ANALYSIS OF THE TRUCK TRIP GENERATION CHARACTERISTICS OF SUPERMARKETS AND CONVENIENCE STORES

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ABSTRACT

Transport engineers and urban planners use truck trip generation as one of the tools to identify the effects of trucks on urban congestion, pollution, safety, and the strain on the road network. Truck trip rates for supermarkets and convenience stores are higher than other retail facilities as they require more frequent and timely movement of goods, particularly perishable items. Supermarkets and convenience stores contribute to significant truck traffic in urban residential areas and thus have high exposure to rising fuel prices.

A manual truck count survey was conducted on the supermarkets and convenience stores in one New Zealand town. The main factors influencing truck trip generation rates of the stores are examined such as the physical and operational characteristics of the store and origin of loading of the truck. Correlation analyses are performed on the parameters to determine their influence on the truck trip generation of the stores.

Moreover, freight energy consumption and fuel intensity were calculated from the truck type and trip length of the deliveries. The major differences in the distribution patterns of the stores highlighted their differences in their freight energy consumption.

I. INTRODUCTION:

Truck trip generation is the first step in modelling and understanding the impacts of truck traffic on congestion and the environment. Supermarkets and convenience stores are ubiquitous features of the urban and suburban landscape. The high turnover in goods necessitates frequent re-supply and thus attracts daily truck trips. According to the National Freight Demands Study, supermarkets are leaning towards a more centralised-distribution to consolidate the deliveries and reduce the vehicles on the road but the same source also forecasted an increase in road freight including commodities such as retail and food products (Paling, 2008). Road freight is usually an unwelcome sign for residents living in the city as they perceive trucks to be road hazards and main congestion and pollution contributor, trucks are also potentially straining the local roads necessitating more maintenance (McKinnon, 2006).

In most studies such as (Paling 2008) and (Bolland, Weir, Vincent 2005), freight generation rates are given for large aggregated sectors such as retail. In some cases, this falls short in providing the necessary micro-level accuracy of the trucking activities in specific sub-industries. Since supermarkets and convenience stores are generally considered to belong in the retail industry, where the number of average trips may expectedly be lower as daily deliveries might not be essential, the resulting modelling outcomes may fail to capture the real dynamics and impact of this industry on the freight transportation system.

In general truck trip generation characteristics of stores are presumed to vary significantly from one country or geographical location to another due to differences in land-use patterns, traffic management and location's dependence on freight movements by truck. Hence, this dependence implies that previous studies done in Washington State (Mc Cormack, 2010), Illinois (Shin and Kawamura, 2005), and Netherlands (Iding, Meester and Tavasszy, 2002) will show different patterns than those found in New Zealand.

A study is conducted on 8 participating stores in one town in New Zealand in May 2011 (town name is withheld for privacy and confidentiality reasons) and will investigate the parameters influencing the truck trip generation characteristics of the stores. Sections II – IV are allotted for this objective. A second part of the study is on the freight energy consumption of the stores derived from the trip generation characteristics and is discussed on Section V. From here on, truck trip generation is defined as the number of trucks being attracted to the stores and trucks arriving at and leaving the facility is counted as 1 truck.

II. REVIEW OF RELATED LITERATURE

The truck trip generation (TTG) for retail industries is a result of complex strategic, tactical and operational business decisions which in general aims to reduce the costs of operations and maximize profits. Logically, firms would seek to optimise their distribution systems so that the total transport and warehousing costs are minimised and that reliability and timeliness are guaranteed. With these tradeoffs, it is thereby possible that the system may result in more frequent deliveries and as a consequence more trucks on the road than what is needed for the deliveries if transport costs are minimised.

Ortuzar and Willumsen (1994) identified three main variables that influence truck trip generation of stores: turnover of goods, floor space and geographical location of the store, and the number of employees (Ortuzar and Willumsen, 1994). Turnover of goods is difficult to obtain due to privacy and confidentiality reasons but floor space, employment data and socio-economic indicators such as population, demographic, age and sex distribution, households, income levels, are used as proxies (Mc Cormack 2010, Shin and Kawamura 2005). Mc Cormack et al (2010) paper challenges the well-accepted TTG method written on "Trip Generation" published by the Institute of Transportation Engineers or ITE (Institute of Transportation Engineers, 2008). This manual is used by transportation engineers in the United States in forecasting trip rates (passenger and trucks) generated by an establishment based on its land-use type and employment information.

New Zealand has an analogous database of trip generation rates published by the Trips Database Bureau (TDB). The database is also classified according to land-use type, of which retail is included, and the variables measured are floor area, employees, car parks and the trips generated on different times of the day (TDB 2011). However the database does not provide any useful information on the freight-only-related trips.

