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Factors Associated with Household Electricity Consumption Expenditure in Sri Lanka

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ABSTRACT: The energy sector plays a crucial role in national gross domestic product, export earnings, and employment generation of any country. This paper aims to examine the factors associated with residential electricity consumption in Sri Lanka. The data for this study obtained from household income and expenditure survey (HIES). The empirical studies show that the household who reside in the urban sector has a positive and significant impact on electricity expenditure compared with non-urban household. Variable such as year of schooling, size of the household, dwelling attributes, household appliances have a positive and significant impact on electricity consumption. This study fills the gap in the literature by understanding the factors associated with electricity consumption and comparing urban and non-urban. This paper contributes to a better understanding of factors associated with domestic electricity consumption in various sectors in the society. Understanding these factors can aid both the implementation of effective energy policy and sustainable use of electricity consumption in the household.

KEYWORDS: *Energy, electricity, household, consumption, Sri Lanka*

I. INTRODUCTION

Energy demand in developing countries serves as a primary driver of their economic growth. Growing industrialization and urbanization increase the demand for energy consumption which leads to an energy crisis in many countries (Athukorala& Wilson 2010). This crisis is due to unsustainable and ineffectiveness of energy consumption. During the last four decades, energy consumption has been increased by 44% from 1971 to 2016 (IEA, 2018). Moreover, worldwide energy demand grew by 2.3% in 2018. Nearly 70 % of the increase in energy demand has been made together by the U.S, China and India. Global energy resources divided by primary type into fossil fuel, natural fuel and renewable resources. The percentage share of energy consumption of oil, coal, natural gas, hydro, nuclear and others are 33%, 30%, 24%, 7%, 4% and 2% respectively. Residential, commercial, industrial and transportation are prime sectors of energy consumption.

Half of the growth in global energy demand came from the power sector, in response to higher electricity consumption. The global electricity demand rose by 4% while the average growth rate in final electricity consumption between 1974 and 2016 was 3.3%. Sri Lanka is the only country in South Asia that has 100% electricity accessibility whereas only 80% of the population is in the world has to access to electricity. In Sri Lanka, the annual total electricity demand is about 10,500 GWh, and the demand is growing at a rate of about 6% per annum while the average daily demand was approximately 40 GWh. The total demand for electricity of the country comprises of 38% from domestic consumers, 39% from industries and 20% from commercial enterprises, with the balance coming from other sectors such as religious organizations and street lighting. The household sector is a substantial consumer of electricity in every country, and hence it is vital to understand the factors associated with energy consumption in the household level.

II. LITERATURE REVIEW

There is a growing interest in reducing electricity consumption and the efficient utilization of electricity in the economy. The household sector is a key in total consumption of electricity in almost all the countries, and therefore a focus for residential energy saving is crucial. Development literature found that energy consumption is associated with the number of household-level factors such as demographic, economic ability, physical characteristics of the dwelling, spatial factors. The household's monthly income, family size, dwelling size, housing type, land ownership categories, per capita energy expenditure and educational status play an important role in determining the desired energy carriers (Foysa et al.,2012).

A large and growing body of literature has investigated income is a significant factor that affects the quantity and structure of energy consumption (Soytas et al., 2007; Asafu-Adjaye 2000). It was found that income, wood fuel usage, iron ownership and credit obtained were significant in determining consumption levels within these households (Nasr et al., 2000). The long-run income elasticity of demand shows that any future increase in household incomes is likely to increase the demand for electricity significantly. Sri Lanka is moving up the energy ladder as a whole, sectorial differences exist, and the income is the main factor that determines the fuel shifting pattern of the urban sector households except for the lower-income classes data collected in several national household surveys between 1978/79 and 2003/04 (Rajmohan and Weerahewa, 2007).

Chen (2017) found that employment rates and residential space may lead to an increase in residential electricity consumption. Using a data set of smart meter data for 1628 household in U. S Kavousian et al. (2013) studied structural and behavioural determinants of residential electricity consumption. They found the weather, location and floor area, number of refrigerators and entertainment devices, electric water heaters are the most significant determinants of daily electricity consumption.

Much of the current literature on domestic electricity consumption needs particular attention to socio-demographic characteristics. Total electricity consumption is positively associated with household size. Younger head of households has more inclined to use electricity later in the evening than older occupants, and this is because the younger generation may use more gadgets which consume more electricity. The number of workers works influences the financial ability of the consumption of electricity at the household level. Whereas, a household with more workers may consume less electricity because they spent less time at home (Huang, 2015). People who have more educated earn much income and consume a higher volume of electricity. Conversely, there may utilize efficient energy consumption due to their knowledge and attitudes (e.g. solar and less energy consume appliances).

