Understanding The Impact Of Electricity Consumption Patterns And Related Factors Among Households In Sri Lanka

Nisal Waruna
Department Of Computer Science & Engineering
University Of Moratuwa
nisal.23@cse.mrt.ac.lk

***Abstract*—This paper investigates the electricity consumption patterns and related factors among households in Sri Lanka, aiming to identify strategies for promoting energy efficiency. The study recognizes the significance of reducing energy consumption and its environmental impact, particularly in a developing country like Sri Lanka. By examining housing characteristics, demographics, and household behaviors, the research explores opportunities to enhance sustainability and decrease electricity consumption. The findings will have implications for policymakers, energy planners, and stakeholders involved in promoting energy efficiency. Additionally, this study contributes to the existing knowledge on electricity consumption patterns by providing insights specific to the Sri Lankan context.**

***Index Terms*—Electricity consumption patterns, Related factors, Energy efficiency, Energy-saving practices, Appliance usage, Awareness of energy consumption, Statistical analysis.**

I. Introduction

A. Objectives

Electricity consumption patterns in households play a significant role in energy demand and carbon emissions, making it critical to understand the factors influencing these patterns and identify strategies to promote energy efficiency. As it strives for economic growth and higher living standards, Sri Lanka faces difficulties managing the demand for electricity, similar to many developing nations. This research study aims to investigate electricity consumption patterns and related factors to explore opportunities for promoting energy efficiency in Sri Lankan households in recognition of the significance of reducing energy consumption and its environmental impact.

B. Significance of the Study

This research project aims to tackle the objectives listed earlier by looking at the housing characteristics, demographics, and household behaviors With a focus on lowering electricity consumption and enhancing sustainability, this study will also explore the potential effects of interventions and behavior change strategies to promote energy efficiency in households.

The findings of this research will have important implications for policymakers, energy planners, and stakeholders involved in promoting energy efficiency in Sri Lanka. By identifying the factors influencing electricity consumption patterns, policymakers can develop targeted interventions and policies to incentives energy-saving behaviors and improve energy efficiency in households. Furthermore, this study will contribute to the existing body of knowledge on electricity consumption patterns and energy efficiency by providing insights specific to the Sri Lankan context.

II. Literature Review

The Department of Census and Statistics (DCS) conducted a Household Income and Expenditure Survey (HIES) [1] and the latest survey 2019 contains information related to monthly household expenditure for food and non-food.

A similar research on electricity consumption patterns of household [3] done to identify patterns in jaffna area.

An online survey on a sample of Western European households [4] measured the CADM variables and data were analysed using structural equation modelling. Their findings suggest that policy makers should move away from motivating householders to save energy and should instead focus their efforts on changing energy habits and creating environments that facilitate energy saving behaviour.

III. Methodology

A. Conceptual Framework

The study adopts a conceptual framework that integrates multiple factors influencing electricity consumption patterns in households. The framework includes three main components: housing characteristics, demographics, and behavior. Housing characteristics encompass variables such as house built period, architecture, construction materials, and energy-efficient features. Demographics include variables such as income level, education level, and occupation. Behavior encompasses variables related to energy-saving practices, appliance usage, electricity bill payment practice and awareness of energy consumption.

B. Operationalization of the variable

The study operationalizes the variables through a structured questionnaire administered to households and each variable defined and measured using appropriate indicators and questions.
Data collected through 3 different methods as listed below.

1) Online (google sheet)
2) Face to Face
3) Telephone / Zoom survey

Also, The questionnaire comprise of six main sections.
I. Housing History and Ownership
II. Demographics
III. Housing Characteristics
IV. Electricity Billing
V. Wiring & Electricity Generation
VI. Behavior

Housing History and Ownership section contain 5 questions to identify the house built period, professional involvement to architecture the house , architecture of the house, no of stories in the house and area of the house.

Demographics section contain questions to get demographics details such as Relationship to the head of the household, Gender, current education attendance, main occupation, average monthly expenditure for food and non-food.

Housing Characteristics section contain questions related to major material of outside walls, ventilation and lighting and type of roof installation.

Electricity Billing section contain no of red notices received last year and normal bill payment practice.

Wiring & Electricity Generation section contain professional involvement of Wiring, electricity generation methods, knowledge of electricity bill calculation.