Traditionally, it has been accepted that a linear or a logarithmic function relates the independent variables, size of the store and number of employees, with TTG rates as the dependent variable. However, the study of Mc Cormack et al (2010) on 8 grocery stores in Puget Sound Washington found that an increase in the store's floor area by 5000 ft^2 (465 m^2) would reduce the total number of trips by one. The study used correlation analyses and the size of the facilities ranged from 23,000 ft^2 to 53,000 ft^2 (2137 m^2 – 4924 m^2). There are 2 possible explanations for this phenomenon. Firstly, larger stores will probably have a regional warehouse or distribution centre which would eventually lead to lower truck trip rates as the centre consolidates freight volumes for its chain of stores. Secondly, smaller stores will have smaller storage capacity necessitating more frequent deliveries. In addition, stores with more direct service deliveries and lower distribution warehouse deliveries may also generate more truck trips because Direct Store Deliveries (DSD) trucks tend to smaller and involve food categories with higher volumes such as soda, bread and milk.

Shin and Kawamura (2005) examined furniture chains and shoe chains, which is another sub-category of the retail industry. The study suggests the impact of the specific businesses' decision making such as replenishment scheduling and trip chaining on the TTG rates. The logistical strategies may be reflected as new independent variables other than the size and employee number of the stores. It was also prescribed to investigate TTG at a disaggregate level and then aggregate to a larger level. Like the McCormack study, the results of the Shin and Kawamura research suggest that the size of the store and the number of employees are poor predictors of truck trip rates.

A study in Netherlands (Irding, 2002) conducted a large-scale survey of 1529 respondents to analyse the freight trip generation of different industries. They perform linear regression analysis with the site area and number of employees of the firms as the independent variables to determine the number of incoming and outgoing freight trips. Depending on the industry, the correlation results differs for the size of the firm and the number of employees. In particular for the wholesale industry, results show that there is a low correlation for both the size and employee number with the truck generation.

III. METHODOLOGY

A survey and truck count study was conducted at eight participating food retail markets in one town in New Zealand in May 2011. The participants are 4 supermarkets, 2 convenience stores, 1 bulk food store and 1 farmer's market.

A. Store Classifications

Table 1: *Store classifications in the study.*

Supermarkets	Large stores selling groceries and a wide range of products. The stores belong to huge chain of stores operating in the whole country. One characteristic of these stores is they offer a huge variety of products and could be a one-stop for all the customers' needs.
Convenience stores	Corner dairies and gasoline/service station with convenience market and characterised by long operating hours and sells a limited variety of products but they offer convenience to the customers.
Bulk food store	Stores carrying general goods plus specialised imported products whose main feature is that they sell items from bulk bins and allows customers to bring refillable containers to buy in-bulk products. They are typically larger than convenience stores but smaller than supermarkets.
Farmer's Market	Community of vendors, mostly farmers that sell their own local produce and were popular form of food distribution system before the industrialised and cheap fossil fuel era.

Figure 1: From *top left, clockwise: Typical Supermarket, Petrol shop with Convenience Store, Bulk Food Store, and Farmer's Market in New Zealand*

B. Data Collection:

The data collection for the study is broken down into 3 major steps:

1. <u>Information about the physical and operational characteristics of the stores</u>

a. Distribution of information sheets to prospective participants. Twenty information sheets were distributed and 8 stores agreed to participate.

b. A face-to-face interview is scheduled with the store managers. Questions included facility information, hours of operation, warehouse location, mode of deliveries, number of trucks expected on a typical day and garbage management.

c. With the consent of the store managers, the store dimensions are recorded using a laser measurer. The retail trading area and storage space are measured separately.
d. The number of parking spaces for each store is counted manually and noted whether that store is located inside a mall or a free-standing facility. For off-mall facilities, 70-90% of the parking spaces are allotted to store depending on the proportion of the size of the store to the mall floor area.

2. Manual Truck Counts
a. For each store, two days of observation for truck counting is allocated except for the Bulk food store in which majority of the deliveries are on specialised days of the month. For each store, these days are chosen at random and must not include the minimum and the maximum delivery days which the store managers have cited on their respective interviews.
b. Each truck arriving at the store is counted as 1 truck. The time of arrival and departure and whether the truck is unloading or loading (mostly garbage collection) is recorded.
c. The truck type as well as the company information (whether it is a store truck, a freight company, or a direct supplier) is also noted.