There is a large volume of published studies describing the association between electricity consumption and dwellings characteristics. The electricity consumption per person decreases as the number of occupants increases (Yohanis, 2008). This is particularly significant in large dwellings but smaller numbers of occupants. A strong relationship also existed between maximum demand and most household appliances but, in particular, tumble dryers, dishwashers and electric cookers had the most significant influence over this parameter (McLoughlin et al., 2012; Bedir et al., 2013).

There is a relatively small body of literature that is concerned with the spatial characteristics of domestic electricity consumption. A study provides an in-depth look at how residences use energy in different parts of the United States, and the variances between home energy use characteristics both within and across different regions (Min & Lin, 2010). Energy consumption pattern varies significantly among the regions within China due to diversities and complex distribution of geography and social economy, and more importantly, access to different energy sources. Socio-economic development is the dynamic factor largely determining temporal evolution and the spatial distribution of rural energy consumption. Coastal areas, especially in the south, experienced more rapid economic progress than the inland regions, which directly affected the rural energy consumption pattern in China (Zhang et al., 2009). Kwakwa (2018) examines the determinants of electricity consumption for the country by using the Autoregressive Distributed Lag model, the Fully Modified Ordinary Least Squares and the Canonical Co-integrating Regression. The models reveal that population, urbanization, education and industrialization positively affect electricity consumption for the country while income negatively reduces it.

Studies have overlooked the factors associated with electricity consumption by comparing urban and non-urban sectors. Overall, these studies highlight the need for further investigation into the dynamics of the factors associated with electricity consumption of household level.

III. METHODOLOGY

Researchers have used several methods to investigate household electricity consumption and characteristics associated with electricity consumption. This study employs the OLS method to understand the factors which determine the consumption expenditure on electricity. The following OLS model was employed.

$$Y = \propto_0 + \propto_1 x_i^1 + \propto_2 x_i^2 + \cdots + \propto_n x_i^n$$

Where Y is the average monthly household expenditure on electricity and is the vector of n number of explanatory variables, the term αn represents the coefficients of the independent variables. Based on Huang(2015), the categories of variables listed in table 1 taken as explanatory variables for this study.

The model applied to the national population to three data surveys and sectoral groups. Sri Lanka's population divided into three sectors, namely urban, rural and estate. The urban sector consists of households in the municipal and urban council areas. The estate sector consists of all households in tea, rubber and coconut estates with 20 or more acres and with ten or more resident workers. The rural sector was specified to be consisting of all households that do not include under the urban and estate sectors. All households in the country grouped into two sectors, such as urban and non-urban. Since the estate sector covers only selected provinces, we combined estate and rural and named non-urban. The model also applied separately to urban and non-urban.

This study uses the household data derived from Sri Lanka's HIES(Household Income and Expenditure Surveys) 2009/10, 2012/13 and 2016. HIES is a yearlong national household sample survey conducted once in every three years, aiming at investigating total living standards of the household population in Sri Lanka.

Table 1: Description of the variable

Variables (independent)	Description
Household head characteristics	
hh_age	Age of the household head
hh_female hh_male	Head of the household is female Head of the household is male
hh_educ	Head of the household's years of schooling
Household characteristics	
hhsize	Household size
child_tot	Number of Children (age<=14) among household members
oldparents_tot	Number of old parents (age >=75)among household members
income	Total income of the household
Dwelling attributes	
Area	Housing area in square feet
tv	1 if household has television at home and 0 not having
fridge	1 if household has refrigerator at home and 0 not having
Wash_machine	1 if household has washing machine at home and 0 not having
Geographic variables	
CP	1 if Central Province and 0 otherwise
SP	1 if Southern Province and 0 otherwise
NP	1 if Northern Province and 0 otherwise
EP	1 if Eastern Province and 0 otherwise
NWP	1 if North Western Province and 0 otherwise
NCP	1 if North Central Province and 0 otherwise
Uva	1 if Uwa Province and 0 otherwise
Sab	1 if Sabragamuwa Province and 0 otherwise
Dependent variable	
exp_electricity	Monthly expenditure for electricity consumption

IV. RESULTS AND DISCUSSION

The descriptive statistics of the explanatory variables set out in table 2. The results of mean show that the average age of the household head is around 52 in the latest years while 51 in 2009/10. Male headed household is in higher proportion respect to all three years. The average years of schooling of the head of the household are around nine years of respect to all years. The number of children in family size is higher per cent compared to old parents, and the average household size is around 4. Average income raised over the period from 2009/10 to 2016; for example, the monthly average income of the household is Rs.35983 in 2009/10 while it is Rs. 59811. The proportion of the household who are having television is not significantly changing whereas having refrigerator and washing machine is significantly increased from 2009/10 to 2016. There is a regional variation in the population, a more substantial proportion of the household is living in Western Province while the least population in Northern Province. Mean score of the consumption expenditure on electricity also reported in Table 2. There is an increasing trend in the amount the household spend on electricity between 2009/10 and 2016.

