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Practical quantitative research on technological impact on Australia post facilities' processing capacity

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Abstract. Australia Post has seen increasing demands for its service and in response to this, an automated sorting station and an artificial intelligence-based prioritization system have been installed separately in Tullamarine and Mascot in 2019. This essay aims to answer the question: "Can the technology – the automated sorting station and the artificial intelligence-based prioritization system effectively improve the processing capability of Australia Post?" Four hypotheses will be raised. Selected data for each hypothesis will firstly be described and visualized, then the data will be tested by the Shapiro-Wilk test for normal distribution. According to the Shapiro-Wilk test result and the hypothesis, different statistic tests will be selected to analyze the data followed by the interpretation of the result. In conclusion, the technology - the automated sorting station and the artificial intelligence-based prioritization system can effectively improve the processing capability of Australia Post, and there is no significant difference between the effectiveness of the two technologies.

Keywords: Practical Quantitative Research, Technological Impact, Shapiro-Wilk Test

1. Background

Australia Post has seen increasing demands for its service and in response to this, an automated sorting station and an artificial intelligence-based prioritization system have been installed separately in Tullamarine and Mascot in 2019. In order to investigate the impacts of the automated station [1] in Tullamarine and the prioritization system [2] in Mascot, data has been gathered from Tullamarine, Mascot, and Brisbane where no new technology was implemented, over the year of 2018 and 2019 regarding the number of letters, small parcels, and large parcels that have been processed on daily basis.

Following from the above background, the question may be asked is: can the technology – the automated sorting station and the artificial intelligence-based prioritization system effectively improve the processing capability of Australia Post? Four hypotheses will be raised. Selected data for each hypothesis will firstly be described and visualized, then the data will be tested by the Shapiro-Wilk test [3] for normal distribution. According to the Shapiro-Wilk test result and the hypothesis, different statistic tests will be selected to analyze the data followed by the interpretation of the result.

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2. Hypothesis 1 – the automated sorting station in Tullamarine and the artificial intelligence-based prioritization system in Mascot have similar small parcel processing capabilities

2.1. Data description and visualization

The selected dataset is the small parcel in Tullamarine and the small parcel in Mascot in the year 2019. The mean of Mascot and Tullamarine is 301256.6 and 299953.3 with a standard deviation of 44040.834 and 43737.355 respectively. The range for Mascot is 151253 with 75760 for the inter-quartile range, and 147904 and 78588 for Tullamarine. Both Mascot and Tullamarine are skewed to the left because of the negative skewness. The summary of the description is presented in Table 1.

Table 1. Hypothesis 1 Summary of data description.

	Mean	Median	Mode	Range	Inter-quartile range	Standard deviation	Skewness
Mascot	301256.6	304954	279581	151253	75760	44040.834	-0.08324
Tullamarine	299953.3	299090	No mode	147904	78588	43737.355	-0.02693

2.2. Hypothesis

Null hypothesis: the daily average number of small parcels processed in Tullamarine and Mascot is the same in 2019. Alternative hypothesis: the daily average number of small parcels processed in Tullamarine is greater than those processed in Mascot in 2019.

2.3. Shapiro-Wilk test

Shapiro-Wilk test [3] is used to test whether the data is normally distributed. For both Mascot and Tullamarine, test result is presented in Table 2, and can be concluded that the data is not normally distributed. Therefore, a non-parametric test [4] would be suitable to analyze this set of data.

Table 2. Hypothesis 1 Shapiro-Wilk test result.

	w	p
Mascot	0.947254	3.99E-10
Tullamarine	0.948965	6.51E-10

2.4. Mann-Whitney U test and result interpretation

Mann-Whitney U test is a non-parametric test for two groups of observations that are independent of each other to test whether two sample means are equal [5]. The test is conducted on the daily small parcel number for Mascot and Tullamarine in 2019. The p-value of the test is 0.34257896, indicating that it is not statistically significant to reject the null hypothesis. As a result, the automated sorting station in Tullamarine and the artificial intelligence-based prioritization system in Mascot have similar small parcel processing capabilities. Data visualization is shown in Figure 1.

