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# A COMPARATIVE STUDY OF CONSUMPTION OF ELECTRICITY USING STATISTICAL MEASURES

**Prakash S. Chougule**[1]
Associate Professor,
Rajarshi Chhatrapati Shahu College,
Kolhapur (MS), India

**Suresh T.Salunkhe**[2]
Principal,
Rajarshi Chhatrapati Shahu College,
Kolhapur (MS), India

**Suresh V.Patil** [3]
Associate Professor,
Rajarshi Chhatrapati Shahu College,
Kolhapur (MS), India

**Sonam A. Amate** [4]
Research Student,
Rajarshi Chhatrapati Shahu College,
Kolhapur (MS), India

**Anjali S. Bhosale** [5]
Research Student,
Rajarshi Chhatrapati Shahu College,
Kolhapur (MS), India

## ABSTRACT

***Electricity is an important promoter of socioeconomic development.It is a vital source of energy in daily life, especially for household appliances, and hence, energy use efficiency can be achieved by applying demand side strategies to these devices. This can be beneficial to consumers in terms of reduction in energy costs, and to the electricity grid in terms of an optimal and efficient allocation of resources. The worldwide consumption of energy has become a crucial problem. The population is rising which leads to an increase in the energy demand and energy consumption. This study aimed to analyze the characteristic of the households affecting energy consumption of household electricity in Kolhapur District, The survey was conducted for collect primary data through questionnaires contains several attributes and collected information are analyzed using various statistical measures.***

**KEY WORDS:** ***Graphical Representation, Parametric Test, Non parametric Test, Level of Significance,***

## INTRODUCTION

Today, electricity has become critical to human life. It is a vital source of energy in daily life.Also is an important promoter of socioeconomic development. It has allowed us to achieve way more than what nature and evolution had restricted us to. But in our world that is constantly in metamorphosis and exponential growth, then finally, electricity is not as equitably distributed to all as it should be. One of the reasons for this could be socio economic geographic conditions added to consumer behaviour towards electricity. From 1973 to 1982 a number of general trends that characterized electricity use between 1960 to 1972 showed distinct changes. The annual percentage change in electricity price, adjusted for inflation reversed direction , from a decrease of 3.8% per year to an increase of 4% per year. Electricity is a type of energy fueled by transfer of electrons from positive and negative points within a conductor. Firstly to generate electricity, we require a fuel source. Such as coal,gas,hydropower or wind regardless of the chosen fuel, most generators operate on the proven principle turn turbine so that it spin magnet surrounded by copper wire, to get the flow of electrons across atoms which in turn generates electricity. Electricity is widely, used for providing power to building electric device and even some automobiles. A number of individuals are responsible for development of electricity but the most notable one is Benjamin Franklin and his flying

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kite experiment. Electricity has several contradictory meanings. There exists an extensive literature on electricity demand projection, and different approaches are found. This section provides a brief review of those that have focused on India's electricity demand. One approach makes use of aggregate macro data at the country or sub-national/state level (for example, Bose and Shukla 1999, CEA 2007a). Essentially, this approach aims to estimate the income elasticity of electricity consumption by econometric analysis of the relationship between electricity consumption and its key determinants, such as gross domestic product (GDP) per capita and electricity price, over a relatively long period of time. Another approach uses micro-level data that reflects individual and household behaviour; this may be referred to as a microeconomic approach. This approach enables analysis across different heterogeneous household sub-groups and takes into account a number of household characteristics. Examples include Pachauri (2004), Filippini and Pachauri (2004), and Tiwari (2000). These authors estimate price and income elasticities of electricity demand in the residential sector using household survey data. Filippini and Pachauri (2004) regressedhousehold electricity consumption on household expenditure (as a proxy for income), the average prices of electricity and other fuels, and a set of other geographic (regional dummies) and socio-economic (such as household size and the age of the household head) variables.An analysis of the development of simulation models for electric appliances use, with respect to their ability to shift their energy demand, was discussed by Stadler et al. (2009). Results from this study indicate that household devices such as electric boilers, off-peak storage heaters, or freezers, are more suited to load balancing than a refrigerator. Moreau (2011) presented a control strategy for water heaters that minimized the consumption demand when the heating elements are reactivated at the end of a load shifting period initiated by utilities shifting hot water demand from peak hours to off-peak hours. The research indicated that the consumption demand of water heaters after such universal load shifting periods can be detrimental to the efficiency of the measure if not adequately controlled. Shu Fan et.al.(2011), Ihbal, A.M et.al.(2011), WANG Qi et.al(2010) carried out frequently to study either consumption or demand but not consumer behaviour. Domestic energy consumption is the total amount of energy used in a house for household work. The amount of energy used per household varies widely depending on the standard of living of the country, the climate, and the age and type of the residence. It is part of our interest to study factors affecting on it. So, we have tried to collect the data related to the consumption of electricity in Rural and Urban area in Kolhapur District. . In our study we had taken a sample of 200 houses using electricity for various purposes such as light , computer, T.V. , fan , refrigerator , etc. Our main focus was comparative study of consumption of electricity in Urban and Rural area.

