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Non Parametric Tests: An Efficient Statistical Method for Data Analysis for Social and Medical Sciences

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Abstract: *Statistical hypothesis testing is an integral and vital part of research in all fields, includingSocial Sciences, Life Sciences and Mathematical sciences. Statistical investigations based on data testing prove the trustworthiness of research and make it more generalized. This qualitative research emphasizes the distinction between parametric and non-parametric tests applied in the social and medical sciences. It also helps to understand the concepts and applications of non-parametric tests over parametric tests.For a researcher who does not belong to a Mathematical or Statistical background, it is often difficult to understand and apply parametric tests in quantitative research. Non-parametric tests help them to easily understand and apply statistical hypothesis testing. This paper is also helpful to distinguish between parametric and non-parametric tests.*

Keywords: *Statistical hypothesis*

I. INTRODUCTION

Every researcher has to go through the collection, visualization, analysis, and interpretation of data while conducting research. Analysis is the soul of research, which consists of calculations based on the data. This later proves the objectives of the research. Testing is usually known as Hypothesis Testing(HT).This testing can be carried out in two ways: By Parametric tests and Non-parametric tests.

Parametric Tests:

Parametric methods are those which follow a specific probabilistic distribution with certain parameters. In HT, it is assumed that the sample taken from the parent population must be Normally distributed with parameters such as Mean (μ) and Variance (σ^2).Here, the Mean is the measure of central tendency, while Variance is the measure of dispersion. Various Normality tests are used to ensure the data fits this criteria before further tests are conducted. Examples of these parametric tests include:z-tests,t-tests,F-tests,One-way ANOVA,Two-way ANOVA.In Social Sciences and Medical Sciences, sometimes the distribution is not Normal. In such cases, checking whether the sample comes from a Normal distribution helps the researcher decide how to test the hypothesis.

Non-Parametric Tests:

Non-parametric tests are those that do not need to follow a specific probability distribution, and hence they are also known as Distribution-Free tests. There are a number of non-parametric tests which can be applied, especially in the fields of Social Sciences and Clinical Trials.In Social Sciences and Medical Sciences, sometimes the distribution is not normal. In such cases, checking whether the sample comes from a Normal distribution helps the researcher decide how to test the hypothesis.

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Objectives of the Research:

- To understand the concept of Parametric and Non-parametric tests in testing of rigor.
- To apply the Non-parametric test in research of social sciences and clinical trials.
- To understand the advantages of Non-parametric tests.
- To understand the applications of Non-parametric tests.

Discussion:

Non-parametric (NP) Tests:

Suppose a random sample of size n, $x_{1,}x_{2,}\ldots,x_n$ is drawn from a population where the form of the population distribution is unknown. To test the hypothesis, one needs to make assumptions about the population from which the sample is taken.Methods that do not make any assumptions about the parameters or the specific form of the population are called Non-parametric tests. NP tests are useful in situations where the test does not depend on the particular functional form of the basic population from which the samples are drawn.

Advantages of Non-parametric (NP) Tests:

Ease of Use: NP tests are easy to understand and apply. They do not require complicated sample theory.
Efficiency: Most of these tests do not require lengthy, time-consuming, or complicated calculations.
Flexibility: NP tests have fewer rigid requirements regarding the parent population and can be applied to a wide range of situations.
Data Type: NP tests can be applied to data involving simple classifications which are measured on a nominal scale (categorical data) or ordinal scale (ranked data).
NP tests are especially suitable for studies in behavioral sciences like Psychology, Education, Social sciences, etc., where the data can generally be categorized or ranked but not exactly measured.
NP tests can be used in all types of data:a) Qualitative data – in Likert'z scale
b) Ranked data – ordinal scaling
c) Quantitative data – interval or Ratio scale.
Here are some NP tests for social science as in clinical trials.

