (0.49)	0.63 (0.48)	0.74 (0.44)	0.58 (0.49)	0.69 (0.47)	0.67 (0.48)

Note: Standard deviations are given in parentheses

4.2. Own price and cross price elasticities

Table 2 and Table 3 showed the estimation of compensated (Hicksian) own price and cross price elasticities for each type of energy (petrol, diesel, electricity and LPG) based on income groups and location in Sabah and Sarawak respectively. The own price elasticity showed the responsiveness of the changes in over consumption to a change in price. It could be concluded that petrol was price elastic for all income groups in Sabah except for high income group in urban area with elasticity of 0.64. In Sarawak, the own price of petrol was only found to be elastic among middle income group (-1.06) and high income group (1.52) in rural area. It showed that low income group in Sabah was responsive to the changes in its own price towards the over consumption of petrol meanwhile low income group was not responsive in Sarawak. This was because the living cost in Sabah was higher than Sarawak, thus real income decreased as petrol price increased. Therefore, low income households in Sabah would be more responsive in adjusting their consumption behavior compared to Sarawak households. The study of Ramanathan (1999) supported the findings and claimed that the greater own price elasticity of gasoline implying that the faster adjustment pattern of use of automobile by households. Meanwhile it did not support the study conducted by Akinboade et al. (2008) who found the gasoline demand was price inelastic. In addition, diesel was only found to be price elastic among middle income (1.18) and high income group (4.24) in rural Sabah as well as high income groups in Sarawak with elasticity of 1.31 and 1.71 for urban and rural areas respectively.

For electricity, there was only high income group in urban Sabah (-1.18) found to respond in elastic to the changes to its own price on the over consumption of electricity. The contrary situation was found in Sarawak where more income groups like low income and middle income groups in both urban and rural areas were responsive to the changes of electricity price in causing the over consumption. This was due to the amount of electricity subsidy given to Sarawak households was distantly lesser than households in Sabah. This was in contrast with the study conducted by Ngui et al. (2011), Gundimeda and Kohlin (2008) and Filippini and Pachauri (2004) argued that electricity was inelastic towards the changes of price. Furthermore, low income group in both Sabah and Sarawak was found to be responsive to the changes in LPG price on the over consumption of LPG. This was supported by Gundimeda and Kohlin (2008) who claimed that LPG was price elastic among low income group in India. Meanwhile other income groups in Sabah and Sarawak were found to be price inelastic for LPG which was supported by Ngui et al. (2011).

On the other hand, the cross price elaticities were used to analyze the impact of policies at different level of income at urban and rural area in Sabah and Sarawak. The pure substitution effect could only be determined from the Hicksian cross price elasticity for each energy type. The findings of cross price elasticity indicated that electricity was a substitution for LPG among low income group in urban and rural areas in Sabah. This showed that low income group would shift to use LPG from electricity for the purpose of cooking when the price of electricity increased. Meanwhile petrol and electricity were substitutes for middle income group in urban Sabah as well as urban low income group and rural middle income group in Sarawak. Besides, the substitution was found between diesels with electricity for high income group in rural Sabah. This showed that high income group might use diesel in the purpose of production business. When the price of diesel increased, electricity was used as a substitution by replacing small diesel engines with electric motors for production. In addition, diesel was a substitute for LPG only among high income group in urban Sarawak. On the contrary, diesel was claimed as a complementary for petrol among low income group in rural Sarawak.

Table 2: Estimation of compensated own price and cross price elasticities in Sabah