## OBJECTIVES

- To study domestic consumption of electricity in rural and urban area through statistical Study.
- To study the comparative effect of number of rooms , equipments and family members on electricity.
- To study financial background of members.
- To study literacy/ awareness towards saving of non renewable energy.
- To Comparison of Urban and Rural area.
- To study the how much time use of electronic appliances.

## METHODOLOGY

The subject of our project is "Domestic consumption of electricity in urban and rural area". For collection of primary data, we use questionnaire and the questionnaire includes the information about the area, no. of family members, no. of appliances and its company, no. of rooms in house, family income, no. of units used per month, etc. We collect information of 100 houses from each Urban and Rural area respectively. The questionnaire is attached on last page of project.

### Method of data collection

For the project work, we have collected primary data from Vicharemal, Jadhavwadi and Kadamwadi as urban points and Mugali, khamalehatti and Bachani as Rural point for data collection. The convenience sampling method is used for collecting data from the following areas by using questionnaires method.

1. Urbanarea
2. Rural area

**Statistical tools used:** Graphical representation, Testing of hypothesis and theory of Attributes.

**Software used:** MS – Excel and MS - Word

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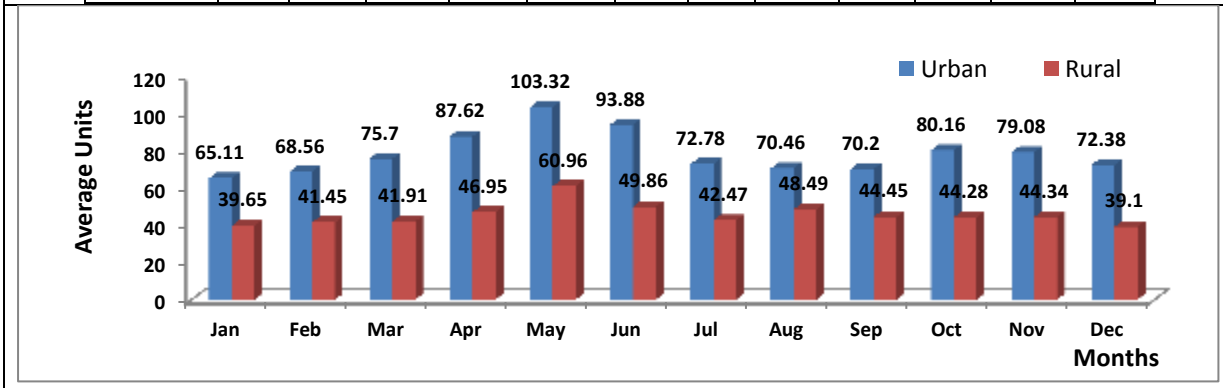
## Graphical Representation

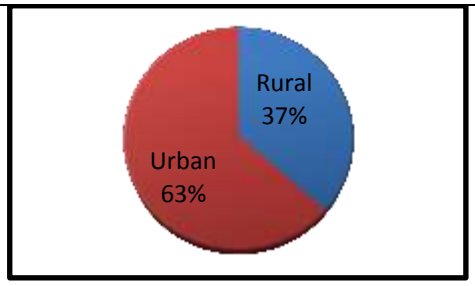
### A) consumption of electricity of months in urban and rural

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Urban | 65 | 69 | 76 | 88 | 103 | 94 | 73 | 70 | 70 | 80 | 79 | 72 |
| Rural | 40 | 41 | 42 | 47 | 61 | 50 | 42 | 48 | 44 | 44 | 44 | 39 |