3. Information about products and origin of loading and trip chaining
a. When possible, the truck drivers were interviewed about the products they are unloading, the origin of loading, and other destination points. However due to time pressure of the driver's job, the answers on other delivery information were mostly vague and cannot be recorded properly.
b. Riding with the truck drivers to determine the trip chaining was accomplished 4 times with one 3rd party freight company contractor.

C. Parameters for the Study

This section gives a brief overview of the parameters used in the study and what kind of correlation is expected from them.

1. Retail trading area – the most commonly used parameter in gauging the truck trip generation of any industry. Assumes to follow a linear or logarithmic relationship with the truck trip generation rate.
2. Storage space – was typically combined with the retail trading area but on its own, this parameter could be a gauge of how frequent deliveries may be needed by the store. That is, a store with a bigger storage space may not necessitate as much deliveries as that of store with a smaller storage space.
3. Parking space – a proxy for demand and number of customers accessing the store by car.
4. Number of full-time equivalent employees (FTE) – is also assumed to be directly correlated with the truck trip rates as more employees mean more customers that need service.

These 4 parameters are often viewed as proxies of the economic activities of the stores. Ideally, the sales and revenue information would be the direct measure of the turnover of goods but is unlikely to be obtained due to privacy and confidentiality reasons.

5. Operation Hours – longer operational hours of stores may translate to higher turnover of goods and number of trucks attracted but is hypothesised to be a weak factor.
6. Product variation score – new factor that will be investigated in this study. Mc Cormack (2010) suggested investigating this parameter to determine how high variation of products affects the truck trip rates. We hypothesise that higher product variation will yield a higher number of truck trips. (Here, 6 kinds of commodities are surveyed and the brands present at each store are tabulated. The products chosen are bread, jam, honey, oil, eggs, and yogurt)

and the total number of brands for each product is used to calculate the cumulative product variation score of each store. A high product variation score implies that a store has a wide range of choices for a specific product and includes some special brands. (See Table 3 for the computation of the product variation score)

7. Trip Length Distribution – distance from the origin of loading. We hypothesise that high percentage of trucks coming from a "local" origin of loading will have a strong correlation with the number of trucks attracted to a store.
8. Truck Type Distribution – classified the trucks into 3 major types: namely SMALL, MEDIUM, and LARGE (see Table 6 for details). We hypothesise that a high percentage of trucks that are small will also yield higher number of total trucks attracted to the store.

Note that parameters 7 and 8 will serve as the basis of the calculation of the freight energy of the stores.

IV. RESULTS AND DISCUSSION

This section presents a summary of the results of the data gathering and analysis of the parameters discussed in the previous section with the truck trip generation rates of the stores.

Table 2: *Store Codes used in the graphs:*

S1 – Supermarket 1	S3 – Supermarket 3	C1 – Convenience Store 1	FM – Farmers Market
S2 – Supermarket 2	S4 – Supermarket 4	C2 – Convenience Store 2	BS – Bulk Food Store

Table 3: *Computation of the Product Variation Score*

	S1	S2	S3	S4	C1	C2	FM	BS
Bread	14	11	13	13	4	3	1	0
Jam	11	9	9	6	3	1	2	1
Honey	11	8	9	8	2	1	1	2
Oil	17	16	18	11	3	0	0	3
Eggs	8	9	8	6	2	0	0	1
Yogurt	19	14	17	19	1	0	1	1
PRODUCT Variation Score	80	67	74	63	15	5	5	8

The following table summarises the results of the data gathering done in the study.

Table 4: *List of participating stores and its physical and operational characteristics and the observed truck counts daily average*

Establishment Code	Retail Trading Area (m^2)	Storage Space (m^3)	Number of Parking Spaces	Number of full-time equivalent employees	Product Variation Score	Operation Hours per Week	Observed Number of Trucks per day (Average)
S1	1800	413.8	165	115	80	98	24.5
S2	700	297	130	51	67	91	17.5
S 3	868	315.3	150	67.5	74	91	18
S 4	2669.6	1174.6	349	255	63	98	27.5

C 1	60	40	2	5	15	105	4
C2	100	12	8	6	5	105	5.5
FM	750	0	45	12	5	3.5	10
BS	183.52	43.3	30	8	8	52	1.1*

*The Bulk Store Average of 1.1 per day is computed using the information given by the store manager on the trucks expected to come on a particular day in a typical month and this value may be not be as accurate as the actual counts for other stores. For the Bulk Store, a truck arriving once a week is calculated as 1/5=0.2 trucks per day using the assumption that other stores would only have regular deliveries on weekdays, that is 5 days a week.