Urban area						Rural area			
Low income group									
	Budget share of over consumption					Budget share of over consumption			
	Petrol	Diesel	Electricity	LPG		Petrol	Diesel	Electricity	LPG
Petrol	-1.42*	0.26	0.38*	-0.51*	Petrol	-1.65*	0.18	0.18**	0.32
Diesel	-0.31*	-0.59*	-0.05*	-0.01	Diesel	-0.39*	-0.82*	-0.06*	0.08
Electricity	0.49	0.26*	-0.51*	1.77*	Electricity	0.85	0.60	-0.36	1.05
LPG	0.19	0.37**	0.18	-1.39**	LPG	0.33	0.13	0.27**	-2.69*
Kerosene	-0.09	0.04	0.01	-0.10	Kerosene	-0.03	-0.08	-0.05**	-0.03
Middle income group									
	Budget share of over consumption					Budget share of over consumption			
	Petrol	Diesel	Electricity	LPG		Petrol	Diesel	Electricity	LPG
Petrol	-1.96*	-0.19	0.44*	0.08	Petrol	-1.38*	0.67*	0.53*	0.25
Diesel	-0.54**	-0.02*	-0.47*	0.58	Diesel	-0.99	1.18*	-0.28	0.39
Electricity	1.02	-0.69	-0.64*	0.56	Electricity	0.69	0.53	-0.75*	0.37
LPG	-0.19**	0.01	-0.11*	-0.07*	LPG	-0.29	0.79*	-0.53*	0.10**
					Kerosene	-0.18	-0.07	-0.04	-0.17

High income group									
	Budget share of over consumption					Budget share of over consumption			
	Petrol	Diesel	Electricity	LPG		Petrol	Diesel	Electricity	LPG
Petrol	0.64*	0.75	0.12	-0.53	Petrol	2.56*	-0.01	-0.41	-0.37
Diesel	0.94	0.39	-0.01	-0.49	Diesel	-0.22	4.24*	1.26	0.56
Electricity	-0.05**	0.73	-1.18**	-0.27	Electricity	0.98**	-0.23	-0.63	1.05
LPG	0.22	-0.37	-0.27	1.04*	LPG	1.09*	-0.06	-0.33	0.68*
Kerosene	-0.01	-0.22	-0.25	-0.25					

* indicate 5% significance level
** indicate 10% significance level

Table 3: Estimation of compensated own price and cross price elasticities in Sarawak

Urban area						Rural area			
Low income group									
	Budget share of over consumption					Budget share of over consumption			
	Petrol	Diesel	Electricity	LPG		Petrol	Diesel	Electricity	LPG
Petrol	-0.55	0.55	1.07*	0.52	Petrol	-0.72	0.31	0.68*	0.69
Diesel	-0.35*	-0.68	-0.30*	-0.06	Diesel	-1.83*	-0.07	-0.73*	0.15
Electricity	0.67*	0.21	-2.39*	0.11	Electricity	0.65*	0.13	-1.55*	0.24
LPG	-0.40*	0.45	-0.03	0.78*	LPG	0.2	0.33	0.44	-1.39*
Kerosene	-0.13	0.09	-0.02	-0.44*	Kerosene	-0.29*	0.26	-0.07**	0.29
Middle income group									
	Budget share of over consumption					Budget share of over consumption			
	Petrol	Diesel	Electricity	LPG		Petrol	Diesel	Electricity	LPG
Petrol	-0.49	0.52	0.63**	0.37	Petrol	-1.06*	0.87*	1.06*	0.56
Diesel	-0.93*	-0.54*	-0.17*	0.19	Diesel	-0.82*	0.15*	-0.34*	0.01
Electricity	0.41	0.09	-1.38*	0.15	Electricity	0.45	0.67**	-1.43*	0.29
LPG	-0.33*	0.04	0.25	-0.15*	LPG	-0.49*	0.28	-0.04	-0.13**
					Kerosene	-0.16	0.03	0.02	-0.02
High income group									
	Budget share of over consumption					Budget share of over consumption			
	Petrol	Diesel	Electricity	LPG		Petrol	Diesel	Electricity	LPG
Petrol	-0.69	0.52	0.67	0.87	Petrol	1.52*	0.12	-0.76	0.38
Diesel	-0.22	1.31*	0.50	1.79*	Diesel	0.41	1.71*	-1.73*	-0.17
Electricity	-0.11	0.84**	-1.02	-0.43	Electricity	-0.23*	0.51	-0.37	0.18
LPG	-0.58	-0.56	-0.34	-0.69	LPG	0.11	-0.52*	0.19	0.74*

