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Engineering Systems Division

ESD Working Paper Series

Survey Design to Unravel Freight Transportation Demand of Establishments in Cities

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Survey Design to Unravel Freight Transportation Demand of Establishments in Cities

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22nd May 2015

Abstract

Freight transportation serves the vital role of fulfilling the goods demand of residents in cities, yet little is known about the mechanisms that generate freight movements and their impact on traffic. Even though technology may allow us to better trace real-time movements, establishment surveys are still important to collect data on strategic and tactical freight transportation decisions. Leveraging state-of-art knowledge, a survey was specifically designed to investigate freight travel demand. This paper shows the preparation, execution and data processing of a survey on establishments in Singapore. Analysis of the survey data allows us to explain variations in delivery, such as, the types of supplier, the size and frequency of goods deliveries, and the timing of deliveries.

1   Introduction

Urbanization and economic development go hand in hand. As cities grow, their economic activities and consumption patterns typically become larger, and more intense. More goods would be delivered into cities to satisfy consumption needs of growing urban populations, and this would also mean that more freight transportation activities would be generated. Based on data from European cities, a city generates about 300 to 400 truck trips per 1000 people per day, and each person consumes about 30 to 50 tons of goods per year. Urban freight takes up 10-15 percent of the total miles traveled on city streets and 3-5 percent of urban land (Dablanc, 2011). In order to better predict and manage freight transportation activities, it is necessary to first understand how freight transportation demand is generated.

The advent of real-time traffic tracking technologies not only enables road users to change daily and within-day travel plans in response to traffic but also enables authorities to measure traffic volume at all times. Increased installation of Global Positioning Systems on freight vehicles holds promise to improve understanding of freight vehicle route choice (Hess, Quddus, Rieser-Schüssler, & Daly, 2014) and operation heuristics (Sharman & Roorda, 2013). Nonetheless, surveys have not become an obsolete tool. At a practical level, research is still needed to interpret freight GPS data, and governments still do not have direct access to business GPS data. At the fundamental level, GPS data alone cannot reveal all the information needed for policy planning (Allen & Browne, 2008; Holguín-Veras & Jaller, 2012; Sharman & Roorda, 2013). Traditional survey methods remain a necessary tool for analyzing most policies.

Establishment surveys are an important input to behavioral studies for analyzing policies because they can model strategic and tactical inventory planning decisions. Strategic decisions are made at the one to five year time frame with regard to the procurement and distribution network (Chopra & Meindl, 2013). Examples are whether to procure from manufacturers instead of wholesalers and whether to own delivering vehicle or outsource the deliveries. Strategic decisions of the establishment predetermine details of the tactical decisions. Tactical decisions are usually made at the monthly to quarterly time frame. An example of a tactical decision is retail establishments would narrow down on a set of suppliers that they would trade with and the order frequency and size associated with the supplier. On a day-to-day basis, companies usually operate based on routines defined by the earlier decisions. Establishment surveys are thus important because they can be used to collect long-term strategies and tactical decisions that would explain observable delivery movements.

Establishment surveys are typically used to collect stated preference and revealed preference from decision makers involved in freight transportations. Holguin-Veras et. al used stated-preference surveys to design incentive packages needed to encourage off-peak hour participation (Holguín-Veras, Pérez, Cruz, & Polimeni, 2006; Holguín-Veras, Silas, Polimeni, & Cruz, 2007), and Edoardo et. al used surveys to gather

stakeholders' reactions to policy and regulations (Marcucci, 2013; Stathopoulos, Valeri, & Marcucci, 2012).

More commonly, surveys are used to collect revealed preference, or revealed behaviors in order to predict freight transportation trips (Alho & Silva, 2014; Holguín-Veras et al., 2012; Muñuzuri, Cortés, Onieva, & Guadix, 2010; Nuzzolo, Crisalli, & Comi, 2012; Russo & Comi, 2010) and analyze policy effectiveness at establishment or zone level (Ambrosini, Patier, & Routhier, 2010; Cherrett et al., 2012). In these papers, freight trip generation models have depended mostly on three types of variables, namely, area, employment size and industry type. The dependent variables are usually an aggregation of deliveries over a period of time, such as peak periods of a day, or a week. One weakness of this approach is that the independent variables are not good predictors of the aggregated delivery frequency; the deviations in the accumulated deliveries among firms are large even when controlling for area, employment and industry type.

This paper proposes a revision in the modeling approach starting from the survey data collection stage to mimic the way firms operate. In addition to (or in place of) questions at delivery, or establishment level, surveys can include questions at receiver-shipper relationship level. This account for the fact that the total delivery frequency is a sum of multiple deliveries from one or more shipping sources, and that the delivery characteristics are unique to each shipping source. This distinction is needed because each shipping source is a separate decision maker and has a different origin location. The information of receiver-shipper relationship would be useful to trace deliveries from destinations to origins, and to predict delivery size, frequency and timings.

Studies that analyzed delivery characteristics based on receiver-shipper relationship include Routhier & Toilier (2007) and Wisejindaewat (2006). Routhier & Toilier (2007) found the supplier type to be important for estimating trip distances. This is sensible because land use plans usually locate industries at varying distances from the city center. Wisejindaewat (2006) estimated the aggregated quantity acquired at each destination zone from each origin zone for three types distribution channels or receiver-shipper relationships. Research has so far highlighted that information on supplier type is important for estimating origin zones, and more importantly, that there are interactions between total quantity flow and the receiver-shipper relationship. So far, studies including shipper-receiver relationship have modeled at zone level, and not at delivery level. Models at delivery level may reveal more underlying mechanism of delivery generation and also provide time of day estimates that can be used for traffic simulations. (Routhier & Toilier, 2007; Wisetjindawat, Sano, & Matsumoto, 2006)

This paper demonstrates how to use surveys to collect disaggregated data on tactical inventory decisions. The sampling and questionnaire design can also provide a framework to any other survey that seeks to understand the behaviors of decision makers in the freight transportation. The survey allows us to relate receiver establishments' characteristics such as industry types, number of employees or sales area to their relationship with their shippers, and then connect the receiver-shipper relationships with delivery-specific data such as time and types of goods delivered.

The objective of this study is to show that receiver-shipper relationships have significant influence over the delivery size, frequency and timing. Industry type is so far the best variable to predict delivery characteristics because it embodies both product nature (such as perishability) and supply management characteristics. Area and employment indicates the demand and scale of the business. However, they do not fully explain the variety of supply chain strategies within the same industry. Researchers and city planners should request for publically available records that can better reflect the supply management of the establishments, and should include shipper-based questions in commodity flows and other surveys that are to be used for modeling and understanding freight trips.

1.2   System boundary

The geographic coverage of the survey is the entire city of Singapore. Singapore is located on a small island of 716 km^2 with a growing population of nearing 6 million. While there are many different establishments that can attract freight flows, the establishment types included in this study are limited to Cosmetics, Pharmaceuticals, Formal Food Services, Food Court, Grocery stores, Fashion Apparel stores and Fashion Accessory stores in order to collect data sufficient for in-depth behavioral analysis. These industry types are selected because of their range in product size, perishability, ownership, and prevalence in Singapore and in other cities. The shops are defined based on the Singapore Standard Industry Code 2010 (Department of Statistics Singapore, 2010).