Finally, Behavior section contain behaviour of ironing clothes, night lighting, checking electricity meter over-consumption, checking energy rating of an appliance when buying, district residing and Secretarial division.

C. Target population / Sample / Sample Size / Sampling method

The target population for this study comprises households in Sri Lanka. A multi-stage sampling technique is employed to ensure representation across different geographic regions and socio-economic backgrounds. At the first stage, districts were selected based on geographical diversity. Within each district, secretarial divisions were randomly chosen. Finally, households are randomly selected within each secretarial division and took a sample of size 50.

D. Data Analysis

I) **Hypothesis testing for one sample mean**
Let,
H_o: Null hypothesis is a tentative assumption about a population parameter.

H_a: Alternative hypothesis is what the test is attempting to establish.

- $H_o : \mu \geq \mu_o$ vs $H_a : \mu < \mu_o$ (one-tail test, lower-tail)
- $H_o : \mu \leq \mu_o$ vs $H_a : \mu > \mu_o$ (one-tail test, upper-tail)
- $H_o : \mu = \mu_o$ vs $H_a : \mu \neq \mu_o$ (two-tail test)

Test Statistic: Case 1: σ^2 is known

$$z = \frac{\overline{x} - \mu_o}{\frac{\sigma}{\sqrt{n}}} \sim N(0,1)$$

Case 2: σ^2 is unknown

$$t = \frac{\overline{x} - \mu_o}{\frac{s}{\sqrt{n}}} \sim t_{n-1}$$

II) **Hypothesis testing for difference between two means**

Two independent populations with means μ_1 and μ_2.
Assume random samples, normal distributions, and equal variances ($\sigma_1^2 = \sigma_2^2$).

- $H_o : \mu_1 - \mu_2 \geq \Delta_o$ vs $H_a : \mu_1 - \mu_2 < \Delta_o$ (lower-tail)
- $H_o : \mu_1 - \mu_2 \leq \Delta_o$ vs $H_a : \mu_1 - \mu_2 > \Delta_o$ (upper-tail)
- $H_o : \mu_1 - \mu_2 = \Delta_o$ vs $H_a : \mu_1 - \mu_2 \neq \Delta_o$ (two-tail)

Test Statistic:

$$t = \frac{(\overline{\chi}_1 - \overline{\chi}_2) - \Delta_o}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \sim t_{n_1+n_2-2}$$

s_p is the pooled standard deviation

Rejection Rules:
Consider test statistic z, and significance value α.

- Lower-tail test: Reject H_o if $z \leq z_\alpha$
- Upper-tail test: Reject H_o if $z \geq z_\alpha$
- Two-tail test: Reject H_o if $|z| \geq z_{\frac{\alpha}{2}}$

III) **Hypothesis testing for Association between two categorical variables**

H_o: Assumes that there is no association between the two categorical variables.

H_a: Assumes that there is an association between the two categorical variables.

Test Statistic:

$$\chi_c^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Where:

O is the observed frequency

E is the expected frequency
c is degrees of freedom (df)

Degree of freedom is calculated by using the following formula

$$DF = (r-1)(c-1)$$

Where:

DF = Degree of freedom
r = number of rows
c = number of columns

IV. Data Presentation and Analysis

A. Questionnaire Validation (Validity and Reliability)

For the content validation, I reached out to two experts in the field and got feedback for the questionnaire in terms of relevancy and coverage of the questions to achieve the main objective of the questionnaire which is understanding the impact of electricity consumption patterns and related factors among households in Sri Lanka. To assess reliability, a pilot study was conducted with a small sample of respondents (n = 30) that represented the target population. The respondents completed the questionnaire, and their responses were analyzed.

B. Descriptive Data Analysis

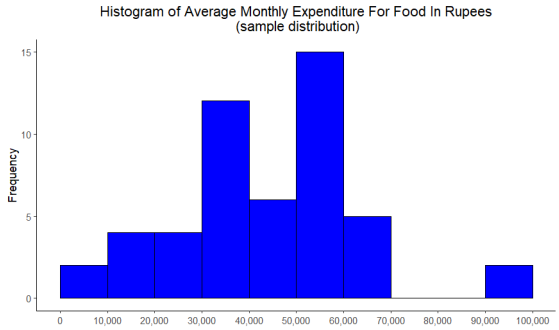

Fig. 1. Histogram of average Monthly expenditure for food Rs (sample Distribution)

Fig.1 depict the sampling distribution of average Monthly expenditure for food in rupees. The sample size of the distribution is 50.

