Data stories from urban loading bays

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1. Introduction

The Singapore Government is introducing pilot collaborative urban logistics schemes to improve freight deliveries from distribution centres or warehouses to retail malls [1]. The proposal is to consolidate and coordinate deliveries to retailers located at selected malls, in order to reduce the number of truck trips into busy urban areas and alleviate traffic congestion. In support of this project, we have proposed a study to evaluate the business viability and impacts of these collaborative logistics schemes in terms of traffic and environmental improvements, if any.

The study comprises two phases: an "empirical" phase and a "modelling" phase. In a first empirical phase we choose two retail malls in Singapore as case studies to collect data in order to characterize the current level of congestion at the loading bays of these malls. Through a high-resolution data collection methodology, we were able to collect data on 1808 goods vehicles over three days of data collection at a single loading bay. An automatic plate recognition algorithm was developed in order to support the manual effort to process the video recordings.

With such large sample size we were able to estimate the goods vehicle handling and queueing times distribution as well as collecting behavioural data such as parking location choices for most of the goods vehicle delivering to the malls. The objective of this first study phase is to provide empirical insights in order to evaluate the current performance of the observed loading bays and to drive the modelling effort in the second phase of the study.

In the current paper we would like to describe the data collection methodology implemented and summarize the key empirical insights obtained from these data collection activities at the loading bays of large urban retail malls in Singapore.

2. Loading bays congestion

A loading bay is a parking area reserved for the exclusive use by freight and service vehicles that temporarily park while delivering/ picking-up goods or perform some service at the stores located inside the mall. This facility tends to experience recurrent congestion for several reasons. First, the loading bay is a shared resource between all the carriers delivering to a mall. Moreover, due to the facts that (i) stores in the malls have limited storage space, (ii) the retail rental costs are high and (iii) the opportunity cost of using space for storage instead of product display is high, the stores at the mall favour smaller and more frequent deliveries, therefore increasing the traffic at the loading bays. Second, delivery times at a mall tends to be long since, at the current state, the drivers of the freight vehicles themselves have to carry the goods up to the stores, while keeping the vehicles parked at the loading bay. In general, loading bays are often not suited to accommodate the large number of truck-trips attracted by urban malls.

The negative impact of loading bay congestion is not limited to the sole location of the loading bay nor is experienced only by the drivers. In the eventuality that the loading bay is full, the vehicles start queueing outside, with possible spillovers in the surrounding streets. Moreover, a commonly observed behaviour of the drivers is to park outside the loading bay: on the road or inside the passenger car-park dedicated to the mall's customers, creating further problems to the passenger traffic and to the shoppers. Lastly, delays in the deliveries/pick-ups might affect the store businesses as well as the mall's operations.

The logistics activities identified by the data collections are described in Figure 1. On arrival, the driver of a goods vehicle decides whether to perform the delivery or to leave the system and come back later. If he decides to perform the delivery, he can choose between parking on the road, inside the passengers' car-park or inside the loading bay. Since the LB has limited space, the vehicle might have to wait in queue until a parking lot becomes available. Once parked, the driver performs the "handling", i.e. he delivers/picks-up goods

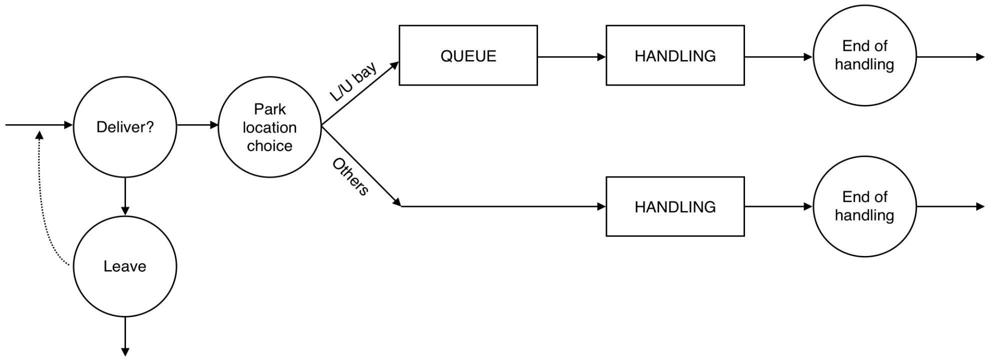


Figure 1. *Flowchart of the logistics activities observed at loading bays of urban retail malls.*

3. Data collection framework

We have designed a data collection framework that is able to:

- Quantify the handling and queueing time of each goods vehicle delivering to the mall.
- Observe vehicles' parking location choices.
- Characterize the type and nature of activity performed (delivery or pick-up, types of goods delivered, size of delivery etc.) and the impact that these variables have on the handling and queueing times as well as the park location choice.

The following data collection methods have been used:

- **Video recordings**: several video cameras are deployed at the entrance of the service road leading to the loading bay, and at the exit of the service road, capturing the license plate and the time at which each goods vehicle enters and exit the road.
- **Direct observations and driver interviews**: several surveyors are simultaneously deployed at the loading bay observing the goods vehicles, the shipments carried and interviewing the drivers.
- **Retailer survey**: a multiple-choice questionnaire was given to the stores' management during an introduction session presenting the collaborative logistics solutions to be trialled. The aim of the questionnaire was to better understand the economic impact of loading bay congestion and potential cost saving opportunities of the new proposed urban logistics initiatives.