Table 2: Mean and proportions of the explanatory variables

	2009/10	**2012/13**	**2016**
Household head characteristics			
hh_age	51.4132	52.0238	52.7163
	(13.9038)	(13.8517)	(14.0711)
hh_male	0.7709	0.7583	0.7433
	(0.4203)	(0.4281)	(0.4368)
hh_female	0.2291	0.2417	0.2567
	(0.4203)	(0.4281)	(0.4368)
hh_educ	8.9257	8.9004	9.0318
	(3.8107)	(3.7179)	(3.8534)
Household characteristics			
hhsize	4.0668	3.9368	3.8089
	(1.6371)	(1.5918)	(1.6011)
oldparents_tot	0.1185	0.1259	0.1234
	(0.3561)	(0.3654)	(0.3649)
child_tot	1.0351	0.9976	0.9649
	(1.0868)	(1.0473)	(1.0344)
income	35983.2656	32798.2549	59811.8575
	(3453.1506)	(1330.1556)	10854.07
Dwelling attributes			
tv	0.8815	0.8999	0.8834
	(0.3232)	(0.3001)	(0.3209)
fridge	0.4627	0.5114	0.5462
	(0.4986)	(0.4999)	(0.4979)
wash_machine	0.1538	0.1876	0.2088
	(0.3608)	(0.3904)	(0.4065)
area	3.9235	4.5420	4.5531
	(1.1322)	(1.5811)	(1.6029)
Geographic variables			
WP	0.2891	0.2785	0.2767
	(0.4534)	(0.4483)	(0.4474)
CP	0.1341	0.1315	0.1297

	(0.3408)	(0.3379)	(0.3360)
SP	0.1311	0.1334	0.1276
	(0.3376)	(0.3400)	(0.3337)
NP	0.0268	0.0329	0.0408
	(0.1615)	(0.1784)	(0.1977)
EP	0.0620	0.0626	0.0801
	(0.2411)	(0.2422)	(0.2714)
NWP	0.1127	0.1227	0.1269
	(0.3163)	(0.3281)	(0.3329)
NCP	0.0574	0.0664	0.0671
	(0.2327)	(0.2490)	(0.2502)
Uva	0.0620	0.0622	0.0665
	(0.2411)	(0.2416)	(0.2491)
Sab	0.0917	0.0977	0.0640
	(0.2886)	(0.2970)	(0.2447)
Dependent variable			
exp_electricity	625.3527	833.0583	911.0628
	(263.8525)	(248.8526)	(385.1370)
observation	19957	20540	21756

Note: Standard deviation in the parenthesis. Sample weights used.
The districts of Mannar, Killinochchi and Mullaitivu were not covered in the HIES 2009/10

To analyze the factors that associated with the household electricity consumption, the linear multiple regression model adopted the average monthly consumption expenditure on electricity as a dependent variable to regress with many explanatory variables considered to be necessary, as shown in the above descriptive analysis. Table 3 sets out the regression coefficient and standard error in the parenthesis of each explanatory variable.

Among the household head characteristics, the coefficient of years of schooling of the household is only significant in 2009/10 and 2013 not significant even in 2016 while the age of the head of the household is statistically significant in 2016. Household size and the number of children among the household members are statistically significant in 2009/10 and 2012/13. For example, when household size increases the consumption expenditure on electricity also increase whereas children numbers increase expenditure on electricity will decrease. Surprisingly, income not significantly associates with electricity consumption expenditure.

The regression coefficients of all variables related to dwelling attributes show a statistically significant impact on expenditure on electricity-related to all three survey data. Moreover, the impact has been increasing over time. For example, the household who has a television at household has a positive impact on electricity expenditure than who does not. The magnitude of the impact is higher in 2016 than 2009/10.

All geographic variables reported have a significant association with electricity expenditure. The household who reside in urban has a positive and significant impact on electricity expenditure than non-urban household. Sri Lanka's Western Province is better endowed and wealthy region (46% of Nation income consumed), which is an omitted province in this model. Hence, household who are living in all other regions have significantly relatively less consumption expenditure on electricity than the Western Province.