Table 1. Industry types that are included in this study

SSIC 2010	Description in this study	Name in this report
4771	Apparel stores, selling clothes, bags and shoes. May sell accessories.	Fashion Apparel store
4773	Personal accessories stores	Fashion Accessory store
47721	Shops that only sells cosmetics and toiletries.	Cosmetics- Toiletries
47722/3	Pharmacies and drug stores. May sell other personal product.	Pharmacy
5611, 56121, 1071	Cafes, restaurants, bars and bakeries baked on site.	Formal Food Services
5614, 56122	Food court and hawkers	Food Courts
471, 472	Grocery store selling wet and dry goods	Food Retail

1.3   Tactical Receiver Decisions

At the tactical level, the establishment has to decide on the number of shippers considering the type of source, mix of product, the quantity, and frequency that they would acquire goods from them. Establishment characteristics can and will affect the total delivery frequency, and are commonly modeled so. Alternatively, the tactical decisions can be analyzed by receiver-shipper relationship. Figure 1 shows how the shipper and delivery specific information is connected with establishment specific characteristics. The decisions are not made sequentially in practice, but through a series of negotiations and trade offs that are unique to each establishment. Large-scale survey data analysis can show correlations between the outcomes of the decisions and the establishment characteristics, such as if a certain type of establishments has higher tendency to choose one type of source and receive deliveries at certain time of the day.
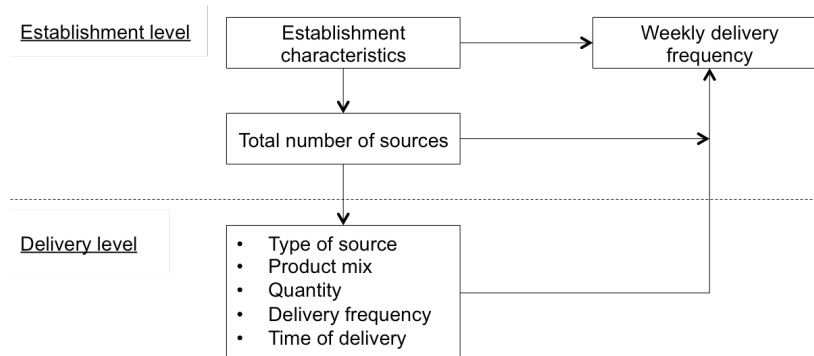

Figure 1 Connection between supplier and delivery specific information with the total deliveries to an establishment

1.4   The survey

The freight survey included interview and observation of the establishment characteristics, such as the establishment names, address, area, and employment size. These were followed by questions on the total delivery frequency per week, and the total number of different sources that ship goods to the establishment for replenishment. Lastly, respondents had to describe the last replenishment they picked up or received. Asking about the last replenishment ensured that the respondent still had a clear memory of the event as well as to resemble a random sample of all possible deliveries to the establishment. When aggregated, it would give a representative sample of deliveries to establishments. Even though it is not a perfect estimate, it is the best trade off given the low commitment of the respondents to answer the surveys.

1.4.1   Types of shipping source

The shipping source refers to the type of facility where the goods are stored before delivery to the retail establishment. It provides two types of information, first, it identifies – or gives clues of – the location of the trip origin, and second, it reveals the supply management of the establishment. The supply management of the establishment can strongly correlate with other deliveries characteristics.

In the survey four options were given: "Another store", "Wholesaler", "Manufacturer" and "Corporate Warehouse". "Another store" is defined as an establishment that may or may not be related with the responding establishment, as long as most of the sales are targeted towards end-consumers. "Wholesaler" refers to establishments that sell in bulk mostly to other retail establishments, but do not exclude end-consumers. "Manufacturer" are manufacturing establishments, and it also include distributors. Both types of shipping source only sell when the order size is large and frequent enough to sustain an transaction account, if not a contract. In this case, they rarely sell to end-consumers. "Corporate warehouse" is the privately owned storage, or consolidation center that belongs to the corporate directly associated with the retail establishment.

1.4.2   Product mix

Product mix of deliveries to stores are often taken for granted, after all, the product types that establishments offer define their industry types. However, the composition of products available at stores can be widely different across cities and cultural contexts. For this reason, the product mix observed in the store and delivered by shippers are both tracked for controlling for such differences. The respondents are allowed to choose multiple options from a list of products, namely, Prepared food, Fresh food, Frozen food, Preserved food, Pharmaceutical, Cosmetics and Toiletries, Household products, Apparel, Accessories, Packing materials and Others.

1.4.3   Quantity

Products are delivered in all shapes and sizes. Most surveys asked the respondents for the weight of the shipment, and sometimes include potential carrying units such as crates or boxes. This survey asked for the upper bound of the total volume of the delivery, considering that all the boxes and bags are stacked together. This is based on the assumption that most vehicles run out of carrying space before they run out of carrying weight capacity for delivery tours. (Other major reasons restricting vehicle capacities are that the total goods needed to deliver are simply lower than capacity, or if the total tour time maximized the work time of the drivers.) Therefore, it is more critical to record shipment sizes than weights. The respondents could choose the upper bounds of the shipment size from $25x25x25cm^3$, $50x50x50cm^3$, $1x1x1m^3$, $1x1x2m^3$, $1x2x2m^3$, or larger.

1.4.4   Delivery Frequency

Delivery frequency with respect to supplier could be defined in multiple ways, but it was defined simply by "Multiple times a day", "Once a day", "Multiple times a week", "Once a week", "Once every two weeks",

"Once a month", "Or less". "Multiple times a week" gives respondent flexibility in answering because the supplier may not be delivering on a regular basis. However, having "Multiple times a week" as an option loses data resolution because four deliveries per week is twice as frequent as two deliveries per week but both fall into this category. Also, certain suppliers deliver on fixed day(s), and this information could have been captured by a following question.

1.4.5 Time of delivery

The time of the last delivery to the store was recorded. Time was asked in bins to reduce respondent burden. The time was recorded in the ranges, 12am to 7am, 7am to 9am, 9am to 11am, 11am to 1pm, 1pm to 3pm, 3pm to 5pm, 5pm to 7pm and 7pm to 12am. The main drawback when asking for the most recent deliveries is the bias to replenishments that took place in the morning and daytime when the interview survey was conducted. Since surveys were done on the weekdays from 10am to 5pm, deliveries in the morning up to around 4pm have highest chances of being recorded.

2   Survey design

To conduct a survey, it involves preparing the survey questionnaire and deploying them for data collection. Many resources were used to design the survey we used in this study, and in this section we summarized our survey design and point to helpful guidance.

2.1   Question formulation

Questions can be asked in a several ways. Questions or statements can be used to collect information. Statement are usually used for stating attitudes, and responded in a Likert scale. Question can be open-ended or closed-ended. Open-ended questions allow the respondent to provide his or her answer in free form phrases and sentences. This type of question is typically useful for exploring issues in-depth. In close-ended questions respondents have to choose answer(s) from a list of options. Close-ended questions limit the variety of responses and are easier to process and analyze compared to open-ended questions. However, close-ended questions need to be carefully structured such that respondents can answer without ambiguity. Asides from these question framing options, there are also many strategies to make questions clear (Babbie, 2007; Converse & Presser, 1986). At the start of survey design, several interviews were conducted with open-ended questions to understand the context and frame better questions before a larger scale survey collection. Eventually, the survey used in this study consisted mainly of closed-ended questions.

2.1.1   Pretesting

Despite careful question formulation, there will still be ambiguous questions. It is a common practice to pretest the survey questions with patient respondents to tease out anything that is unclear in the questions (Miller, Willson, Chepp, & Padilla, 2014; Willis, 2004). In our first pilot survey attempt, we found out that subjects were adverse to a survey that takes too long (e.g. 20 minutes). The questions are increasing sensitive starting from opinions and attitudes, operation process (e.g. timings and frequencies), to employment size and finally income level. The question on income level was eventually removed from the survey. The shortened questionnaire (that requires around 3 to 5 minutes to response) is then tested with friends and family members that had experience operating retail and service establishments.

2.1.2   Mode of collection

Establishment based surveys can be conducted through several modes. In this section we present selected advice from (Babbie, 2007) that can be relevant to establishment surveys.

Self-administered In self-administered surveys, respondents are invited to complete the questionnaire themselves. The surveys may be mailed or delivered in-person to the targeted respondents. This method is less costly and common. One example is the survey applied in Bordeaux where representatives from the

establishments had to record their operations for a week (Ambrosini et al., 2010). The U.S. commodity flow survey is deployed by mail, and selected establishments have to report their shipment details for one week in each four quarters of a year (U.S. Department of Commerce, 2012). This method requires a high level of compliance and commitment from the establishments.

Face-to-face interview In face-to-face interview surveys researchers send trained interviewers to ask the questions orally and record the responses. This is a typical strategy by academic researchers and has been applied in many cities (Alho & Silva, 2014; Muñuzuri et al., 2010; Nuzzolo et al., 2012; Russo & Comi, 2010) This method can have higher response rate but high cost. It also allows more flexibility in both rephrasing questions for clarification and probing for answers. Lastly, the interviewer can collect observation data that are too sensitive to ask, or simply to reduce the number of questions asked.