4. Data stories

We have used the above-described methodology at the loading bays of two retail malls in Singapore. Below we provide some observations obtained from the first data collection.

Arrival process. Figure 2 depicts two empirical step functions in which each "step-up" by one unit represents a goods vehicle entering the system and a "step-down" is a vehicle leaving the system, where the system is defined as the area containing the service road leading to the access of the loading bay and the loading bay itself. The green line is for all goods vehicles that performed a delivery; the dashed red horizontal line represents the total capacity of the loading bay (6 parking lots). The Figure shows the total number of goods vehicles present in the system at any time during one day of data collection. We can see that, from the 8:30 am on, the total number of goods vehicle in the system overpassed the loading bay capacity, with a peak congestion at around 11:30 am when the total number of goods vehicle in the system was six times the capacity of the loading bay.

Parking location choice. Looking at figure 2 a natural question is: where are the goods vehicle in excess parked? The blue line in figure 2 reports the arrival process only for the vehicles that parked inside the loading bay. Which means that most of the goods vehicles that performed a delivery have parked inside the car-park reserved for the mall's customers (44% of all goods vehicle that delivered at a mall) as well as on the road (20%). If caught, a driver parking on the road might incur into a fine.

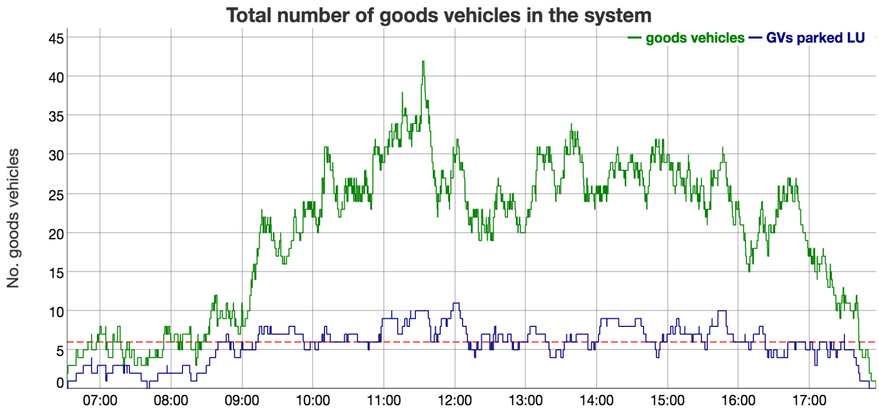
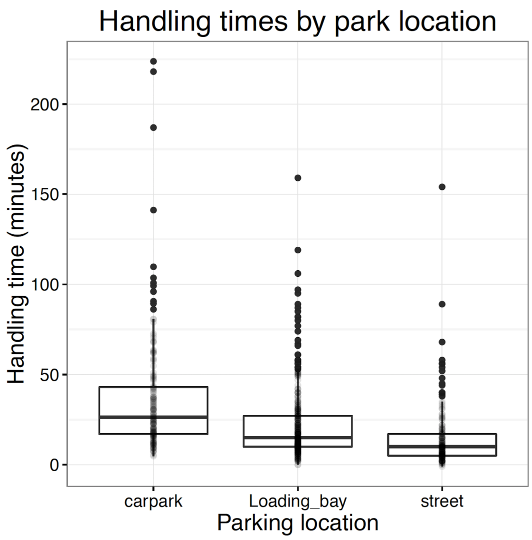


Figure 2. *Empirical step function where each "step-up" represents a goods vehicle entering the service road, and every "step-down" represents a goods vehicle exiting. The above green line is for all goods vehicles, the blue line underneath is only for those goods vehicles that parked inside the loading bay.*

Handling time distribution. The handling time is defined as the time it takes the driver and/or helpers in performing the delivery or pick-up. It was observed that the handling time for goods vehicles parked on the road illegally tends to be on average shorter than those parking inside the loading bay or passenger car-park. Figure 3 shows the different first, second and third quartile of the three different empirical distributions observed. The mean for the three groups are statistically significantly different. Therefore we can conclude that the expected handling time is a key variable in explaining the parking location choice. Other potential important explanatory variables are the type of vehicle used (only vans are able to access the passenger car-park) the delivery size and the presence of helpers.

Figure 3. *Box plot of the handling times distribution observed for the goods vehicles that parked inside the loading bay, in the passenger car-park and on the street.*



5. Conclusion

The current papers presents some of the empirical results obtained from data collection activities implemented at two large urban retail malls in Singapore. Through the use of automated video camera recording we are able to obtain high-resolution data at the level of a single goods vehicle. Further, by collecting a large sample size we are able to estimate the empirical handling and queueing time distribution. Further, we have collected behavioural data on the parking location choice by the goods vehicle drivers and assessed the challenges faced by retailers in receiving goods from a congested loading bay.

The current empirical results are part of a larger project which aim is to evaluate possible urban logistics solutions to smooth the logistics operations at retail malls' loading bays centre.

References

[1] "S$20m pilot to transform domestic logistics: Tharman," *Channel News Asia*, Singapore, 23-Oct-2015.