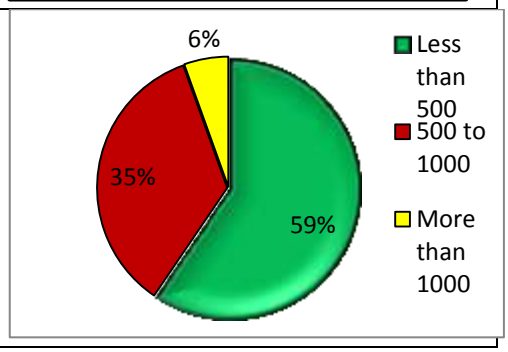

**Average Units of Electricity used in Rural and Urban area**

| Area | Average Units |
|---|---|
| Rural | 45.33 |
| Urban | 78.32 |




**Electricity Bill Paid Per Month**

| Bill Amount | Less than Rs. 500 | Rs. 500 to Rs.1000 | More than Rs. 1000 | Total |
|---|---|---|---|---|
| Frequency | 119 | 70 | 11 | 200 |




**No of Appliances used in Rural and Urban Area.**

| Appliances | TV | Mixer | Iron | Heater | Fan | Fridge | Mobile | Washing Machine | Computer | Oven | Electric motor | Flour mill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rural | 98 | 98 | 87 | 8 | 184 | 59 | 229 | 6 | 18 | 2 | 47 | 4 |
| Urban | 102 | 96 | 90 | 10 | 190 | 84 | 266 | 21 | 15 | 3 | 33 | 10 |

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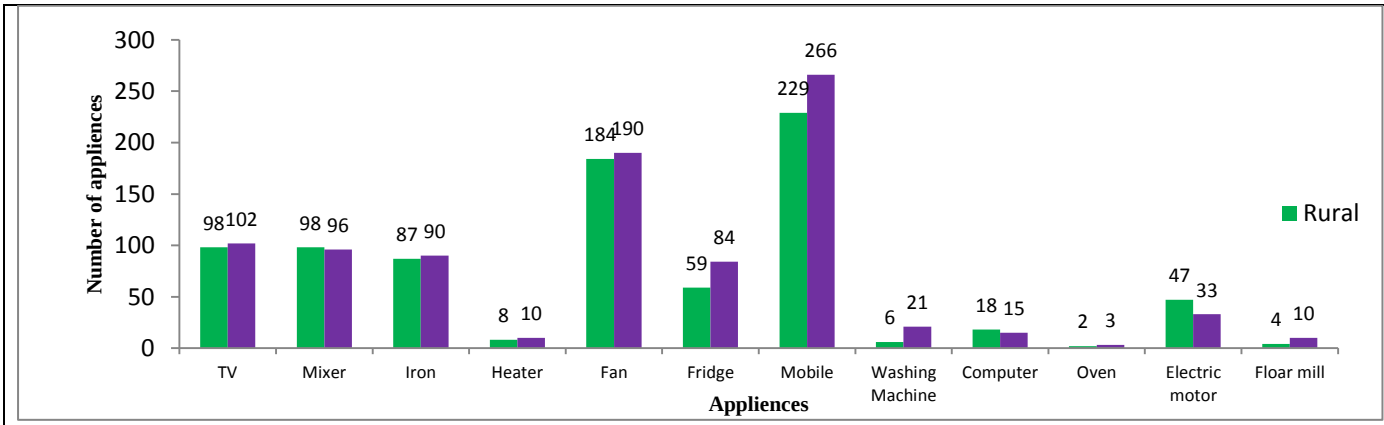


**Families having equal number of males and females**

| No. of house | M | F | Average Unit | Per Head Unit | No. Of Rooms | Average Per room |
|---|---|---|---|---|---|---|
| 33 | 1 | 1 | 59.16 | 29.58 | 3.24 | 19.33 |
| 49 | 2 | 2 | 60.28 | 15.07 | 4.29 | 16.65 |
| 11 | 3 | 3 | 76.43 | 12.74 | 3.55 | 24.59 |
| 1 | 5 | 5 | 62.58 | 6.26 | 9 | 6.95 |
| | | | | 15.92 | 5.02 | 16.88 |