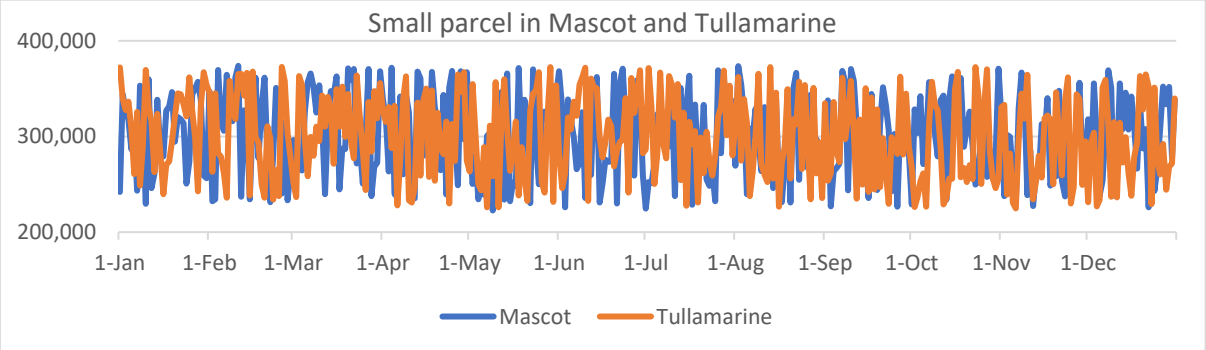

Figure 1. Hypothesis 1 data visualization.

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3. Hypothesis 2 – the automated sorting station effectively improves the small parcels processing capability in Tullamarine

3.1. Data description and visualization

The selected dataset is the small parcel in Tullamarine. For small parcels processed in Tullamarine in 2018 and 2019, the daily average is 273888.9 and 299953.3 with a standard deviation of 39214.63277 and 43737.35463 respectively. The range and inter-quartile range is 135140 and 70012 for 2018, and 147904 and 78588 for 2019. Both 2018 and 2019 are skewed to the left because of the negative skewness. The summary of the description is presented in Table 3.

Table 3. Hypothesis 2 Summary of data description.

	Mean	Median	Mode	Range	Inter-quartile range	Standard deviation	Skewness
2018	273888.9	277223	No mode	135140	70012	39214.633	-0.04665
2019	299953.3	299090	No mode	147904	78588	43737.355	-0.02693

3.2. Hypothesis

Null hypothesis: the daily average number of small parcels processed in Tullamarine is the same between 2018 and 2019. Alternative hypothesis: the daily average number of small parcels processed in Tullamarine in 2019 is greater than those processed in 2018.

3.3. Shapiro-Wilk test

Shapiro-Wilk test [3] is used to test whether the data is normally distributed. For both year 2018 and 2019, the p-value is less than 0.05 and w is not close to 1.0 presented in table 4, concluding that the data is not normally distributed. A non-parametric test [4] would be suitable to analyze this set of data.

Table 4. Hypothesis 2 Shapiro-Wilk test result.

	w	p
2018	0.947572	4.37E-10
2019	0.948965	6.51E-10

3.4. Wilcoxon signed-rank test and result interpretation

Wilcoxon signed-rank test [6] is a non-parametric statistical test for comparing two samples that are paired or related, conducted on the daily small parcel number in Tullamarine in the year 2018 and 2019. The p-value of the test is 3.95495E-15, and the one-tailed p-value is 1.97747E-15, indicating that the null hypothesis is rejected at the confidence interval of 0.05 and the alternative hypothesis is accepted. As a result, the daily average number of small parcels processed in Tullamarine in 2019 is greater than those processed in 2018. In another word, the automated sorting station implemented in Tullamarine in 2019 effectively improves the process of small parcels. Data visualization is shown in Figure 2.

