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**Project 2: Independent Samples t-test**

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## Conduct tests to determine if an independent samples t-test can be conducted on the OTP data.

1. Both depots have skewed distribution of OTP. T the dispersion of data appears to be the same.

Chart

Description automatically generated

Samples violate assumption of Normality. However, with huge sample according to Central Limit Theorem, so we can assume that T-test will give reliable results.

2. Checking the homogeneity of variance.

Means Report:

|  |  |  |  |
| --- | --- | --- | --- |
| *Report* | | | |
| OTP On-time percentage | | | |
| Depot | Mean | N | Std. Deviation |
| DEPOT\_15 | 91.33 | 4517 | 2.4915 |
| DEPOT\_18 | 91.90 | 4518 | 2.6805 |
| Total | 91.61 | 9035 | 2.6032 |

Standard Deviations of samples are close,

Ratio of variances = 1.1575

We can assume that populations have homogenous variances.

Checking with Levene test. Test supposed to be robust with relatively equal sized of samples

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Tests of Homogeneity of Variances* | | | | | |
|  | | Levene Statistic | df1 | df2 | Sig. |
| OTP On-time percentage | Based on Mean | 36.342 | 1 | 9033 | 0.000 |
| Based on Median | 21.158 | 1 | 9033 | 0.000 |
| Based on Median and with adjusted df | 21.158 | 1 | 9001.859 | 0.000 |
| Based on trimmed mean | 28.721 | 1 | 9033 | 0.000 |

The result is significant p-value close to 0. It means than variances have significant difference.

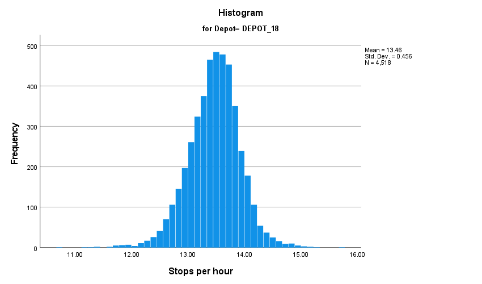
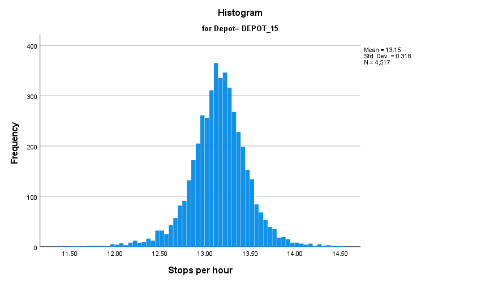
While conducting t-test, I would check the results for both assumptions.

Conclusion: T- test assumptions of normality are violated, but due to huge sample size, we can still use it. We can use T-test assuming OTP has different variance.

1. SPH data.

1 . Conduct tests to determine if an independent samples t-test can be conducted on the SPH data.

Does it violate any assumptions which prevent the independent sample t-test from being conducted? Provide evidence (graphs, any test results) to support your decision.



Chart, diagram, schematic

Description automatically generated with medium confidence

Visually symmetrically distributed data with heavy tales. Visually different spread of data for depot 15 and depot 18.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Descriptives* | | | | | |
|  | Depot Depot | | | Statistic | Std. Error |
| SPH Stops per hour | 1 DEPOT\_15 | Mean | | 13.1538 | 0.00474 |
| 95% Confidence Interval for Mean | Lower Bound | 13.1445 |  |
| Upper Bound | 13.1631 |  |
| 5% Trimmed Mean | | 13.1579 |  |
| Median | | 13.1600 |  |
| Variance | | 0.101 |  |
| Std. Deviation | | 0.31831 |  |
| Minimum | | 11.37 |  |
| Maximum | | 14.54 |  |
| Range | | 3.17 |  |
| Interquartile Range | | 0.36 |  |
| Skewness | | -0.288 | 0.036 |
| Kurtosis | | 2.254 | 0.073 |
| 2 DEPOT\_18 | Mean | | 13.4649 | 0.00678 |
| 95% Confidence Interval for Mean | Lower Bound | 13.4516 |  |
| Upper Bound | 13.4782 |  |
| 5% Trimmed Mean | | 13.4707 |  |
| Median | | 13.4900 |  |
| Variance | | 0.208 |  |
| Std. Deviation | | 0.45574 |  |
| Minimum | | 10.68 |  |
| Maximum | | 15.71 |  |
| Range | | 5.03 |  |
| Interquartile Range | | 0.55 |  |
| Skewness | | -0.300 | 0.036 |
| Kurtosis | | 1.553 | 0.073 |

Ratio of variances is 0.208/0.101 = 2.06

SPSS test of Normality results

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *Tests of Normality* | | | | | | | |
|  | Depot Depot | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|  | Statistic | df | Sig. | Statistic | df | Sig. |
| SPH Stops per hour | 1 DEPOT\_15 | 0.049 | 4517 | 0.000 | 0.975 | 4517 | 0.000 |
| 2 DEPOT\_18 | 0.038 | 4518 | 0.000 | 0.986 | 4518 | 0.000 |
| 1. Lilliefors Significance Correction | | | | | | | |

Tests of Normality (p-value=0)s, Skewness and Kurtosis suggest that data are not normally distributed.