Table 3: Impact of covariates on consumption expenditure on electricity in 2009/10, 2012/13 and 2016

	2010	2013	2016
Household head characteristics			
hh_age	0.0274	-0.1190	1.4606*
	(0.6100)	(0.8684)	(0.7163)
hh_male	-21.5886	-0.1756	-20.2152

	(15.1590)	(20.3109)	(22.2042)
hh_educ	11.2646***	16.9180***	2.6778
	(1.5092)	(2.1541)	(1.9097)
Household Characteristics			
hhsize	86.1306***	134.5323***	3.6376
	(8.0900)	(16.3474)	(8.3652)
Oldparent_tot	8.7516	-23.2188	32.1281
	(20.6643)	(29.6950)	(37.1612)
Child_tot	-40.2017***	-75.5384***	5.5374
	(9.6250)	(18.4479)	(11.8266)
income	0.0001	0.0010**	0.0005
	(0.0001)	(0.0004)	(0.0003)
Dwelling attributes			
tv	28.4938*	37.3346*	114.1993***
	(13.3607)	(18.7493)	(21.4157)
fridge	324.3649***	312.0145***	467.3868***
	(11.3522)	(17.0374)	(12.2477)
wash_machine	614.3832***	721.3675***	974.0882***
	(32.6933)	(34.9116)	(35.0468)
area	25.4827***	65.3618***	1.7584
	(4.3294)	(7.2727)	(6.2170)
Geographic variables			
urban	412.5854***	560.7972***	446.0510***
	(28.9088)	(36.3208)	(35.7786)
CP	-268.0667***	-404.9181***	-513.9471***
	(19.6995)	(24.0222)	(24.3815)
SP	-255.6084***	-349.6322***	-465.5850***
	(17.2608)	(20.9435)	(21.9565)
NP	-255.9813***	-180.2601***	-205.1645***
	(32.8137)	(35.6657)	(33.6508)
EP	-148.6140***	-148.1519***	-302.2231***
	(21.7822)	(27.7981)	(28.4515)
NWP	-230.0114***	-292.0191***	-379.7912***
	(19.2465)	(25.5755)	(26.3688)
NCP	-193.8736***	-333.0505***	-495.6518***
	(19.7354)	(23.7344)	(25.1426)
Uva	-302.9141***	-415.2180***	-448.7216***
	(16.2422)	(25.1243)	(24.9802)
Sab	-292.2467***	-357.7888***	-513.2721***
	(17.4165)	(25.1492)	(25.7354)

****Significant at the 10% level. **Significant at the 5% level. *Significant at the 1% level.*

Note: The omitted categories in the dummy variable analyses are male head of the household; household does not have a television at home; household does not have a refrigerator at home; household does not have a washing machine at home; residence in urban; residence in Western province.

To further understand the association between selected explanatory variables and electricity expenditure, we applied the model into urban and non-urban population separately. As far as this study concerned three consecutive HIESs 2009/10, 2012/13 and 2016, the separate model applied to all three years of data. According to table 4, education of the head of the household significantly associated with the expenditure on electricity in both urban and non-urban, however, the impact is stronger among the urban population than the non-urban population. For instance, if schooling increased by one year, expenditure on electricity will increase by Rs. 58.5 in urban but it is only Rs. 10.4 in non-urban during the survey period 2012/13. Similar findings have observed in the studies (Rao & Reddy 2007; Miah et al., 2011)

Dwelling attributes shows a significant difference between urban and non-urban. Household electrical appliances consume more electricity however; urban household spends more on electric appliances than non-urban. According to Table 4, the household who are having television, refrigerator and washing machine have higher consumption expenditure than the household who are not having those appliances. Besides, the magnitude of the impact is higher in urban than the non-urban. Likewise, the Provincial variables also show the significant influence on electricity expenditure for example compared to Western Province other provinces spend less on electricity consumption and also, the amount of expenditure is higher in Urban than non-urban.