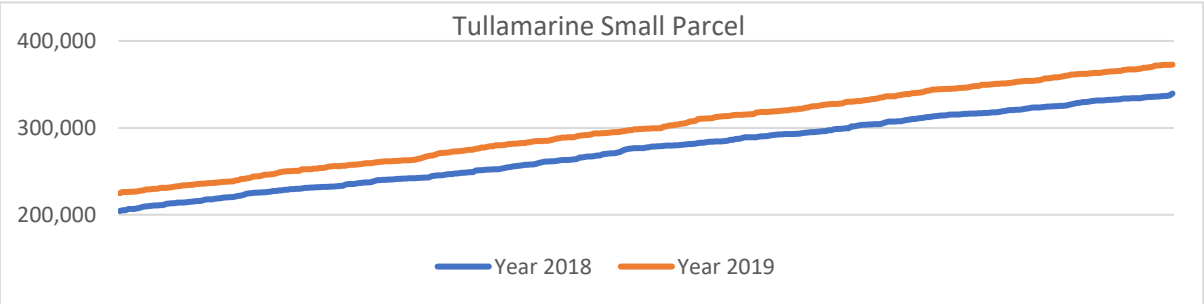

Figure 2. Hypothesis 2 data visualization.

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4. Hypothesis 3 – the artificial intelligence-based prioritization system in Mascot process small parcels fastest

4.1. Data description and visualization

The selected dataset is the number of daily processed small parcels in all three areas – Tullamarine, Brisbane, and Mascot in 2019. Tullamarine implemented the automated sorting station and Mascot implemented the artificial intelligence-based prioritization system to help process small parcels. Brisbane did not implement any technology. The mean, median, mode, range, inter-quartile range, and standard deviation for Mascot, Tullamarine, and Brisbane are presented in Table 5. Both Mascot and Tullamarine are skewed to the left and Brisbane is skewed to the right according to skewness.

Table 5. Hypothesis 3 Summary of data description.

	Mean	Median	Mode	Range	Inter-quartile range	Standard deviation	Skewness
Mascot	301256.6	304954	279581	151253	75760	44040.834	-0.08324
Tullamarine	299953.3	299090	No mode	147904	78588	43737.355	-0.02693
Brisbane	188373.3	188938	152905	91039	43462	25642.329	0.018044

4.2. Hypothesis

Null hypothesis: the daily average number of small parcels processed are the same between Tullamarine, Brisbane, and Mascot in 2019. Alternative hypothesis: at least one of the three areas daily number of small parcels processed is different from the others.

4.3. Shapiro-Wilk test

Shapiro-Wilk test [3] is used to test whether the data is normally distributed. For all three areas, the p-value is less than 0.05 and w is not close to 1.0. It can be concluded that the data is not normally distributed. Therefore, a non-parametric test [4] would be suitable to analyze this set of data.

Table 6. Hypothesis 3 Shapiro-Wilk test result.

	w	p
Mascot	0.947254	3.99E-10
Tullamarine	0.948965	6.51E-10

4.4. Kruskal-Wallis test and result interpretation

The Kruskal-Wallis test [7] is used to determine whether two or more groups of an independent variable originate from the same distribution. The test is conducted on the daily number of small parcels processed in Tullamarine, Brisbane, and Mascot in 2019. The p-value is 1.46032E-157, indicating that the null hypothesis is rejected at the confidence interval of 0.05 and the alternative hypothesis is accepted. Therefore, there is at least one of the three areas had the number of small parcels processed significantly different from the others. Data visualization is shown in Figure 3.

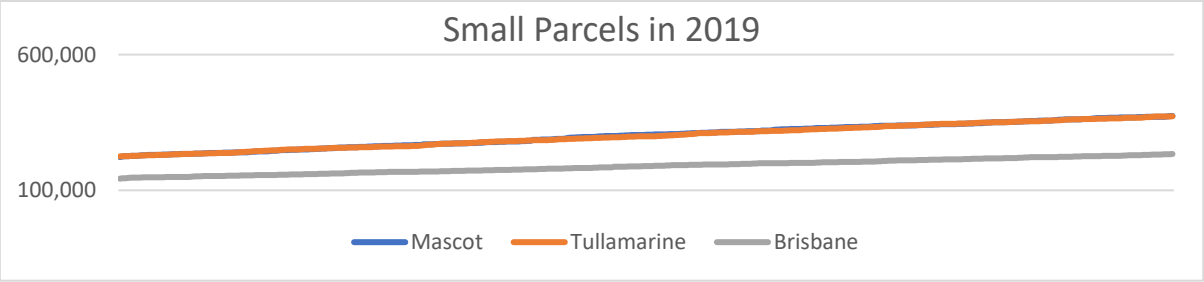

Figure 3. Hypothesis 3 data visualization.