Run Test

Single sample sign test (small & large sample):
Wilcoxon Signed Rank test (for single sample & matched pairs for small sample & large sample)
Mann-Whitney U test for 2 independent samples (small & large)
Kruskal-Wallis test or H test (as efficient as ANOVA)

Run test:

If the sample drawn from population is random then it provides the generalized result. Run test is applied to test whether the obtained sample is random or not. This test is applied in both qualitative as well as quantitative data sets for large & small samples. The null hypothesis is set as:
H_0: The given sample shows random pattern.
H_1: The given sample is non-random.
Run is referred as the continuous sequence of identical symbols.
eg. B B BG G GBGBG GBG GB
Here n_1 = total number of 'B' = 7
n_2= total number of 'G' = 8
Total number of runs = R = 10 :is the test statistic. By using the critical values from the statistical table at n_1 = 7 and n_2 = 8 at 5% level of significance,

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if $n_1 < R < n_2$, then H_0 is accepted i.e. the pattern is random.

Run test is very easy to check the randomness of the sample with very less calculations without calculating any parameter.

Single sample sign test:

Case i) Sign test is applied for both single sample and double sample / paired sample.

If sample contains n is less than or equal to25 units, it is a small sample. This test is used to test the hypothesis concerning the measure of median as it is a positional average and can be calculated for both quantitative and qualitative data as well.

The null hypothesis is H_0: Median of the sample is Me(say) against

H_1: Median $\neq$ Me …………… two tailed test

or H_1: Median < Me …………… left tailed test

or H_1: Median > Me …………… right tailedtest

Test procedure:

i) Subtract value of Me from each value of sample observation.

ii) If the difference is +ve give '+' sign and if difference is -ve give '-' sign. If difference is zero drop the observation.

x : Minimum [+ , -] …….. test statistic

n : total no. of '+' & '-' signs

Refer statistical table for α % LOS for critical value of sign test.

if x $\leq$ critical value at α% LOS for given 'n',

then H_0 is rejected.

i.e. Median of the sample is not Me.

Case ii) Single sample sign test for large sample (if n > 25):

To test the single sample containing more than 25 observations, the test statistic is calculated by standardization - Central Limit Theorem i.e. normal test.

$H_0$and H_1 are as in above test case ii.

Test Procedure:

Set + or - signs to the sample as in previous method.

x : total number of + signs (if sample starts from + signs)

n : total no. of + & - signs (drop 0's)

The test statistic is:

$Z_{cal} = \{(x + 0.5) - (n/2)\}/(\sqrt{n}/2)$ ……..if x < (n/2)

$Z_{cal} = \{(x - 0.5) - (n/2)\}/(\sqrt{n}/2)$ ……..if x < (n/2)

Refer statistical table to get critical value at α % LOS for two tailed or right tailed or left tailed alternative Hypothesis of probabilities of standard normal distribution, say $[Z_{table}]_{\alpha\%}$

If $|Z_{cal}| > [Z_{table}]_{\alpha\%}$, then reject H_0.

P-value Method:

Carry out all the steps up to Z_{cal} .

P -value = $P(Z < Z_{cal})$ ……. For left tailed alternative Hypothesis.

If P -value > α %, then H_0 is accepted otherwise rejected.

Case iii) Paired sample sign test :

This test is extended form of single sample Sign Test. Here to test whether the two samples have the same medians.

H_0:$Median_1 = Median_2$ against

H_1: $Median_1 \neq Median_2$

Let us denote the observations in first sample by x_i (i=1, 2, …., n) and observations in second sample by y_i. Take deviation $d_i = (x_i - y_i)$. Replace the deviations by + or - sign.

If d_i is positive give '+', and if d_i is negative give '–'.Drop '0' if any.

Follow the test procedure as in single sample sign test for small sample or large sample.

Wilcoxon Signed Rank-Test :

The test is the best alternative for paired-t-test, which is usually used to check the effectiveness of the treatment provided to the sample. The observations are given in the form of before and after treatment i.e. in matched pairs. It is as efficient as paired t-test used for both single and double samples.

Case i) Single-sample Wilcoxon signed ranked test :For (small sample ≤ 30)

This method is applied to test the null hypothesis that population median is Me or not.

Here to find the terms : Set null and alternative hypothesis as in single sample sign test case (i)

Subtract Me from all sample values.

Assign ranks to each deviation of the so obtained.

To find R^+ : sum of the positive ranks and R^- : sum of the negative ranks

Test statistic is R_{cal} = Minimum $\{R^+, R^-\} = R_0$ (say)

At α % LOS and 'n' : number of observations after dropping 'zero' difference between observations and Me (sample size will reduced accordingly).