Phone interview Phone interview provide the same flexibility as face-to-face interviews and at the same time saves traveling time and costs and increases safety. It also allows the interviewer to clarify directly with the research manager during the interview process. The main concerns are that the respondents need to first have access to a sample frame with phone numbers, and second that most of the population has access to phones. Another drawback is that the respondents can end the surveys abruptly.

It was foreseen that a lot of clarification and flexibility is needed for our data collection because establishments have many different strategies in managing their suppliers, and also use different terminologies to refer to the same physical process. Face-to-face interview survey was the best option. To reduce the number of questions we needed to ask, we made store area, and store industry type observational questions.

2.1.3   Interviewer training

Interviewers are the interface between respondent and the answer collected, making it important that they are trained (Babbie, 2007; Bourque & Clark, 1992). The interviewers were trained to understand the purpose of the survey, the total survey process, the ethics of interviewing, the logic of the questionnaire, sampling approach and how to fill the survey. The interviewer's understanding of the question can directly affect the answer collected and thus it was checked again after they conducted around 20 interviews. Lastly, at the end of the survey the interviewers did a debrief survey to share their experience, their understanding of the questions and also, their assessment of the accuracy of the answers given the body language of the respondents.

2.2   Pilot survey

This survey served as a pilot test to a later larger scale survey in Singapore. The purpose of this survey was to make sure that (1) the respondents are willing to answer them and (2) can understand the questions, (3) options to closed-ended questions the are distinct and altogether inclusive of all possible answers, (4) the length of the survey is not so long that it affects the quality of the response (Babbie, 2007; Bourque & Clark, 1992). In total 206 completed surveys were collected. The response rate was 67%.

The requirement of the sample design for the pilot test was that it is representative of the types of shops that we can find in Singapore. We eventually decided to collect 200 surveys in a downtown and a non-downtown location. Both locations were indicated as commercial areas in the Urban Redevelopment Authority Master Plan 2008 (Urban Redevelopment Authority, 2008).

2.3   Supermarket surveys

Another ten surveys were collected from supermarkets across Singapore in a separate data collection effort. These were self-administered. The vice-manager of logistics compiled the responses from the respective store managers. This was to reduce the burden of face-to-face interview on the store managers.

2.4   Approaching respondents

The way we approached respondents turned out to be an art that needs to be mastered overtime. In the first stage of our pilot survey, we had a long introduction to explain motivation of the survey but it intimidated respondents because it was hard to understand. We were turned down because (1) the survey was too long, and (2) they did not feel adequate to provide answers. We eventually settled down on an introduction that is no more than 3 sentences long.

"I am a student from <<educational institution>> doing a research on how to improve logistics efficiency. Can I ask you 9 questions about your deliveries? It will only take 3 to 4 minutes please."
This simple approach as this was extremely helpful because it explained that it was an academic research, gave a very simple motivation for the research and lastly, informed the respondents that it was a short survey. Before we started the survey we assured them that the data is only used for the study and would remain confidential.

2.5 Data collection instrument

There are multiple types of data entry options available for face-to-face interviews, online surveys, offline surveys and paper surveys. Online and offline surveys such as SurveyMonkey, and Google forms are most useful when it is safe to carry the electronic device around and the battery life is long enough for a day of survey making. Using electronic surveys makes data processing easier in the later stage. Paper surveys are easier and safer to carry around, and it allows the interviewer to record extra information and take notes. However data processing is tedious. It may be best to use paper forms during pilot survey because the researchers can take notes on question design (also called pretests) and move on to electronic surveys when the questions are fixed. We used paper survey because electronic surveys introduced problems with battery life and data transmission.

3 Sampling

3.1 Pilot survey results

The pilot survey provided estimates of the frequencies and standard deviations that allow us to estimate the total sample size needed.

Table 2. Average and standard deviation of weekly delivery frequency by industry type, based on pilot survey results.

Establishment industry type, k	Pharmacy	Cosmetics	Food service	Food retail	Apparel and accessories
Singapore standard industry code	47722/ 47723/ 47729	47721	561	471/ 472	4771/ 4773
Number of establishments, n_{ps}	6	9	68	13	43
Average deliveries per week, $\widehat{s_{f,k}}$	18.17	3.50	11.35	4.75	3.32
(Standard deviation)	(16.40)	(4.82)	(12.28)	(3.45)	(4.03)

3.2 Total sample size

Since the main objective of this survey is to estimate the number of replenishment orders that an establishment demands, the main dependent variable of the survey is the total delivery frequency of a retail store on a weekly basis. We assume that each store is an independent observation, and requires f deliveries per week. The assumption that each store is independent is reasonable in this application since the order of stores is dependent on the supply management of stores that is unique to each store. We also assume that the distribution of f across all stores in the city is normally distributed. This is a poor assumption because there delivery frequency is non-negative. We would assume that when the sample is large the distribution would converge to a shifted normal distribution. The total sample size given the true mean delivery frequency of the population and the frequency standard deviation would be

$$n_{sample} \leq \left(\frac{z_{\alpha/2}\sigma}{\epsilon}\right)^2 \qquad \textbf{Eq. 1}$$

where $z_{\alpha/2}$ is the z-score at confidence level of $\alpha/2$ and ϵ is the margin of error (Ben-Akiva & Lerman, 1985; Lohr, 2010; Thompson, 2012).

It is not possible to know the true standard deviation σ but it is possible to calculate an estimate (s_{ps}) based on the pilot survey results in Table 2. We estimated the pilot sample frequency standard deviation s_{ps} with Eq. 2 assuming that all establishments have the same delivery frequency.

$$s_{ps}^2 = \sum_k w_g^2 \left(\frac{\widehat{s_{f,k}}^2}{n_{ps,k}} \right) \qquad \textbf{Eq. 2}$$

Here w_g is the proportion of the population in each stratum, calculated based on data provided by the Department of Statistics in (Ministry of Trade and Industry of Singapore, 2012) shown in Table 3, and $\widehat{s_{f,k}}$; is the standard deviation in the delivery frequency, and $n_{ps,k}$ is the number of establishments by industry k in the pilot survey, both calculated in Table 2. The confidence level is 0.95 ($z_{\alpha/2}$ =1.96) and the margin of error is 0.05. Using Eq. 2, we compute s_{ps}^2 to be 0.72 and using Eq. 1, the target sample size n_{sample} is 1091.

Table 3. Number of stores in each product category based on the Economic Survey of Singapore

| Establishment industry type, k	Cosmetics	Apparel and accessory	Food Service	Food Retail	Pharmacy	Total
Number	767	5073	5901	3522	514	15591
w_g	0.05	0.32	0.37	0.22	0.03	

3.3 Multistage Sampling

There are two requirements in the sampling approach. First, the sample has to be representative of the population. Second, it should be feasible to collect sufficient completed interview surveys within the projected timeframe. Considering two requirements, the best option is multistage sampling. In multistage sampling, primary units are first sampled, and then secondary units are sampled within the primary units. There can be tertiary units or more embedded units (Babbie, 2007; Thompson, 2012). We have two stages, and the primary sampling units are Metropolitan Traffic Zones (MTZs), and the secondary sampling units are the physical establishments.

3.3.1 Stage one sampling: MTZs

Metropolitan Traffic Zones (MTZs) are zones that the transportation authority of Singapore uses for planning. There are 1092 Metropolitan Traffic Zones (MTZs) in Singapore, ranging from the size of $0.014km^2$ to a maximum of $129.228km^2$. The MTZs were selected using proxies to the land use mix, under an assumption that land use mix has impact on the delivery frequency, size and timings to the establishments. This assumption will be tested as a hypothesis in another study. The proxies to land use mix are the retail employment, office employment, manufacturing employment and residential densities based on estimates from the year 2008 (Density = counts / ground area of the MTZ), provided by the Land Transportation Authority of Singapore. The MTZs were classified into 10 groups based on their densities using k-means algorithm in JMP SAS package. The resulting classification was visually similar to the land use plan of year 2008 and 2012 published by the Urban Redevelopment Authority of Singapore. A big portion of the residential area was not detected because they are landed properties with low residential density compared to the other detected residential areas. This means that the sampling will be skewed to the dense areas.