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5. Hypothesis 4 – the artificial intelligence-based prioritization system effectively improves the letters processing capability in Mascot

5.1. Data description and visualization

The selected dataset is the number of daily processed letters in Mascot in the year of 2018 and the year of 2019. The mean of the year 2018 and 2019 is 33371369 and 35250431 with a standard deviation of 1206640.200 and 1263194.412 separately. The median is 33646013 for the year 2018 and no mode. For the year 2019, the median is 35465841 and there is also no mode. The range of the year 2018 is 5537256 with the inter-quartile range as 1754881. For the year 2019, the range is 6505662 and the inter-quartile range is 1842918. Both the year 2018 and the year 2019 are skewed to the left because of the negative skewness. The summary of the description is presented in Table 7.

Table 7. Hypothesis 4 Summary of data description.

	Mean	Median	Mode	Range	Inter-quartile range	Standard deviation	Skewness
2018	33371369	33646013	No mode	5537256	1754881	1206640.200	-0.84582
2019	35250431	35465841	No mode	6505662	1842918	1263194.412	-0.8297

5.2. Hypothesis

Null hypothesis: the daily average number of letters processed in Mascot is the same between 2018 and 2019. Alternative hypothesis: the daily average number of letters processed in Mascot in 2019 is greater than those processed in 2018.

5.3. Shapiro-Wilk test

Shapiro-Wilk test [3] is used to test whether the data is normally distributed. For both the year 2018 and the year 2019, the p-value is less than 0.05 and w is not close to 1.0, concluding that the data is not normally distributed. Therefore, a non-parametric test [4] would be suitable to analyze this set of data.

Table 8. Hypothesis 4 Shapiro-Wilk test result.

	w	p
2018	0.930821	5.69E-12
2019	0.938096	3.41E-11

5.4. Wilcoxon signed-rank test and result interpretation

Wilcoxon signed-rank test [6] is a non-parametric statistical test for comparing two samples that are paired or related. The test is conducted on the number of daily letters processed in Mascot in the year 2018 and the year 2019. The p-value of the test is 1.432254E-61. The one-tailed p-value is 7.16127E-62. The result indicates that the null hypothesis is rejected at the confidence interval of 0.05 and the alternative hypothesis is accepted. As a result, the daily average number of letters processed in Mascot in 2019 is greater than those processed in 2018. In another word, the artificial intelligence-based prioritization system implemented in Mascot in 2019 effectively improves the process of letters. Data visualization is shown in Figure 4.

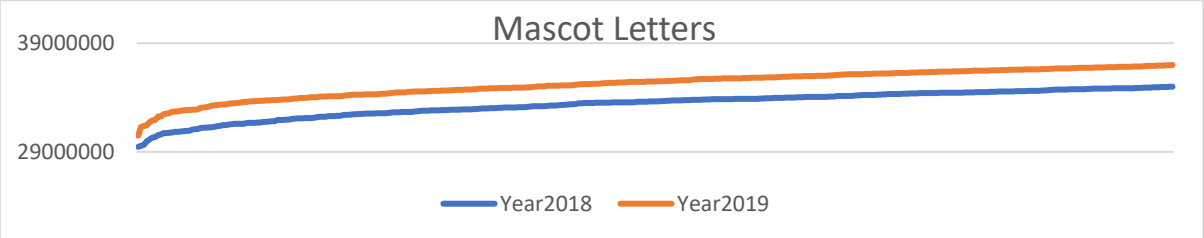

Figure 4. Hypothesis 4 data visualization – by date.

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6. Conclusion

In summary, based on the statistical analysis, for Tullamarine, the automated sorting station implemented in 2019 significantly improved the small parcel processing capabilities as the test shows the significant difference in the daily number of small parcels processed between 2018 and 2019 with the year 2019 has a greater mean. For Mascot, the artificial intelligence-based prioritization system implemented in 2019 significantly improved the letter processing capabilities as the test shows the significant difference of the daily number of letters processed between 2018 and 2019 with the year 2019 has a greater mean. Compared Tullamarine and Mascot for the effectiveness of two different technologies, for daily small parcel processing, there is no significant difference.

In conclusion, the technology - the automated sorting station and the artificial intelligence-based prioritization system can effectively improve the processing capability of Australia Post, and there is no significant difference between the effectiveness of the two technologies.

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