

Parcel Sorting Facility Efficiency Report

Introduction

The dataset contains 718 parcel records, each with 8 attributes and no missing values. In the context of parcel sorting operations, efficient handling of parcel is essential to ensure timely deliveries and maintaining customer satisfaction. One of the key operational challenges in a parcel sorting facility is processing time, which refers to the duration a parcel remains in the facility before being dispatched. Delays in processing time contribute to facility congestion, increased operational costs, and potential disruptions to delivery schedules. Therefore, the objective of this report is to analyse factors affecting processing time using linear regression and exploratory descriptive analysis.

Feature Engineering

In this analysis, 'processing_time' is defined as the difference between 'enter_time' and 'leave_time', representing the duration of a parcel remains in the facility. 'congestion' is measured by calculating the number of parcel presents in the facility during the period between 'enter_time' and 'leave_time'.

Exploratory Data Analysis

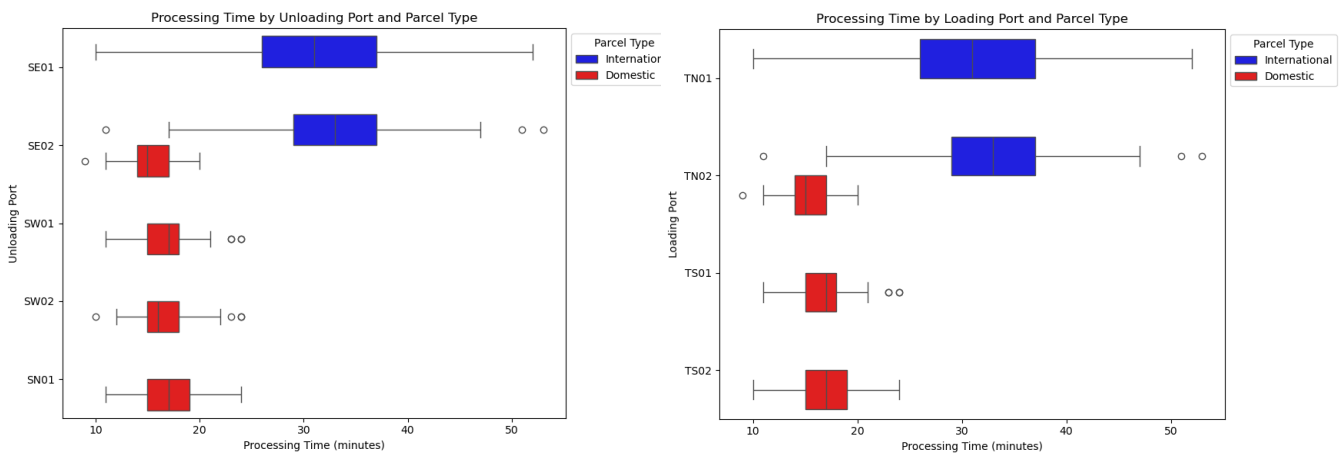


Figure 1 Processing Time by Parcel Type in Unloading Port and Loading Port

In this analysis, international parcels handled at SE01 and SE02 during unloading, as well as at TN01 and TN02 during loading, consistently show longer processing times compared to other ports that primarily process domestic parcels, which demonstrate shorter and more consistent durations. Notably, SE02 and TN02, which manage both international and domestic parcels, exhibit a broader range of processing times and higher median values. This suggests potential operational bottlenecks, including a noticeable 15-minute transition delay when switching between the sorting of international and domestic parcels (Appendix A).