Figure 2 Classification of the Metropolitan Traffic Zones with data from 2008, compared to the Master plan of Singapore in 2008

Classification of the Metropolitan Traffic Zones   Master plan of Singapore in 2008

Offices   Retail   Residential   Industrial   Others
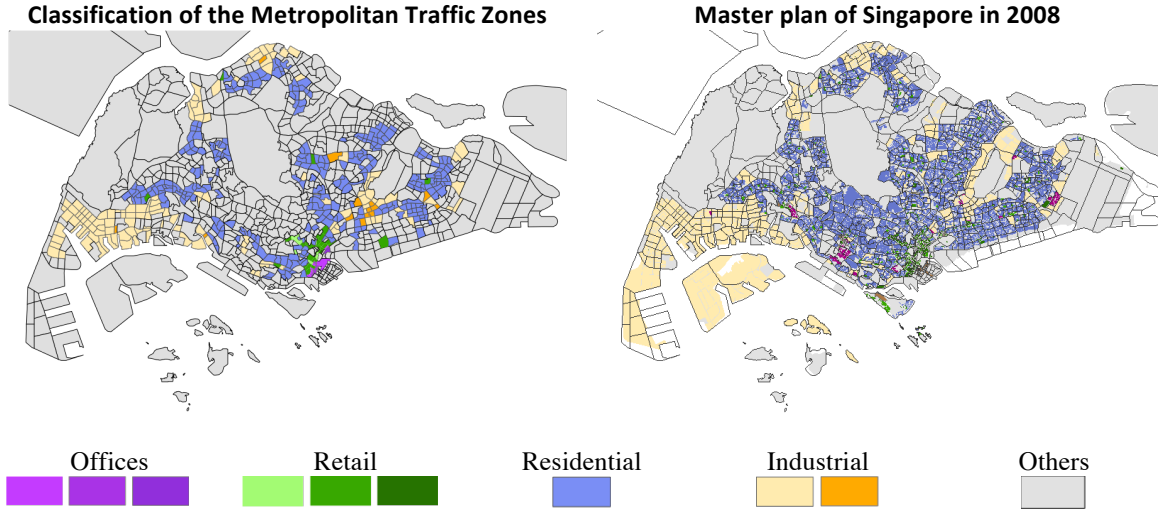
3.3.2 Stage two sampling: Establishments

The number of surveys that we will collect from each MTZ will be based on the proportion of establishments by industry k in the ten zones. The number of establishments by industry is calculated by

$$n_{MTZ,k} = \frac{N_{MTZ,k}}{\sum_k \sum_{MTZ} N_{MTZ,k}} \times n_{sample} \qquad \textbf{Eq. 3}$$

where $N_{MTZ,k}$ is the number of establishment in MTZ and industry k. This is the most viable option because we have limited number of respondents in each MTZ. For example if we used stratification sampling giving weigh to establishments by the delivery frequency, we would want to survey 20 pharmacies in each zone. Realistically there are few zones with even 5 pharmacies. Thus we are limited to sampling proportionally to population.

4 Data processing

In this section we will process each variable collected in the pilot survey as recommended by Bourque and Clark (Bourque & Clark, 1992).

4.1 Outliers identification

Outliers are observations that appear to deviate markedly from other members of the sample. Barnett and Lewis had defined sources of variability to inherent variability, measurement error, and execution error (Barnett & Lewis, 1994). Inherent variability refers to a nature feature of the population, the distribution of properties that cannot be controlled. Measurement errors are due to inadequacies in the measuring instrument, such as rounding errors, and mistakes in recording. We can exert some control over this type of error. Lastly, execution errors arise from the imperfect data collection design, such as including individuals that are not truly representative of the population we are interested in. If we are aware of this, we can change our basic population model.

Outliers exist in two forms: first, they can be due to randomness, or other reasons that cannot be explained, or second, they are deterministic. For the first type of error, we can identify and decide if we would incorporate it in the analysis, separate it for another analysis, or reject the data all together. Deterministic errors can be due to traceable artificial errors. Once an erroneous observation is identified to be deterministic in nature, it can be rejected, corrected or repeated. In this study we prefer to test and identify

the outliers before we accommodate them in our modeling because the data quality is low. We will not repeat any of the erroneous observations.

We also note that in regression there are observations that are referred to as influential. Influential observations can greatly change the coefficients in the regression estimate before and after its inclusion. It is not entirely clear what forms our model will turn out to be, or if outliers are errors because supply management strategies can vary greatly from one establishment to another. Thus we will not delve in the identification of influential observations.

4.2   Missing values

There were some missing values in the responses, both due to non-response and error in recording. We performed list wise removal of cases (only removing the cases when the necessary variable is missing) to conserve data (Bourque & Clark, 1992).

4.3   Consistency tests

There can be a lot of inconsistent responses from survey interviews and the outliers are identified by consistency checks guided by the discussions by Bourque and Clark (1992). Consistency checks help to identify cases where the respondents had misunderstood the questions. This is done by several logic equations to make sure that the numerical values that were given by the respondents are logically feasible.
One of the drawback of using survey as the only source of data is that responses can be inconsistent. The responses may be inconsistent for multiple reasons, such as if the respondent misunderstood the question, if he remembered events incorrectly or if he was not telling the truth. We used three consistency tests. The first test makes sure that when a respondent says that they have only one supply source, their response of the total delivery per week is the same as their response to the number of deliveries the last shipper makes in a week. In the second test, we picked out cases where the number of deliveries per week was less than the number of deliveries the last shipper makes in a week.

We noticed that there are some responses where the number of suppliers is much higher than the other establishments of the same industry type. In some cases this may be true, but based on our survey experience, the question on the number of shippers could have been misunderstood in two ways. We are interested in only the number of last locations the goods were stored before it was delivered to the establishment, however the question could have been interpreted in two ways. First, the respondents may have understood the question as the number of independent companies they purchase their supplies from. In this case, they would give us a large number even though they consolidate their goods in a local storage. An example would be that a storeowner cited 4 suppliers from China. Second, some establishments change suppliers frequently. In these cases, the respondents may tell us the number of suppliers that they consider, instead of the net number of shippers they made actual transactions with. Thus the third test removes cases where the number of suppliers is too high compared to the number of deliveries they receive.

4.4   Visual inspection for outliers

Lastly, we visually inspected the data by industry type to detect outlying data. We plot the number of deliveries per week and number of suppliers against the shop size and the number of employees by the shop type to detect outliers. If needed, we used Google to search for the establishment name to decide if the data point was reasonable.

5   Results

Singapore's Establishment-based Freight Survey was deployed between March and June 2014. While 719 surveys were collected, only 555 remained after data processing. One of the most prevailing statistics gathered was that 97% of the replenishments were delivered instead of the establishment picking it up from its source, and only deliveries are analyzed in this report.

The nature of the freight transportation demand will be analyzed by industry type as it is an important factor in determining delivery characteristics (Lawson et al., 2012). It reveals the characteristics of goods

that are moved, and suggests the supply chain characteristics of the business and both characteristics strongly influence inventory policies. For example, while mom-and-pop grocery stores and supermarkets both supply fresh food, daily experience will suggest that grocery stores are usually small-scale and sole-proprietary while supermarket involves a large company to support the logistics and administration of the business.

5.1   Summary statistics

The number of establishments and their characteristics are shown in Table 4. Almost all food retail and pharmacies that could be located in the zones were interviewed. Many more surveys are collected from fashion shops and food services because they are much more common. The standard deviations for all variables across all industries are very large implying that even though industry type can differentiate shops for practical purposes, it is not enough to explain the variations in the physical size, employment size and delivery characteristics. This matches our daily experience where establishments of the same industry exist in all physical and employment sizes. An example, fast food restaurant and a normal restaurant are both classified as restaurant but the former may have only a daily delivery from the corporate warehouse in contrast to the latter that may have around ten deliveries from various sources.

Most notable distinctions are the following:
- On average, Cosmetics and Fashion establishments receive 2.60 and 2.27 deliveries per week respectively, much lower than the average deliveries that the other stores receive per week.
- Even though Food Court and Formal food services both provide food services, Food Courts are relatively smaller and require lesser employees. This makes sense because Food Courts usually share the sitting areas with other Food Court stores and require lesser employees to serve and clean.
- Pharmacies have relatively high average number of suppliers compared to other industries, 17 versus a range of 1.50 to 8.63, disregarding supermarkets.
- Supermarkets are significantly larger in all dimensions. This is indicative of a high goods demand and large product variety.
- In general, the number of shippers increases with brand and product variety.