Fig.2 depict the Bootstrap distribution of the average Monthly expenditure for food in rupees with a sample size of 50 and 10000 bootstrap samples.

Fig.3 shows the sampling distribution of average Monthly expenditure for non-food in rupees. The sample size of the distribution is 50.

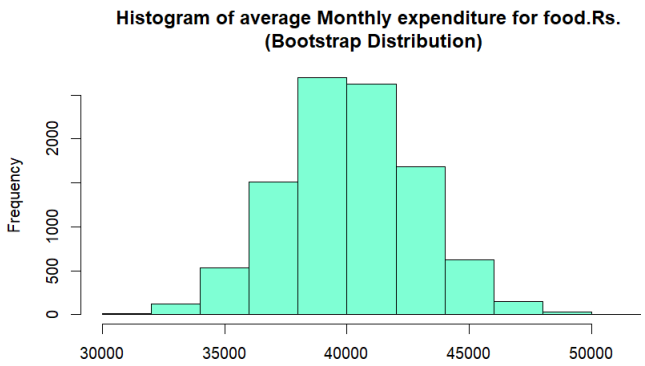

Fig. 2. Histogram of average Monthly expenditure for food Rs (bootstrap Distribution)

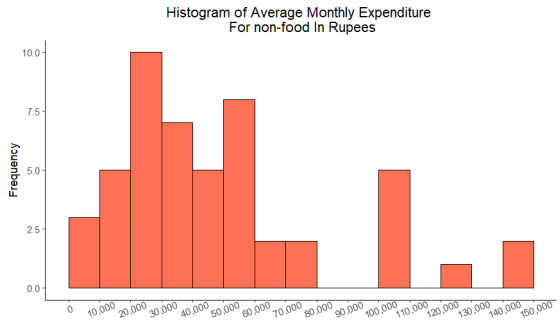

Fig. 3. Histogram of average Monthly expenditure for Non food Rs (sample Distribution)

Fig.4 depict the Bootstrap distribution of the average Monthly expenditure for non-food in rupees with a sample size of 50 and 10000 bootstrap samples.

C. Inferential Data Analysis

1) Hypothesis 1

check whether mean of average Monthly expenditure for food(Rs) equal to the mean of average Monthly expenditure for Non food(Rs). Let,

μ_1 = mean of average Monthly expenditure for food(Rs)
μ_2 = mean of average Monthly expenditure for Non food(Rs)

$$\text{Ho: } \mu_1 = \mu_2$$
$$\text{H1: } \mu_1 \neq \mu_2$$

	Statistic	Value
1	t-value	-0.9797
2	df	76.61
3	p-value	0.3302
4	95% CI	(-17225.12 , 5865.12)

Since P-value > 0.05 we do not have enough evidence to reject Null Hypothesis, mean of average Monthly expenditure for food(Rs) is equal to the mean of average Monthly expenditure for Non food(Rs) at 95% Significant level.

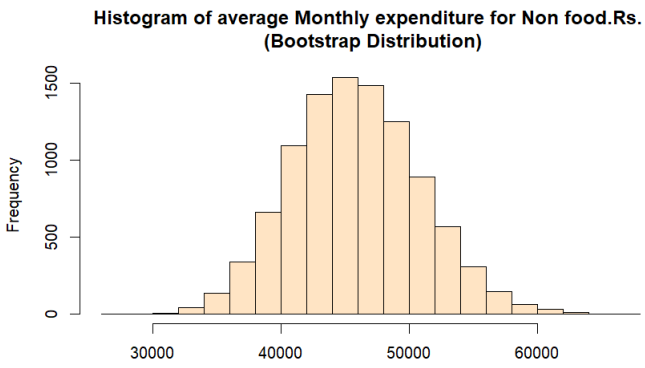

Fig. 4. Histogram of average Monthly expenditure for Non food Rs (bootstrap Distribution)

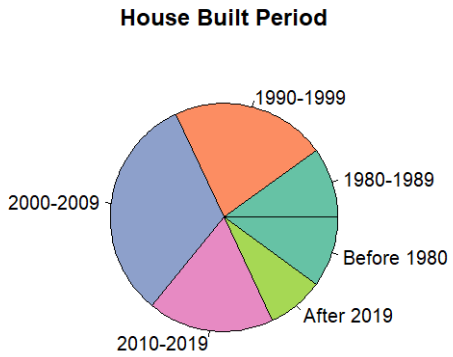

Fig. 5. House Built Period

2) Hypothesis 2

Economic and Social Statistics 2022 CBSL [1] states that average Monthly Household Expenditure for food equal to 22,130 rupees. Lets check with that using our initial sample.