With reference to statistical table ,critical value is $[R_{table}]_{\alpha\%.}$

Conclusion :if $R_{cal} \leq [R_{table}]_{\alpha\%.}$ Then reject H_0.

Note: If tie of diff occurs, give average of the ranks to ties.

P-value Method: If P-value <α%, Reject H_0.

Where P -value = $P(R \leq R_0)$

Here if we use sign test and WSR test for the same sample, it is the conclusion may differ. Since W.S.R. test uses more information, it is regarded as better choice among two.

Case ii) W.S.R. for matched pairs:—

If both samples are not normal and to test the effect of the treatment provided to the sample, this test is applied. To test whether both samples have same median value.

The null hypothesis is as in paired sample sign test :

Here the test statistic is :

$R = R_{cal}$ = Minimum $\{R^+, R^-\}$

If $R_{cal} \leq [R_{table}]_{\alpha\%.}$ Then reject H_0.

iii) W.S.R. Test for large sample: (n > 30)

If the sample size is large, the test follows procedure as above up to find test statistic

R_{cal} = Minimum $\{R^+, R^-\}$

Wheretest statistic is:

$Z_{cal} = (R - \mu_R) / \sigma_R$ where $\mu_R = n(n+1)/4$ $\sigma_R = \sqrt{n(n+1)(2n+1)/24}$

at α %LOS with n : number of observations after dropping zeros in deviations.

$[Z_{table}]_{\alpha\%}$ is critical value can be referred from standard Normal table.

Conclusion: If $|Z_{cal}| > [Z_{table}]_{\alpha\%}$, then reject H_0.

P-value method : Carried out calculations up to$|Z_{cal}|$.

P-value $= P(Z < -Z_{cal}) = P(Z > Z_{cal})$ …… Due to symmetricity of Normal Distribution.

If P-value <α % , reject H_0.

Mann-Whitney U Test:

The test is used when to test whether the two independent samples drawn from same population i.e. to test that they have same medians.

H_0: $(Me)_1 = (Me)_2$

Here Mergetwo samples and then assign ranks.

Test statistic is U_{cal} = Minimum (U_x, U_y) ……… where $U_x = R_x–(n_1(n_1+1))/2$ and $U_y = R_y–(n_2(n_2+1))/2$

Test Statistic is U_{cal} = Minimum(U_x, U_y)

where R_x: sum of ranks of 1st sample X and R_y: sum of ranks of 2nd sample Y

Conclusion:Refer Mann-Whitney U test critical value table α% LOS say $[U_{cal}]_{\alpha\%}$ for given n_1 & n_2.

If $U_{cal}>[U_{table}]_{\alpha\%}$, reject H_0.

P-value method:

P –value=$P(U \leq U_{cal})$ …..by standard Normal Distribution.

If P -value ≤ α% …….Reject H_0.

Kruskal-Wallis test or H-test:

This non-parametric test is the substitute to one-way ANOVA. Usually ANOVA test is used to test the equality of several population means. It is an extension of Mann-Whitney U Test for more than three independent random samples containing more than 5 observations in each sample.

H_0: The k independent samples are drawn from population which are identically distributed.

H_1: The k independent samples are not identically distributed.

Test Procedure:

Combine all the samples to obtain a single sample. Arrange all the observations in increasing order and give ranks.

R_i : sum of ranks of i^{th} sample.Under null hypothesis the test statistic is,

$H_{cal}=[\{12/n(n+1)\}\ \Sigma(R_i^2/n_i)] - 3(n+1) \sim [\chi^2]_{k-1}$degrees of freedom.

At α% LOS , $[\chi^2]_{k-1}$is table value.

here if $H_{cal}> [\chi^2]_{k-1}$, reject H_0.

II. CONCLUSION

In the research of social sciences and medical sciences or in clinical trials ,the collected data shows skewness or non Normal ,in such situations it find difficult to apply Parametric tests in testing. Non parametric tests are the best and efficient methods for prdictions. The NP methods are easy ,less time consuming, provides good predictions even for non Mathematical backround researchers. Some of the NP tests proves more accurate over Parametric Tests.

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