Table 4. Establishment area, number of employees, number of deliveries per week and number of shippers.

	Cosmetics	Accessory Store	Apparel Store	Food Court	Formal Food Service	Food retail	Pharmacy	Supermarket
Number of surveys	39	19	185	91	263	52	35	10
Average number of employees	5.44	4.89	5.67	3.42	11.38	4.40	6.14	71.30
	(5.89)	(4.04)	(6.10)	(3.26)	(9.93)	(3.59)	(5.53)	(59.66)
Average deliveries per week	2.60	2.65	2.23	10.35	10.86	8.26	10.69	395.50
	(3.59)	(1.98)	(1.86)	(8.95)	(9.90)	(8.05)	(11.00)	(159.15)
Average number of shippers	3.18	2.47	1.50	4.30	7.44	8.63	17.66	53.80
	(6.54)	(3.01)	(1.64)	(2.92)	(7.15)	(7.57)	(18.00)	(31.13)
Median of area	10 - 25 m^2	10 - 25 m^2	25 - 50 m^2	Less than 10 m^2	25 - 50 m^2	10 - 25 m^2	25 - 50 m2	100 - 200 m^2

Note: The standard deviations are provided in the parenthesis.

5.3   Supply sources

In total, 46% of all replenishments that were surveyed were supplied from the corporate warehouse, indicating that the establishments in the sample belong to a larger corporate organization. This may be a general trend in Singapore or it may be due to sampling at high shop density areas.

- Specifically, Cosmetics and Fashion establishments mostly receive supplies from their corporate warehouses.
- Food Courts less often receive deliveries from corporate warehouse and more often acquire goods from another store, indicating that they are usually sole-proprietary and have a more fragmented supply chain.
- Formal Food Service, Food Stuff and Pharmacy mostly have supplies coming from wholesalers, and corporate warehouses, than from the manufacturer, or another store.

Table 5. Supply source type for one delivery for establishments in each industry

Supply source type	Cosmetics	Accessory Store	Apparel Store	Food Court	Formal Food Service	Food Retail	Pharmacy
Another store	0.00%	0.00%	1.80%	12.31%	1.51%	0.00%	0.00%
Wholesaler	18.75%	10.00%	6.59%	53.85%	43.72%	42.86%	34.38%
Manufacturer	9.38%	10.00%	16.17%	21.54%	16.08%	19.05%	15.63%
Corporate warehouse	68.75%	80.00%	70.66%	7.69%	34.17%	35.71%	46.88%
Others	0.00%	0.00%	1.80%	1.54%	1.01%	0.00%	0.00%
Don't know	3.13%	0.00%	2.99%	3.03%	3.50%	2.38%	3.13%

5.4   Products replenished by establishments

There has always been an implicit relationship between the industry type and the product types they receive, and researchers have been analyzing delivery frequency by industry type and product type without addressing their connections. While the definition of industry type is dependent mostly on the types of goods and services the establishment provides, it does not always predict directly the types of goods the establishment receives. For example, pharmacies in the United States may sell prepared food while and those in Singapore do not.

While most of the establishment stock goods that are predictable (e.g. apparel stores stock apparels and sometimes accessories), some findings are worthy to highlight:
- Deliveries of cosmetics and toiletries account for 20% of the deliveries to accessories stores.
- Food Retail receives preserved/dried food on a higher frequency than Food Courts and Food Services.
- Formal Food Services tend to receive a combination of food of vary degrees of preservation in one delivery (0.24 in Food Service versus 0.12 in Food Court). This indicates that the deliveries to Formal Food Service are at higher level of consolidation, while those to Food Court are more direct from source.
- Deliveries of dried and preserved food account for 18% of the deliveries to pharmacies. Pharmacies also receive deliveries consolidated with toiletries, and other preserved food along with pharmaceuticals. This indicates that the Pharmacies sell snacks in addition to drugs and toiletries, and also suggests that they carry out consolidation of less perishable goods at corporate warehouses.

5.6 Delivery frequency and size

The delivery frequency and size depends on the inventory management of the receiving establishment, and the inventory management is influenced by the product characteristics, product demand and other costs. The medians provide a sense of the most common frequencies and sizes, and the averages provide a sense of the spread, e.g., if the average size is larger than the median, it indicates that there are a few very large deliveries that increase the size of all deliveries on average. The average was calculated using ordinal values (1=Less than $25\times25\times25cm^3$… 6=Bigger than $1\times2\times2m^3$).

Examining the delivery <u>frequency</u> across product types (Table 6), the following trends can be observed:
- Perishable food products, such as fresh and prepared food are generally delivered once a day.
- Less perishable food products are generally delivered multiple times a week.
- Other products do not show any consistent trend in delivery frequencies, and generally receive deliveries once a week.
- Dry food, Pharmaceutical, Cosmetics and Toiletries appear to have high delivery frequency but it is mostly because there is a low sample size.

Examining the delivery <u>size</u> across product types (Table 6), the following trends can be observed:
- Accessories, fresh food and frozen food are ordered in small volume. Accessories are smaller and thus it is expected that the delivery volumes are small. On the other hand, fresh and frozen food are usually (1) sold as a single item, without being combined with other products (e.g. ice, or chicken), and (2) have high turnover, and thus are order in smaller quantities.
- When product types are mixed the order size usually increase, e.g. Apparel-Accessories, and Dry food-Pharmaceutical, Cosmetics and Toiletries have higher average size of $1\times1\times2$ m^3.
- Apparel order volumes are generally bigger than food products.

Table 6. Delivery frequency and size by product type

Product type	Frequency			Size	
	Count	Median	Average	Median	Average
Accessories	13	Once a week	Once a week	50x50x50 cm3	50x50x50 cm3
Apparel	136	Multiple times a week	Once a week	1x1x1 m3	1x1x1 m3
Apparel-Accessories	17	Once a week	Once a week	1x1x1 m3	1x1x2 m3
Cosmetics and Toiletries	35	Multiple times a week	Once a week	1x1x1 m3	1x1x1 m3
Pharmaceutical	14	Once a week	Once a week	50x50x50 cm3	1x1x1 m3
Dry food, Pharmaceutical, Cosmetics and Toiletries	5	Multiple times a week	Once a day	1x1x2 m3	1x1x2 m3
Fresh food	83	Once a day	Once a day	50x50x50 cm3	50x50x50 cm3
Prepared food	15	Once a day	Once a day	1x1x1 m3	1x1x1 m3
Frozen food	32	Multiple times a week	Multiple times a week	50x50x50 cm3	50x50x50 cm3
Dry food	85	Multiple times a week	Multiple times a week	50x50x50 cm3	1x1x1 m3
Any combination of Fresh, Frozen, Dry and Prepared food	76	Multiple times a week	Multiple times a week	50x50x50 cm3	1x1x1 m3
Packaging	5	Multiple times a week	Multiple times a week	50x50x50 cm3	1x1x1 m3

Examining the delivery frequency and size across industry types (Table 7), the following new trends can be observed:

- Since the establishments that carry the products types Accessory, Apparel, Cosmetics and Pharmacy do not deviate from the expected industry types, the delivery frequencies and sizes to these stores do not show any surprising deviation from the frequency and size by product type.
- Dry food and Food Service receive larger deliveries than Food Courts at lower frequencies.

Table 7. Delivery frequency and size by industry type

		Frequency		Size	
	Count	Median	Mean	Median	Mean
Cosmetics	33	Multiple times a week	Once a week	1x1x1 m3	1x1x1 m3
Accessory Store	10	Multiple times a week	Multiple times a week	50x50x50 cm3	50x50x50 cm3
Apparel Store	168	Multiple times a week	Once a week	1x1x1 m3	1x1x1 m3
Food Court	66	Once a day	Multiple times a week	50x50x50 cm3	50x50x50 cm3
Formal Food Service	204	Multiple times a week	Multiple times a week	1x1x1 m3	1x1x1 m3
Food Retail	40	Multiple times a week	Multiple times a week	1x1x1 m3	1x1x1 m3
Pharmacy	32	Multiple times a week	Once a week	50x50x50 cm3	1x1x1 m3

5.7 Nature of deliveries by different supply source type

Lastly, the delivery frequency and size is tabulated by industry and supply source type. The average is tabulated and medians are not presented, as they are similar to the average. It is observable that large deliveries for Pharmacies in Table 7 are most likely delivered from corporate warehouses, since the average size is $1 \times 1 \times 2 \text{ m}^3$. Deliveries from corporate warehouse are generally larger and deliveries from manufacturers generally smaller.