**Families having number of males is greater than females:-**

| No. of house | M | F | Average Unit | Per Head Unit | No. Of Rooms | Average Per room |
|---|---|---|---|---|---|---|
| 1 | 6 | 5 | 247.25 | 22.48 | 6 | 41.21 |
| 2 | 6 | 4 | 159.34 | 15.94 | 4 | 39.84 |
| 3 | 5 | 1 | 30.39 | 5.07 | 1 | 23.23 |
| 3 | 4 | 3 | 102.53 | 14.65 | 4 | 24.96 |
| 1 | 4 | 2 | 36.58 | 6.10 | 4 | 9.15 |
| 1 | 4 | 1 | 36.34 | 7.27 | 1 | 36.34 |
| 20 | 3 | 2 | 62.71 | 12.54 | 4 | 17.76 |
| 15 | 3 | 1 | 61.72 | 17.51 | 3 | 20.15 |
| 9 | 2 | 1 | 66.59 | 22.20 | 3 | 22.23 |
| | | | 89.27 | 13.75 | 3 | 26.09 |

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**Families having number of males is less than females:-**

| No. of house | M | F | Average Unit | Per Head Unit | No. Of Rooms | Average Per room |
|---|---|---|---|---|---|---|
| 4 | 1 | 3 | 55.29167 | 13.8229 | 2.75 | 25.925 |
| 17 | 1 | 2 | 69.70588 | 23.2353 | 2.764706 | 26.81903595 |
| 4 | 2 | 4 | 39.08333 | 6.51389 | 4.25 | 9.147916667 |
| 18 | 2 | 3 | 51.8287 | 10.3657 | 4.388889 | 14.61743827 |
| 3 | 3 | 4 | 63.30556 | 9.04365 | 4.666667 | 13.06111111 |
| | | | | 12.5963 | 3.764052 | 17.9141004 |

**Testing Part:**

**a) Chi-square test**

Let us defined the attributes are A and B be Average of electricity unit used and Number of rooms respectively. The level of significance $\alpha$ can be taken as 5% .and the hypothesis are stated as

$H_o$: The attributes A and B are independent.v/s $H_1$: The attributes A and B are dependent.

**Observation Table :-**

| | M<F | M=F | M>F | Total |
|---|---|---|---|---|
| **Above Average number of room** | 21(16.2769) | 44(33.2615) | 4(19.4615) | 69 |
| **Below Average number of room** | 25(29.7230) | 50(48.6871) | 51(35.5384) | 126 |
| | 46 | 94 | 55 | 195 |

$\chi^2_{cal} = 36.6852$

$\chi^2_{tab} = \chi^2_{2,5\%} = 5.991$

$\chi^2_{cal} > \chi^2_{tab}$,

**b) Association between families & bill payment type urban & rural**

**Here we use the notations as** A be number of families in Rural area and B be the number of families paying offline bill and $\alpha$ be number of families in Urban area $\beta$ be the number of families paying online bill the observed frequencies are $(AB) = 84$, $(A\beta) = 16$, $(\alpha B) = 85$, $(\alpha\beta) = 15$

**Yule's coefficient of association**

$$Q = \frac{\{(AB)(\alpha\beta) - (A\beta)(\alpha B)\}}{\{(AB)(\alpha\beta) + (A\beta)(\alpha B)\}} = -0.03817$$

**Coefficient of colligation**

$$Y = \frac{\sqrt{(AB)(\alpha\beta)} - \sqrt{(A\beta)(\alpha B)}}{\sqrt{(AB)(\alpha\beta)} + \sqrt{(A\beta)(\alpha B)}} = -0.01909$$

**c) Paired t – test**

Ho: There is no significant difference between unit consumption of urban & rural area.

H1: There is significant difference between unit consumption of urban & rural area.

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**Observation Table**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Urban (Xi) | 65.11 | 68.56 | 75.7 | 87.62 | 103.3 | 93.88 | 72.78 | 70.46 | 70.2 | 80.16 | 79.08 | 72.38 | 939.25 |
| Rural(Yi) | 39.65 | 41.45 | 41.91 | 46.95 | 60.96 | 49.86 | 42.47 | 48.49 | 44.45 | 44.28 | 44.34 | 39.1 | 543.91 |
| di=Xi-Yi | 25.46 | 27.11 | 33.79 | 40.67 | 42.36 | 44.02 | 30.31 | 21.97 | 25.75 | 35.88 | 34.74 | 33.28 | 395.34 |

**Here the pair of observations are** $n_1 = 12$ , $n_2 = 12$.
**Average** unit consumption are $\bar{X} = 78.271$ , $\bar{Y} = 45.6$ and $\bar{d} = 32.95$

**The Variance** $S^2 = 50.261$ the value of test statistic is

$t_{cal} = \frac{\bar{d}}{\sqrt{S^2/n}} = 16.1$ ; $t_{table}$ :-$t_{n-1} = t_{12-1} = t_{11} = 1.796$ and $t_{cal} > t_{tab}$