Let,

μ = average Monthly expenditure for food(Rs)

$$\text{Ho: } \mu = 22,130$$
$$\text{H1: } \mu \neq 22,130$$

	Statistic	Value
1	z-value	-6.3906
2	p-value	8.260522e-11

Since P-value < 0.05, we have enough evidence to reject Null Hypothesis of average Monthly expenditure for food(Rs) equal to 22,130. In fact p value is really small even for 1% error, implying there is a huge shift from average Monthly expenditure for food from 22,130.

3) Hypothesis 3

Economic and Social Statistics 2022 CBSL [1] states that average Monthly Household Expenditure for Non-food equal to 41,000 rupees. Lets check with that using our initial sample.

Let,

μ = average Monthly expenditure for Non food(Rs)

$$\text{Ho: } \mu = 41,000$$
$$\text{H1: } \mu \neq 41,000$$

	Statistic	Value
1	z-value	-0.9553
2	p-value	0.1696

Since P-value > 0.05, we do not have enough evidence to reject Null Hypothesis of average Monthly expenditure for non-food(Rs) equal to 41,000 rupees at 95% significance level.

4) Hypothesis 4

TABLE I
FREQUENCY OF IRONING CLOTHES AND NIGHT LIGHTING

	don't keep any	less than two	more than two
daily	7	4	1
don't iron	0	1	0
need arises	8	11	3
twice a week	1	0	0
weekly	12	2	0

check whether the night lighting associated with ironing clothes

H0: Night lighting not associated with ironing clothes

H1: Night lighting associated with ironing clothes

	Statistic	Value
1	X-squared	11.348
2	df	8
3	p-value	0.1828

Since P-value > 0.05, we do not have enough evidence to reject Null Hypothesis meaning that there is no evidence to reject the fact Night lighting not associated with ironing clothes

5) Hypothesis 5

check whether the energy rating appliance check associated with electricity meter over-consumption

H0: Energy rating appliance check not associated with electricity meter over-consumption

H1: Energy rating appliance check associated with electricity meter over-consumption

	Statistic	Value
1	X-squared	3.1671
2	df	3
3	p-value	0.3666

Since P-value > 0.05, we do not have enough evidence to reject Null Hypothesis of energy rating appliance check not associated with electricity meter over-consumption.

V. Discussion and Conclusion

In this research the variables average monthly expenditure for food and non-food analyzed thoroughly as a related factor to electricity consumption using mean difference test and one sample mean test. The results showed that there was no evidence for mean difference in two variables at 95% significant level. Also, results showed that there is a significant shift of average monthly expenditure for food compared to the (HEIS) survey conducted in 2019 by department of census and statistic. But for single mean hypothesis testing for monthly expenditure for non-food did not have any evidence to reject Null hypothesis.

hypothesis 4 and 5 tested association of two categorical variables, I.e Night lighting associated with ironing clothes and energy rating appliance check associated with electricity meter over-consumption using chi squared test. But both tests had p-value grater than 0.05 and did not had any evidence to reject respective null hypothesis.

References

[1] Economic and Social Statistics 2022 CBSL - Table 2.12: https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/publications/ess_2022_chapter_2_e.pdf

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[4] K. L. Van Den Broek, I. Walker, and C. A. Klöckner, "Drivers of energy saving behaviour: The relative influence of intentional, normative, situational and habitual processes," Energy Policy, vol. 132, pp. 811–819, Sep. 2019, doi: 10.1016/j.enpol.2019.06.048.

VI. Appendix

All the Response Data Set and R codes for the analysis are available with the below Git Repository.

https://github.com/nisalasanga/Statistical-Inference-Project