Table 8. Delivery frequency and size by supply source type and industry type

	Cosmetics	Accessory Store	Apparel Store	Food Court	Formal Food Service	Food retail	Pharmacy
Another store							
Count	0	0	3	8	3	0	0
Avg. frequency			Once a week	Multiple times a week	Multiple times a week		
Average size			1x1x1m^3	.5x.5x.5m^3	1x1x1m^3		
Wholesaler							
Count	6	1	11	35	87	18	11
Ave. frequency	Once a week	Once a day	Once every two weeks	Multiple times a week	Multiple times a week	Multiple times a week	Multiple times a week
Average size	.5x.5x.5m^3	1x1x1m^3	1x1x1m^3	.5x.5x.5m^3	1x1x1m^3	1x1x1m^3	.5x.5x.5m^3
Manufacturer							
Count	3	1	27	14	32	8	5
Avg. frequency	Once every two weeks	Once a week	Once a week	Multiple times a week	Multiple times a week	Once a week	Once every two weeks
Average size	.5x.5x.5m^3	.5x.5x.5m^3	1x1x1m^3	.5x.5x.5m^3	1x1x1m^3	1x1x1m^3	.5x.5x.5m^3
Corporate warehouse							
Count	22	8	118	5	68	15	15
Avg. frequency	Once a week	Multiple times a week	Multiple times a week	Multiple times a day	Multiple times a week	Multiple times a week	Multiple times a week
Average size	1x1x1m^3	.5x.5x.5m^3	1x1x1m^3	1x1x1m^3	1x1x1m^3	1x1x2m^3	1x1x2m^3

5.9   Time of delivery by establishment industry

Delivery timings closely overlap with the opening hours of the establishments. The store opening hours range from 10 to 11am and the closing hours range from 8 to 9pm. Formal Food Service and Food Court appear to be the only industry types that receive deliveries before 7am. It is also interesting to note that deliveries to Formal Food Service is lower during lunch hours, 11 to 1pm, while there is no such trend in other industries. Most deliveries took place while the establishment is open, and before 3pm. This may be biased because the respondents were asked for the most recent deliveries and the survey took place from 10am to 5pm. Still, the survey data corroborates with the observation in the period observation data was collected. Other parking observation data that were collected showed that the peak delivery timings are between 9am to 3pm and few deliveries took place from 6am to 9am, and from 3pm to 6pm. No observation was made from 6pm to 6am.
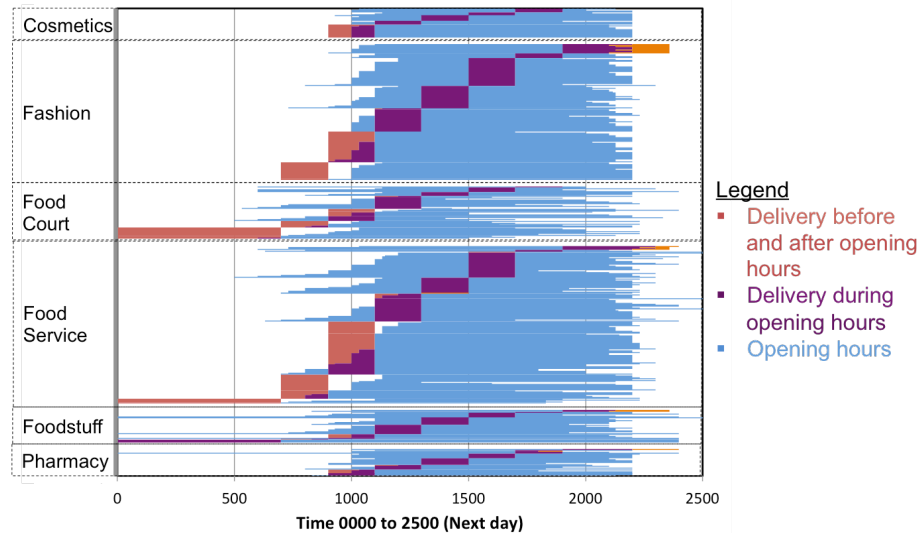

Figure 3. Delivery timings by industry type

6   Discussion

6.1   Discussion by industry

6.1.1   Food Courts vs. Formal Food Services

Formal Food Services (FFS) have their own seating and Food Court (FC) establishment usually shares the seating area with other FC establishments. Thus FC establishments are generally small, with around 4 employees and less than 10 m^2 when the shared seating space is not considered (Table 4). They also tend to be self-proprietary and have more decentralized shipping sources, purchasing from manufacturers, wholesalers and other stores rather than having their own distribution center (Table 5). FFS in Singapore are generally medium in size, with 11 employees on average, and with area 25 - 50 m^2 (Table 4). A majority of them receive deliveries from a corporate warehouse, indicating that the establishments belong to a more centralized distribution system. Delving deeper into the data (Table 9), it was found that FFS always have a higher average number of shippers than FC even when they share the same type of shipping source for the last delivery. This can be an expression of how FFS need wider variety of products. For example, FFS usually provide beverages, rice and noodle at the same time, while FC is specialized one type of food, only beverage or rice or noodle. Another observation from Table 9 is that the number of shipper for stores with corporate warehouse is on average lesser than establishments that received deliveries from non-corporate warehouse. This indicator is fuzzy by the fact that some of the other stores may have a corporate warehouse but it did not serve the last delivery. This variable could have been improved by a question that directly asked if the establishment has a corporate warehouse.

Despite that FC has less suppliers than FFS, FC receive about the same number of total deliveries as FFS (Table 4) but its shipper delivery frequency is once a day, in volume that is a quarter the size of deliveries to FFS (Table 7). The delivery volume may be small due to space constrain, increasing order frequency, or it may be because FC uses products that are more perishable. One simple way to make sense of this is that FFS have twice the number of suppliers that deliver at half the frequency of FC. The outcome for total delivery frequency would be the same for both cases. It should be noted that FC usually exists with other FC in order to provide for the customers. It is thus likely that a congregation of FC with the same area as a single FFS can create more deliveries than the FFS by having more individual establishments. However, this do not mean that FC is less efficient than FFS because we do not account for the number of customers FC and FFS can serve given the same floor area.

In comparing FC and FFS, it is observed that industry code is useful to distinguish the types of food service because it reveals underlying differences in supply management. Even though the total number of deliveries appears to be the same for FC and FFS, other dimensions that are critical for transportation demand modeling are different.

- Each FFS has more shipping sources and one of the sources is often a corporate warehouse. FC has fewer shipping sources and they consist of manufacturers, and wholesaler, and sometimes including another store.
- FFS makes bigger orders on a lower frequency while FC has few supplying sources, and makes small orders on a higher frequency.
- It is observed that food industry, including FC and FFS receive deliveries before 7am in the morning mostly because the store opens early.

Table 9. Comparing the number of suppliers between Food Courts and Formal Food Services given the type of the one shipper that was recorded. The average is reported, and the standard deviation is in the bracket.

	Food Court		*Formal Food Service*	
	Count	Number of suppliers	Count	Number of suppliers
Another store	7.00	6.00	3.00	10.67
		(5.03)		(13.28)
Corporate warehouse	3.00	1.67	58.00	3.10
		(0.58)		(4.75)
Manufacturer	10.00	3.90	24.00	10.04
		(2.56)		(8.68)
Wholesaler	30.00	4.20	71.00	10.42
		(3.34)		(6.81)

Note: The standard deviations are provided in the parenthesis.