SPSS Levene test results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Test of Homogeneity of Variance* | | | | | |
|  | | Levene Statistic | df1 | df2 | Sig. |
| SPH Stops per hour | Based on Mean | 432.201 | 1 | 9033 | 0.000 |
| Based on Median | 424.984 | 1 | 9033 | 0.000 |
| Based on Median and with adjusted df | 424.984 | 1 | 8236.889 | 0.000 |
| Based on trimmed mean | 430.005 | 1 | 9033 | 0.000 |

Levene tests suggests that depot 15 and depot 18 have different variances (Levene Statistic W=432.201, p=0.000).

### independent samples t-test to compare SPH.

Assuming that 2a(SPH) allows for the independent samples t-test to be conducted, determine if there is a statistically significant difference in SPH for the two depots. Note: You may need to create a dummy variable (for example DEPOT\_15=1 and DEPOT\_18=2) in order to conduct the t-test.

SPSS Independent Sample T-Test results:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Group Statistics* | | | | | |
|  | Depot Depot | N | Mean | Std. Deviation | Std. Error Mean |
| SPH Stops per hour | 1 DEPOT\_15 | 4517 | 13.1538 | 0.31831 | 0.00474 |
| 2 DEPOT\_18 | 4518 | 13.4649 | 0.45574 | 0.00678 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Independent Samples Test* | | | | | | | | | | |
|  | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| Lower | Upper |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| SPH Stops per hour | Equal variances assumed | 432.201 | 0.000 | -37.619 | 9033 | 0.000 | -0.31114 | 0.00827 | -0.32735 | -0.29493 |
| Equal variances not assumed |  |  | -37.620 | 8076.959 | 0.000 | -0.31114 | 0.00827 | -0.32735 | -0.29493 |

H0: means are equal

H1: means are not equal.

We reject H0 based on p-value=7.576E-288<<0.05 (For both assumptions, equal variances, and not equal variances)

An independent-samples t-test was conducted to compare Stops per Hour (SPH) scores for depot 15 and depot 18. There was a significant difference in scores for depot 15 (M= 13.1538, SD =0.3183 ) and Depot 18 (M = 13.4649, SD = 0.00678; t(9033) = 37.620, p= 7.576E-288, two-tailed).

## Productivity analysis

Two Independent tests are conducted for two deports to compare the mean of Stops per hour(SPH) to figure out is there is any significant change under new management.

Results:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Group Statistics* | | | | | | |
| DEPOT\_ALIAS | | Year | N | Mean | Std. Deviation | Std. Error Mean |
| DEPOT\_15 | SPH | 1 | 252 | 12.932262 | 0.7963027 | 0.0501624 |
| 2 | 252 | 13.667528 | 0.9344166 | 0.0588627 |
| DEPOT\_18 | SPH | 1 | 252 | 13.179444 | 1.0711131 | 0.0674738 |
| 2 | 252 | 12.782815 | 1.0653059 | 0.0671080 |

Mean SPH for Depot 15 second year is bigger than first year, conversely, mean for depot 18 in first year is bigger. Based on this, we can hypothesize that manager of the depot 15 in first year and depot 18 in the second year (the same person after swapping) didn’t perform well with regard to SHP.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Independent Samples Test* | | | | | | | | | | | |
| DEPOT\_ALIAS | | | **Levene's Test for Equality of Variances** | | **t-test for Equality of Means** | | | | | | |
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| Lower | Upper |
| DEPOT\_15 | SPH | Equal variances assumed | 3.600 | 0.058 | -9.507 | 502 | 8.0814E-20 | -0.7352659 | 0.0773374 | -0.8872108 | -0.5833209 |
| Equal variances not assumed |  |  | -9.507 | 489.684 | 0.000 | -0.7352659 | 0.0773374 | -0.8872201 | -0.5833117 |
| DEPOT\_18 | SPH | Equal variances assumed | 0.190 | 0.663 | 4.168 | 502 | 0.000036 | 0.3966298 | 0.0951640 | 0.2096609 | 0.5835986 |
| Equal variances not assumed |  |  | 4.168 | 501.985 | 0.000 | 0.3966298 | 0.0951640 | 0.2096609 | 0.5835986 |

Lavene’s test for equality of distributions is not significant for both Depots, so we can assume the variances are the same is both cases for year 1 and 2.

Two independent-samples t-tests were conducted to compare SPH for year one and year two.

* + 1. Did the intervention of swapping the Senior Managers between depots have a statistically significant impact on the stops per hour productivity at either depot?

In depot 15, SPH in year one (M=12.932262, SD=0.7963027) is significantly smaller than SHP in year two ( M=13.667528, SD=0.9344166; t=-9.507,p=8.0814E-20,left tailed).

In depot 18, SPH in year one (M=13.179444, SD=1.0711131) is significantly larger than SHP in year two ( M=12.782815, SD=1.0653059; t=-4.168 ,p=0.000036,right tailed).

Conclusion, the manager who managed Depot 15 in year one and depot 18 in year two shows significantly smaller performance.

* + 1. What will you advise the company regarding the management situation at DEPOT\_15 and DEPOT\_18?

**Suggestion: Find the root cause of the problem, develop best practices based on better performer and provide training for poorer performing manager.**