## d) F-test for variances in rural and urban area

$H_0$ : There is no significant difference between variances of unit consumption between Urban and Rural areas. v/s $H_1$ : There is significant difference between variances of unit consumption between Urban and Rural areas

**Test statistics** $F = \frac{S_u^2}{S_r^2}$

Where, $S_u^2$ = Sample mean square of urban area. $S_r^2$ = Sample mean square of rural area.
$S_u^2 = \frac{1}{n_1 - 1}\sum[(Xi - \bar{X})^2] = 129.804$ and $S_r^2 = \frac{1}{n_2 - 1}\sum[(Yi - \bar{Y})^2] = 35.1173$

$F_{cal} = 3.696321$ and $F_{tab} = F(n_1\text{-}1, n_2\text{-}1) = F_{(11,11)} = 2.818$ at 5% level of significance

## e) Run test

1) **Rural area :** $H_0$ :- Sample is random. V/s $H_1$ :- Sample is not random.

**Observation table**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 64.7 | A | 33.1 | B | 32.9 | B | 82.4 | A | 120.6 | A | 41.7 | A |
| 49.8 | A | 44.2 | A | 64.3 | A | 48.0 | A | 108.9 | A | 53.3 | A |
| 201.9 | A | 46.9 | A | 32.8 | B | 62.2 | A | 87.0 | A | 42.3 | A |
| 36.8 | B | 30.2 | B | 21.3 | B | 37.1 | B | 34.5 | B | 49.2 | A |
| 23.3 | B | 53.3 | A | 40.9 | A | 16.7 | B | 49.6 | A | 39.6 | A |
| 44.5 | A | 76.6 | A | 40.4 | A | 51.2 | A | 29.9 | B | 29.6 | B |
| 34.5 | B | 22.9 | B | 29.7 | B | 5.1 | B | 36.8 | B | 32.9 | B |
| 49.6 | A | 62.6 | A | 20.8 | B | 34.9 | B | 36.1 | B | 44.2 | A |
| 29.9 | B | 70.3 | A | 42.3 | A | 6.5 | B | 41.3 | A | 36.8 | B |
| 143.7 | A | 58.7 | A | 28.8 | B | 29.5 | B | 35.5 | B | 36.1 | B |
| 36.1 | B | 104.0 | A | 73.3 | A | 5.2 | B | 30.2 | B | 41.3 | A |
| 41.3 | A | 68.0 | A | 89.3 | A | 24.6 | B | 31.9 | B | 35.5 | B |
| 35.5 | B | 45.0 | A | 108.3 | A | 26.0 | B | 38.7 | A | 30.2 | B |
| 41.7 | A | 76.4 | A | 26.0 | B | 15.5 | B | 56.7 | A | 31.9 | B |
| 31.9 | B | 63.8 | A | 49.2 | A | 12.9 | B | 33.1 | B | 38.7 | A |
| 38.7 | A | 39.6 | A | 2.3 | B | 27.8 | B | 22.9 | B | | |
| 56.7 | A | 29.6 | B | 16.3 | B | 19.3 | B | 46.9 | A | | |

Here, $X_m$ = Sample Median = 38.70 (Denote 'A' if $X_i \geq X_m$ and denote 'B' if $X_i < X_m$)

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r = Number of runs = 49 , $n_1$ = Number of A's = 51, $n_2$ = Number of B's = 49.

The test statistic is, $Z_o = \frac{r-E(r)}{\sqrt{Var(r)}} \sim N(0,1)$ If $|Z_0| \geq Z_{\alpha/2}$ then , we reject $H_0$ .

**Calculation part**

$E(r) = \frac{(n+2)}{2} = 51$, var $(r) = \frac{n(n-2)}{4(n-1)} = 24.7474$

$|Z_0| = \frac{49-51}{\sqrt{24.7474}} = 0.4020$ and $Z_{tab} = Z_{\alpha/2} = 1.96$

**2) Urban area**

$H_0$ :- Sample is random V/s $H_1$ :- Sample is not random.