* indicate 5% significance level
** indicate 10% significance level

4.3. Integrated expenditure elasticities

According to Table 4, energy was categorized in different types like luxury, necessity and inferior good based on income group and location in Sabah and Sarawak. This was in contrast with the study conducted by Ngui et al. (2011) who found no inferior goods for each energy type in Kenya. The integrated expenditure elasticities showed that petrol was a luxury good for low income group at urban and rural areas in Sabah and Sarawak. High income and middle income group treated petrol as necessity good except for households in rural Sarawak treated it as an inferior good. Besides, it was obviously found that diesel was a luxury good for high income and middle income group. On the other hand, low income group used diesel as a necessity good. The findings that the gasoline and oil were categorized as luxury goods were supported by Olivia and Gibson (2006).

For electricity, most of the income group used it as necessity good. All the income groups in Sabah treated electricity as necessity good except for high income group in rural area. Electricity was also known as a necessity good for low income group in rural Sarawak and middle income group in both urban and rural areas in Sarawak. The finding was in line with the study of Ngui et al. (2011) and Gundimeda and Kohlin (2008). On the other hand, high income group in rural Sabah treated electricity as an inferior good which was similar to high income group in urban Sarawak. Meanwhile both urban low income group and rural high income group in Sarawak used electricity as a luxury good. This was supported by Gebreegziabher et al. (2010), Olivia and Gibson (2006), Filippini and Pachauri (2004) who claimed that electricity was a luxury good.

Last but not least, LPG was known as a necessity good for all income groups in Sabah. But Sarawakian might have different view on LPG based on different income groups and location. Middle income group in urban Sarawak also treated LPG was a necessity good. It was supported by the study of Ngui *et al.* (2011) and Gundimeda and Kohlin (2008). On the other hand, LPG was an inferior good for low income group in both urban and rural areas as well as high income group in urban area. In addition, high income and middle income group in rural area viewed LPG as luxury good. This was in line with the study of Olivia and Gibson (2008) that found LPG was a luxury good in Indonesia.

Table 4: Integrated Expenditure elasticities based on income groups

	Sabah						Sarawak					
	Urban			Rural			Urban			Rural		
Income Group	Low	Middle	High	Low	Middle	High	Low	Middle	High	Low	Middle	High
Budget share												
Petrol	1.99*	1.14	0.71	1.82*	0.80	0.07	1.51*	0.99*	0.46	1.59*	-0.02*	-0.05
Diesel	0.63	1.54*	1.09	0.59	0.39	2.16*	0.05**	1.01*	3.21*	0.84	1.33	4.12*
Electricity	0.39*	0.15*	0.23	0.52*	0.22*	-0.08	1.88*	0.28	-0.48*	0.88	0.77	1.78
LPG	0.19	0.03*	0.73	0.17*	0.59	0.74	-1.05*	0.25	-1.47*	-0.25*	1.42	1.93

* indicate 5% significance level
** indicate 10% significance level

5. Conclusion and policy implication

Energy subsidy is an important assistance to improve households' welfare and wellbeing. The main purpose of energy subsidy is to alleviate the poverty rate, assist the poor household and improve the equity in the economy of nation. However, negative impacts were discovered from the provision of energy subsidies due to failing to achieve their intended objectives. The inefficient distribution of energy subsidies created fiscal burden on the budget of nation. Besides, energy subsidies was also believed to encourage wasteful consumption or also known as over consumption that lead to depletion of finite energy resources as well as dishearten rationalization and efficiency improvements in energy intensive industries. These negative impacts could be overcome only if the energy subsidy was directed to the eligible individuals where subsidy should not be distributed in a blanket basis.

Previous researchers in Malaysia only looked into the changes on energy price towards the macroeconomic variables using time series data. However, the actual consumption behavior could only be analyzed using cross sectional data. The cross sectional data that questioned the changes in households' consumption pattern with subsidy and without subsidy would help to estimate the cost of over consumption. In addition, the LA-AIDS model was integrated in order to derive the essential elasticities of over consumption for each type of energy. The appropriate system could be utilized to decide the targeted subsidy recipients, the type of energy and the rightful of subsidy amount.