6.1.2 Pharmacy

Pharmacies in Singapore carry a range of products, including snacks, cosmetics and toiletries in addition to drugs. They are usually medium in size, with 6 employees on average and with area 25 to 50 m^2. The number of deliveries is large, average around 11 deliveries per week like FFS and FC. However the delivery frequency is caused by a mechanism different from FFS and FC. The number of shippers is large, averaging 18 per store, and the delivery frequency ranges by shipping source type (Table 4). Pharmacies get replenishments from a mix of wholesale, manufacturer and corporate distribution center, and never from another store (Table 5). There are chances that wholesalers are interpreted as distributors, which are common in the pharmaceutical industry. The manufacturer delivers on average, infrequently (once every two weeks) with volume of 50x50x50 cm^3, while delivery from the corporate warehouse and from wholesaler is frequent (multiple times a week) in large volume, 1x1x2 m^3 and smaller volume, 50x50x50 cm^3 respectively (Table 8). It shows that Pharmacies have a corporate warehouse for certain items, and perhaps the rest are not stock because the distributors do not allow inventory storage at the distribution center in order to control product shelf life.

- Pharmacies usually receive multiple deliveries from their corporate warehouse once a week.
- The deliveries from the corporate warehouse are large and frequent, and the deliveries from other sources are small, and at varying frequencies.

6.1.3 Fashion and Cosmetics

Fashion establishments are usually medium in size, with 6 employees on average and with area 25 to 50m^2 (Table 4). Since the products are non-perishable, they are replenished at a much lower frequency. There are 2 deliveries per week on average and deliveries are usually quite large, 1x1x1m^3. The number of shippers is low, averaging 1.5 shippers. A large portion, 71% of the Fashion establishments receive deliveries from their corporate warehouse (Table 5). Some of the Fashion Apparel stores can have more frequent deliveries and/or very large delivery sizes (Table 7).

Cosmetics stores are usually smaller in size, with 5 employees on average and with area 10 to 25m^2 (Table 4). The replenishment is also at a low frequency of around 3±2 a week. The deliveries are medium, around 50x50x50cm^3 on average (Table 7). The number of suppliers is low, averaging 3.2. Again, a large portion, 80% of the establishments receives deliveries from their corporate warehouse (Table 5).
- Many of the Fashion and Cosmetic stores in the sample are franchise of a corporate company and receive deliveries mainly from the corporate warehouse.
- The delivery frequencies are low.
- The only difference between Fashion and Cosmetics deliveries is that the delivery size is larger in the former case because the items are larger.

6.1.4 Foodstuff

Supermarket dominates the grocery industry in Singapore. Few foodstuff retailers exist in the city. Of the foodstuff retailers that were located, they were specialized/ niche stores, such as Chinese herbal and medicine stores, and ethnic grocery stores. These stores are especially clustered in certain regions, and sometimes the cluster of stores act as a wholesale-retail center. Nonetheless, the variability that is observed in this industry is not larger than those observed in other industries. The stores are usually small in size, with 4 employees and with area 10 to 25m^2. The number of shippers and delivery frequencies are quite high, on average, 8 suppliers and 9 deliveries (Table 4). They get replenishments from a mix of wholesale, manufacturer and corporate warehouse, and never from another store (Table 5). The manufacturer delivers on average, infrequently (once a week) with volume of 1x1x1m^3, while delivery from the corporate warehouse and from wholesaler is frequent (multiple times a week), and large, 1x1x2m^3 or smaller, 1x1x1 m^3 respectively (Table 8). The delivery pattern to grocery industry is very similar to that of Formal Food Service with the exception that the store area is smaller. This can be because the variety of products available at Grocery stores is as high as Formal Food Service, spanning across beverages, dry and fresh food, but they require lesser employees and no sitting areas for the customers.

6.1.5 Supermarket

Even though we have only ten surveys from supermarkets, it is astonishing to find that supermarkets receive a large number of deliveries and can have 395 deliveries per week and 53.8 suppliers on average. The number may be slightly over-estimated so we directly observed the supermarket that claimed to receive the most deliveries, 100 deliveries per day for 8 hours in the one day. There were 72 deliveries. This is a very large number in comparison to the other industries. Since there are very few grocery stores in Singapore, can imply that the demand of goods at supermarket is extremely high. Based on personal communications, we found that it is typical that supermarkets assign shelf space to manufacturers and share a portion of the sales profit and loss. This reduces the supermarkets' risks but increases the number of deliveries.

6.1.7 The Role of Corporate Warehouse

Establishments of the same industry can differ a lot in their delivery characteristics depending on if they have a corporate warehouse. Corporate warehouse provide large deliveries to most stores. Having a corporate warehouse reduces the total deliveries to store by increasing delivery volume. However, having a corporate warehouse does not mean that stores would only receive deliveries from the corporate warehouse. This assumption only applies for fashion industry, and does not apply for food service, pharmacy or supermarkets. It is observed that food service, pharmacies and supermarkets have many supplies, indicating that they require a lot of different items. Part of these items can be consolidated, but others have to be delivered from the suppliers, thus keeping total deliveries high. This can be because manufacturers have control over the deliveries, or that the retail corporate prefers to have the suppliers manage their own products.

7   Conclusion

Most existing freight trip generation models predict aggregated deliveries to stores based on industry type, area and employment, but there are still a lot of deviations that cannot be explained. The existing models revealed little about underlying mechanisms that generate deliveries and have limited policy applications. This study shows that delivery-based questions directly linked with supplier relationship help explain heterogeneous delivery patterns and qualitatively revealed insights on the supply management of different industries. Variables that reflect the supply management of establishments can improve delivery demand models. Unfortunately the proxy used in this study only indicated if the establishment have corporate warehouse, and was not an accurate indicator otherwise (that the establishments do not have corporate warehouse), and this can be improved in future surveys.

The analysis presented in this paper is not yet proven to be statistically significant; two-dimensional descriptive statistics neglect the probability distribution of the variables and assume no correlation between the independent variables. The next step is to model these decisions jointly, and ideally, account for the interdependencies of these decisions.

The challenge in scaling up this model to city level is the lack of data on receiver-shipper relationship in public records. There are proxies that are strong predictors of receiver-shipper relationships; for example, the corporate nature of supermarket chain is a strong indicator that they have a corporate warehouse. Information on company registration should be available and can improve the model explanation power, and application in policy analysis. For example, city planners can understand how policies will affect policy impact on establishments of varying scales, and how increasing the number of upscale establishments, or small-scale sole-proprietary businesses can affect freight traffic in cities.

Lastly, while the survey provides an abundance of information, in order to predict the correct number of trip stops that is attracted to a stop or zone, it is necessary to correct for the chance that deliveries would be bundled in the same trip (e.g. a truck makes three deliveries in one zone or even one stop). A suggestion is to multiply the total deliveries to all establishments in the same time period to bundling factors, which needs to be modeled with separate truck drivers' survey data. This extra work is necessary to reduce an overestimation in trip generation.

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Shop ID: **This replaces Shop ID:**

Instruction to interviewer: Please read and ask the respondent questions 1 to 4.

1) What is the total number of workers in the establishment, including owners, full-time, part-time, unpaid workers? ……………………………………………………….………………… ⬚⬚⬚

2) How big is your storeroom? (Show them the options)……………………..…………………… ⬚
   a) There is no storage space.
   b) Less than 10 m^2
   c) 10 m^2 - 25 m^2
   d) 25 m^2 - 50 m^2
   e) 50 m^2 - 100 m^2
   f) 100 m^2 – 200 m^2
   g) 200 m^2 – 500 m^2
   h) more than 500 m^2

3) How many deliveries did you receive per day?.. ⬚⬚
   If they say too many to count, ask them on per day basis, and multiply it by 6.

4) How many suppliers do you have? (Includes their own warehouse)…………………………⬚⬚

If the answer to question 4 is **1**, go to Module 1.
If the answer to question 4 is **more than 1**, if the time now ends in odd minute, go to Module 1, if it ends in even minute, go to Module 2. Zero is an even minute. E.g. If the time right now is 13:32, go to Module 2.

2

Module 1
Words in brackets are hints you can use if needed. Remember you don't have to ask all questions if the answer was already given in the previous answer.