**Observation Table**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 66.25 | B | 17.58 | B | 49.92 | B | 83.08 | A | 98.75 | A | 39.50 | B |
| 84.58 | A | 64.17 | B | 82.92 | A | 105.83 | A | 59.50 | B | 110.17 | A |
| 41.33 | B | 65.17 | B | 292.83 | A | 74.75 | A | 72.33 | A | 101.83 | A |
| 26.17 | B | 114.08 | A | 69.92 | B | 70.08 | A | 85.83 | A | 99.67 | A |
| 143.67 | A | 91.83 | A | 159.33 | A | 151.50 | A | 47.92 | B | 114.08 | A |
| 64.67 | B | 83.67 | A | 48.08 | B | 70.08 | A | 26.42 | B | 91.83 | A |
| 247.25 | A | 97.25 | A | 115.67 | A | 108.92 | A | 137.42 | A | 83.67 | A |
| 44.75 | B | 53.17 | B | 48.00 | B | 101.42 | A | 66.92 | B | 97.25 | A |
| 74.17 | A | 43.50 | B | 83.42 | A | 93.00 | A | 113.42 | A | 53.17 | B |
| 61.50 | B | 35.67 | B | 80.75 | A | 94.33 | A | 63.00 | B | 43.50 | B |
| 28.83 | B | 41.08 | B | 118.00 | A | 63.17 | B | 174.25 | A | 35.67 | B |
| 95.00 | A | 24.08 | B | 184.67 | A | 92.08 | A | 63.83 | B | 41.08 | B |
| 36.58 | B | 69.17 | B | 65.75 | B | 20.50 | B | 82.25 | A | 24.08 | B |
| 15.67 | B | 115.17 | A | 159.83 | A | 96.67 | A | 56.50 | B | 69.17 | B |
| 30.83 | B | 1.75 | B | 97.42 | A | 56.42 | B | 74.17 | A | 115.17 | A |
| 36.33 | B | 43.00 | B | 67.33 | B | 6.00 | B | 60.83 | B | | |
| 25.42 | B | 72.17 | A | 40.08 | B | 142.17 | A | 79.50 | A | | |

Here, $X_m$ = Sample Median = 70.08 , (Denote 'A' if $X_i >= X_m$ and denote 'B' if $X_i < X_m$ )
r = Number of runs = 52 , $n_1$ = Number of A's = 51, $n_2$ = Number of B's = 49.
The test statistic is, $Z_o = \frac{r-E(r)}{\sqrt{Var(r)}} \sim N(0,1)$ and If $|Z_0| \geq Z_{\alpha/2}$ then , we reject $H_0$ .

**Calculation part**

$E(r) = \frac{(n+2)}{2} = 51$, var $(r) = \frac{n(n-2)}{4(n-1)} = 24.7474$ and $|Z_0| = \frac{52-51}{\sqrt{24.7474}} = 0.2010$ and $Z_{tab} = Z_{\alpha/2} = 1.96$ .

**f) Mann whitney U test**

$H_0$: The two samples comes from same population v/s $H_1$: The two samples comes from different population.
Level of significance = α % = 5%

The test statistic, $Z_o = \frac{U-E(U)}{\sqrt{Var(U)}} \sim N(0,1)$

Where, U = min ($U_1$ , $U_2$) and $U_1 = n_1.n_2 + \frac{n1(n1+1)}{2} - R_1$ and $U_2 = n_1.n_2 + \frac{n2(n2+1)}{2} - R_2$

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E (U) = $\frac{n1 \cdot n2}{2}$ and Var (U) = $\frac{n1.n2\ (n1+n2+1)}{12}$ If $|Z_o| \geq Z_{\alpha/2}$ then we reject $H_o$ at α% level of significance.

The observed values are $n_1$= 100, $n_2$=100, $R_1$= 12655, $R_2$ = 7445, $U_1$ = 2395, $U_2$ = 7605, E (U) = 5000, Var(U) = 167500 Therefore , U = min ($U_1$ , $U_2$) = 2395 ,

$Z_o = \frac{U-E(U)}{\sqrt{Var(U)}}$ = - 6.3650 Then , $|Z_o|$ = 6.3650 and $Z_{\alpha/2}$ = 1.96

## Overall Conclusion

- Consumption of electricity in house used within one year is maximum in urban area as compared to rural area.
- The average electricity unit of used and family size are dependent.
- The average electricity unit of used and number of rooms are dependent.
- The attributes of families & bill payment type are negatively associated to each other.
- There is significant difference in average units between Urban & Rural area.
- There is significant difference in variance of unit consumption of electricity in Urban and Rural areas.
- The Rural and Urban area samples are randomly taken.
- The two samples ( i.e average unit of rural & urban area. ) comes from different population.

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