For petrol, higher over consumption was found among high income group in both Sabah and Sarawak. This revealed that high income group who deemed to own vehicle with high cylinder capacity misused the petrol subsidy given. The compensated own price elasticity showed that petrol was elastic for certain low income and middle income groups in Sabah and Sarawak. Moreover, the integrated expenditure elasticity asserted that petrol was a luxury good for low income groups in Sabah and Sarawak where they were not affordable to consume it. Therefore, it is recommended that a rationing subsidy distribution system based on block price discrimination to be inaugurated. The Inland Revenue Department (LHDN) Malaysia who has the completed detail information on households is able to identify the eligible low income and middle income groups. Those targeted groups will be issued a ration card with electronic chip where the quota of subsidy amount was set up by referring to the statistical mean of monthly consumption. Initially, after a certain amount of petrol is utilized, the next block of consumption will be given a lesser percentage of subsidies. The distribution of subsidy is halted once the consumers achieve the limited amount. This mechanism can effectively monitor the subsidy recipients in order to avoid the misuse of subsidy or lead to over consumption.

On the other hand, the own price elasticity for diesel was found to be elastic among high income group in both urban and rural areas in Sabah and Sarawak. This indicated that high income group was responsive to the changes in own price in causing the over consumption of diesel. This could be explained by the descriptive analysis showing that high income group was the one who possessed the largest consumption and over consumption of diesel. Moreover, the highest expenditure elasticity went to high income group implying that the group was highly responsive to the changes in income towards the budget share of diesel over consumption. This indicated that high income group was the one who obtained the greatest benefit from the distribution of diesel subsidy. After the analysis, it would be preferable if diesel subsidy be wiped out for households.

As for electricity, the own price elasticity showed that electricity was only price elastic among urban high income group in Sabah. This was contrary in Sarawak where low income and middle income groups in both urban and rural areas were found to be responsive to the changes in own price towards the electricity over consumption. This was explained by the higher amount of subsidy was distributed to households in Sabah compared to Sarawak households. This supported that electricity subsidy should be further reduced in Sabah. Meanwhile the LA-AIDS model also showed that raised up the electricity price would decrease the over consumption of electricity for low income and

middle income groups in Sabah and Sarawak. However, the integrated expenditure elasticity indicated that electricity was a necessity good for all income groups in Sabah except for high income group in rural Sabah treated electricity as an inferior good. In Sarawak, low income group in rural area as well as middle income group used electricity as necessity good. This ascertained that subsidy should not be totally eliminated due to it was a necessity good for low income group especially in rural area.

The saving from the electricity subsidy removal can be used to provide the basic electricity infrastructure especially in remote area. Meanwhile the fund can also be used to provide rebates for energy efficient appliances to reduce the wastage of electricity consumption. Moreover, government can have more budgets to concentrate on the production of renewable energy such as hydro power and solar. This may help to reduce air pollution and greenhouse gas emissions in our country.

Moreover, the own price elasticities indicated that LPG was price elastic for low income group in both urban and rural areas in Sabah and Sarawak. In addition, the integrated expenditure elasticities asserted that LPG was a necessity good for all income groups in Sabah and middle income group in Sarawak. Therefore, LPG subsidy is highly recommended because it is found to be essential for preparing food. However, the amount of subsidized LPG should be restricted based on the average monthly consumption per household. For business, factors like the nature and size of the business will determine the number of tanks that need to be subsidized.

Last but not least, the limitation of using cross-sectional data in this study was difficult to estimate the energy price elasticities due to the lack of variation in price. The price of each energy type was found to be constant. For the further research on the estimation of energy price, panel data analysis together with more flexible functional forms can be applied. Although this research collected the comprehensive data using survey questionnaire on energy consumption patterns from households, the effects of households energy consumption on environment and health was not further investigated. Therefore, the further research to determine the effects of household energy consumption on environment and health is recommended.

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