5) In the most recent time your store restock (or top-up your stock or replenish), was it delivered, or did you or your colleague pick it up? …………………..…………………………………….…………………….… ☐
   a) It was delivered from the source to us
   b) We hired a courier to pick up the goods for us.
   c) We picked it up from the source
   d) Others
   e) Don't know

If the answer to Q5 is a), d) and e) proceed with Q6 to 12.
If the answer to Q5 is b) or c) proceed with Q13.
Delivery Module
6) In the most recent goods delivery, which of the following best describes the supplier? (Do not ask if they already mentioned. If not, show them the options) ………………..……………………………..……..……… ☐

   a) From the manufacturer or the exclusive distributor (They usually only sell specific brands or products, such as Coca Cola, or Gardenia)
   b) From our corporate warehouse/ office
   c) From a wholesaler (They sell a mix of different brands and products to meet a niche needs of the store)
   d) From another store
   e) Others
   f) Don't know

7) How frequently does this "supplier" deliver goods to this store? Once a day or once a week? ….…..… ☐
   a) Multiple times a day
   b) Once a day
   c) Multiple days a week
   d) Once a week
   e) Once every 2 weeks
   f) Once a month
   g) Or less

8) In the last delivery, what was delivered? (Show them the card) …………………..…..................... ☐

Cooked, Prepared food	
Fresh food (e.g. Vegetable, meat)	
Frozen food (e.g. Frozen meat, cake)	
Dry/ Preserved food (e.g. Soda, canned food, snacks, sauce)	
Medicinal and pharmaceutical products	
Cosmetics	
Other household cleaning products	
Clothes, shoes, bags	
Personal accessories/ effects (Watch, jewelries)	
Packaging materials, e.g. plastic boxes and bags	
Others	

9) How big was your last delivery? Can it be stacked here? （This refers to the total volume including packaging. Use your hand to gesture a space that the goods might have been placed during delivery. They will disagree and gesture another size. You, the interviewer, will choose the box that describes the space best.）

☐

   a) 25 x25x25cm
   b) 50x50x50cm
   c) 100x100x100cm
   d) 200x100x100cm
   e) One to two 200x100x100cm boxes
   f) More

Say: Just a few more questions to go..

10) What time did the delivery arrive?.. ☐
   a) Before 7:00 AM
   b) 7:00 AM - 9:00 AM
   c) 9:00 AM - 11:00 AM
   d) 11:00 AM - 1:00 PM
   e) 1:00 PM - 3:00 PM
   f) 3:00 PM - 5:00 PM
   g) 5:00 PM - 7:00 PM
   h) After 7:00 PM
   i) Don't remember

11) Who decides the delivery time? (Read options to prompt them) .... ☐
   a) The other party.
   b) We negotiate the delivery time together.
   c) The store, the goods are delivered at a time we specified.
   d) Others
   e) Don't know.

This is the last question!
Please ask the following question only if this store is in the ERP affected area.

☐

12) Did ERP pricing affect the time they make the delivery? ....
   a) Not in ERP affected zone
   b) Yes
   c) No
   d) Don't know

Pick Up Module
13) In the most recent time you pick up goods, which of the following best describes the supplier? (Do not ask if they already mentioned. If not, show them the options) .... ☐
   a) From the manufacturer
   b) From the exclusive distributor (They usually only sell specific brands or products, such as Coca Cola, or Gardenia)
   c) From our corporate warehouse/ office
   d) From a wholesaler (They sell a mix of different brands and products to meet a niche needs of the store)
   e) From another store
   f) Others
   g) Don't know

4

14) How frequently do you pick up goods from this store? Once a day or once a week? …...................... ☐
   a) Multiple times a day
   b) Once a day
   c) Multiple days a week
   d) Once a week
   e) Once every 2 weeks
   f) Once a month
   g) Or less

15) In the last pick up, which of the following goods were collected? (Show them the card) .... ☐

Cooked, Prepared food	
Fresh food (e.g. Vegetable, meat)	
Frozen food (e.g. Frozen meat, cake)	
Dry/ Preserved food (e.g. Soda, canned food, snacks, sauce)	
Medicinal and pharmaceutical products	
Cosmetics	
Other household cleaning products	
Clothes, shoes, bags	
Personal accessories/ effects (Watch, jewelries)	
Packaging materials, e.g. plastic boxes and bags	
Others	

16) How big was the goods altogether? Can it be stacked here? （This refers to the total volume including packaging. Use your hand to gesture a space that the goods might have been placed during delivery. They will disagree and gesture another size. You, the interviewer, will choose the box that describes the space best.) .... ☐

17) What vehicle did you use?
   .... ☐
   a) Light Goods Truck (<18ft long)
   b) Pick up
   c) Van
   d) Car
   e) Motorcycle
   f) Bicycle
   g) Did not use vehicle, walked
   h) Heavy Goods Truck (>18ft long)

Please ask the following question only if this store is in the ERP affected area. ☐
18) Did ERP pricing affect the pick up time? .... ☐
   a) Not in ERP affected zone
   b) Yes
   c) No
   d) Don't know

Module 2

1) What products does your main supplier deliver?

	Most frequent supplier	Less frequent supplier	Less frequent supplier	Less frequent supplier	Less frequent supplier	Less frequent supplier	Less frequent supplier	Less frequent supplier	Less frequent supplier	Less frequent supplier
Prepared food										
Fresh food (e.g. Vegetable, Meat)										
Frozen food (e.g. Frozen meat, cake)										
Dry/ Preserved food (e.g. Soda, canned food, snacks)										
Medicinal and pharmaceutical products										
Cosmetics										
Other household cleaning products										
Clothes, shoes, bags										
Personal accessories/ effects (Watch, jewelries)										
Packaging materials, e.g. plastic boxes and bags										
Others										
How frequently do they deliver?										
a) Multiple times a day b) Once a day c) Multiple days a week d) Once a week e) Once every 2 weeks f) Once a month g) Or less										

Repeat until the total number of suppliers are listed, or up to 10.

6

This part of the survey is filled only after you have finished the interview with the subject. Do this outside the shop.

1) Establishment name… ⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚⬚

2) Postcode………………………………………………………………………… ⬚⬚⬚⬚⬚⬚

3) Where is this store located? …………………………………………………………………. ⬚
   a) Indoor/underground mall;
   b) Street/ street houses;
   c) Others

4) What is the visible shop area? ……………………………………………………………… ⬚
   a) Less than 10 m2
   b) 10 m2 - 25 m2
   c) 25 m2 - 50 m2
   d) 50 m2 - 100 m2
   e) 100 m2 – 200 m2
   f) 200 m2 – 500 m2
   g) More than 500 m2

5) Is this store outlet part of a retail chain? …………..………………..…………………..…………………...……Yes/No

6) How many outlets do they have? ………………………………………………………… ⬚

7) Weekday opening hours:
   Opening time **hhmm (24 hour format)** …………………………………………………… ⬚⬚⬚⬚

   Closing time **hhmm (24 hour format)** ………………………………………………… ⬚⬚⬚⬚

8) Describe the establishment's industry……………………………………………………… ⬚
   a) Pharmacies and drug stores. May sell other personal products (47722/3)
   b) Shops that only sells cosmetics and toiletries (47721)
   c) Cafes, restaurants, bars and bakeries baked on site (5611, 56121, 1071)
   d) Food court and hawkers (5614, 56122)
   e) Grocery store mainly selling fresh products (e.g. a mix of vegetables, meat, fish, others) (472)
   f) Grocery store mainly selling several types of dry goods (consumer packaged goods) (471)
   g) Apparel stores, selling clothes, bags and shoes. May sell accessories (4771)
   h) Personal accessories stores (4773)
   i) Others

9) **Please circle** the relative amount of products that are sold in the shop. If you do not circle, it would mean that the shop does not sell any of the products in that category.

	Most	Some	Least	None
Prepared food products that are usually consumed immediately and are perishable. (561)	3	2	1	0
Fresh or frozen products. E.g. fruit, vegetables, meat, fish, and milk. (4630, 4721)	3	2	1	0
Food items that may expire but are not as perishable as fresh goods. E.g. Liquor, soda, chips, tobacco, and candies. (4630)	3	2	1	0
Cosmetics/perfumes	3	2	1	0
Toiletries (4642)	3	2	1	0
Medicinal and pharmaceutical products. (4646)	3	2	1	0
Clothing, shoes, bags and luggage. (4641)	3	2	1	0
Watches, jewellery, silver products, fashion jewellery. (4642)	3	2	1	0
Others	3	2	1	0