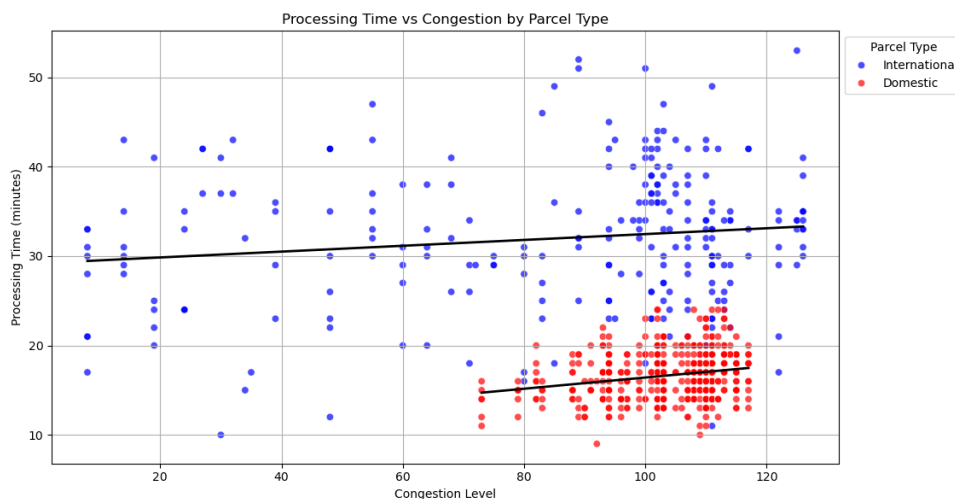


Figure 2 Processing Time vs Congestion by Parcel Type

From Figure 2, it is evident that international parcels (in blue) generally experience higher processing times than domestic parcels (in red), which cluster at the lower end of the processing time scale. Additionally, as congestion levels increase, there is a slight upward trend in processing time, particularly for international parcels. This visual insight supports the hypothesis raised by the operations manager. Specifically, when there is a higher number of parcels are present, the time taken to process individual parcels tends to increase. Therefore, this suggests that there is a correlation between congestion and longer processing times.

Linear Regression Analysis

Given that factors like congestion and parcel type affect how long a parcel remains in the facility, a simple regression formula was developed:

$$\text{processing time} = \text{congestion} + \text{parcel type}$$

From Figure 3, the results show that international parcels take significantly longer to process than domestic ones. On average, an international parcel spends about 16 minutes more in the facility compared to a domestic parcel. This confirms the earlier observations that international parcels require more handling or experience more delays in the system. The second key insight relates to congestion in the facility. As the number of parcels in the facility increases, the time taken to process each parcel also increases. Even though the additional time for each extra parcel in the system may seem small, these effects can quickly add up during busy periods, contributing to longer wait times and potential backlogs.

In this analysis, both the type of parcel and level of activity in the facility have a clear and meaningful impact on how long parcel stays in the system. Therefore, managing congestion and streamlining the handling of international parcels could lead to noticeable improvements in operational efficiency and overall delivery performance.

OLS Regression Results

Dep. Variable:	processing_time	R-squared:	0.681
Model:	OLS	Adj. R-squared:	0.680
Method:	Least Squares	F-statistic:	762.5
Date:	Thu, 17 Apr 2025	Prob (F-statistic):	5.04e-178
Time:	22:09:14	Log-Likelihood:	-2175.6
No. Observations:	718	AIC:	4357.
Df Residuals:	715	BIC:	4371.
Df Model:	2		
Covariance Type:	nonrobust		

	coef	std err	t	P> t	[0.025	0.975]
Intercept	12.8645	0.956	13.454	0.000	10.987	14.742
parcel_type_International	16.0109	0.429	37.346	0.000	15.169	16.853
congestion	0.0365	0.009	4.071	0.000	0.019	0.054

Omnibus:	54.735	Durbin-Watson:	2.030
Prob(Omnibus):	0.000	Jarque-Bera (JB):	257.461
Skew:	0.040	Prob(JB):	1.24e-56
Kurtosis:	5.933	Cond. No.	524.

Figure 3 Linear Regression Results

Limitations

This analysis is based on data collected over a short period from 2021-05-17 08:02:00 to 2021-05-17 10:38:00. Just over two and a half hours on a single day may not reflect typical or peak operational conditions. Important factors such as parcel weight, staff availability and equipment usage were not included, which could also influence the processing time.

Appendix A – Parcel Sorting Transition Timeline at TN02 Loading Port