Table 4: Impact of covariates on consumption expenditure on electricity in 2009/10, 2012/13 and 2016 by urban and non-urban

	Urban			Non-Urban		
	2009/10	2012/13	2016	2009/10	2012/13	2016
Household head characteristics						
age	0.4368	-2.3173	2.5891	-0.1038	0.5996	1.3327*
	(2.7698)	(3.7370)	(3.2621)	(0.4551)	(0.5873)	(0.5195)
hh_male	-40.7071	-19.2296	-140.2915	-13.9833	-4.2838	-9.3879
	(54.5994)	(83.4904)	(101.8796)	(12.2737)	(14.8564)	(16.5323)
hh_educ	24.8061***	58.5219***	20.7949*	9.1503***	10.4399***	0.5323
	(7.1945)	(10.6388)	(9.4245)	(1.1995)	(1.6847)	(1.5146)
Household characteristics						
hhsize	162.3555***	342.0492***	1.6454	59.7848***	75.3875***	-0.3742
	(31.8518)	(63.9605)	(32.6089)	(5.0207)	(6.2143)	(6.0872)
Oldparents_tot	127.1704	-123.6082	85.7336	4.2092	-0.6440	-2.3116
	(79.3153)	(115.1889)	(153.1666)	(17.8093)	(22.3665)	(22.1373)
Child_tot	-35.9725	-248.6305***	-3.6814	-32.6169***	-24.3126*	7.8369
	(42.8990)	(74.7377)	(47.9179)	(7.5880)	(9.6199)	(9.6811)
income	0.0031*	0.0014	0.0013	0.0001	0.0005***	-0.0000
	(0.0016)	(0.0007)	(0.0009)	(0.0001)	(0.0001)	(0.0001)
Dwelling attributes						
tv	43.7081	170.8880*	305.3514***	29.4791*	23.2300	79.8355***
	(57.2767)	(75.7196)	(62.2943)	(11.9376)	(13.1542)	(22.4425)
fridge	470.8583***	428.2334***	738.6856***	313.7788***	324.8691***	426.9220***

	(41.3843)	(59.0231)	(53.3626)	(10.7445)	(11.9985)	(10.8612)
wash_machine	851.8785***	839.1297***	1363.5067***	465.7244***	592.6981***	735.6245***
	(82.7389)	(80.1270)	(97.4541)	(29.3223)	(32.6832)	(29.2864)
area	87.5887***	212.1630***	13.7338	20.2568***	42.5865***	-3.1826
	(18.6923)	(38.4362)	(30.4087)	(3.9834)	(4.7274)	(3.9495)
Geographic characteristics						
CP	-628.366***	-819.893***	-1128.906***	-206.993***	-307.0953***	-331.832***
	(81.1154)	(86.7951)	(104.1907)	(19.4182)	(23.1831)	(22.4863)
SP	-681.039***	-701.5785***	-973.1054***	-186.275***	-265.5783***	-291.212***
	(65.6639)	(64.8367)	(74.1898)	(17.0272)	(20.9174)	(21.1286)
NP	-431.329***	-467.2773***	-453.4406***	-87.1643**	-38.4470	-64.5426*
	(57.5725)	(79.4465)	(117.7553)	(32.5485)	(38.2194)	(28.8375)
EP	-274.242***	-176.7114**	-404.9526***	-66.8158***	-61.0156*	-147.647***
	(53.6384)	(63.8949)	(96.7039)	(19.4199)	(25.8721)	(26.0188)
NWP	-562.725***	-464.4055***	-624.4801***	-180.002***	-225.0044***	-229.426***
	(69.9925)	(104.9156)	(171.9724)	(19.4543)	(25.8847)	(25.4894)
NCP	-516.316***	-1130.036***	-1200.168***	-156.929***	-270.6736***	-340.410***
	(116.9092)	(152.7965)	(125.8216)	(19.5504)	(23.4606)	(24.6349)
Uva	-927.326***	-1266.599***	-908.1942***	-252.233***	-326.6530***	-307.840***
	(72.6941)	(116.2724)	(108.9135)	(16.0485)	(24.9682)	(24.5943)
Sab	-826.149***	-898.4907***	-913.7887***	-237.122***	-277.020***	-341.651***
	(67.9312)	(107.9654)	(141.1491)	(17.5205)	(25.6488)	(24.3074)

V. CONCLUSIONS

Household energy efficiency has contributed significantly to meet the future demand for electricity and can prevent the future energy crisis. This study has shown that educational level plays a vital role in the efficient utilization of energy in both urban and non-urban sector. Household electrical appliances consume much electricity; therefore, household needs to consider the new generation of materials, devices and system of energy appliances. Moreover, household income has a positive and significant impact on electricity consumption.

Sri Lankan electricity demand highly dependents on public investments and successive governments bears a more significant financial burden. Clean energy can play a vital role in future electricity demand. The country needs to reform the energy consumption by the appropriate energy policy by reducing the wastage of electricity consumption and introducing less energy to consume appliances.

Overall, the findings of this study show the necessity to look at sectoral composition and provincial level disparities in electricity consumption. The study directs the energy-efficient society and better formulation of policy-making towards mitigating future socio-political unrest.

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