The manual truck counts result shown in the last column of Table 4 gives an interesting result as compared to the Mc Cormack et al study (2010). The supermarkets average for this study in one town in New Zealand is 21.88 trucks while stores in the Puget Sound region, Washington have an average of 18 trucks per day (Mc Cormack et al 2010).

The next step is to determine the relationship between each of the parameter cited above with the observed average number of truck trips per day of the stores.

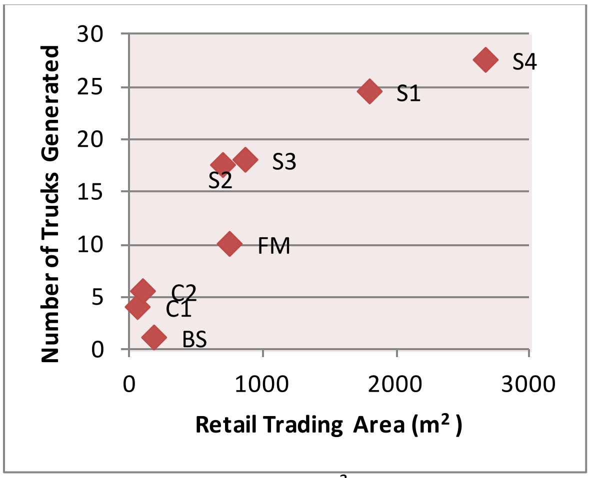


Figure 2: *Retail trading area (m^2) and truck counts*

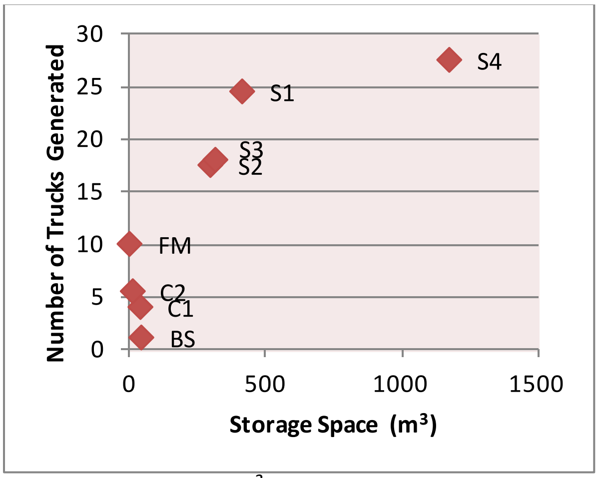


Figure 3: *Storage area (m^2) and truck counts*

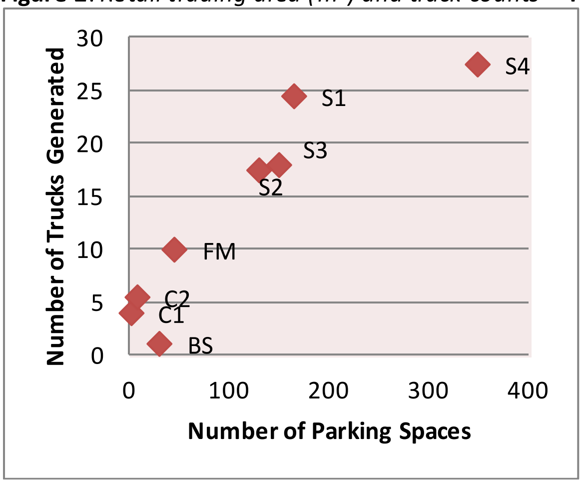


Figure 4: *Number of parking spaces and truck counts*

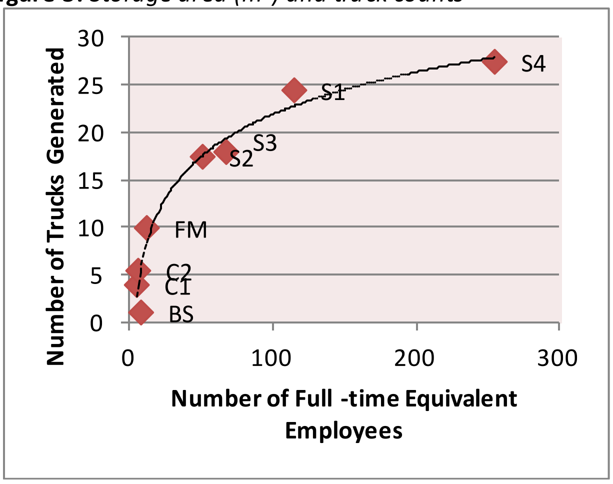
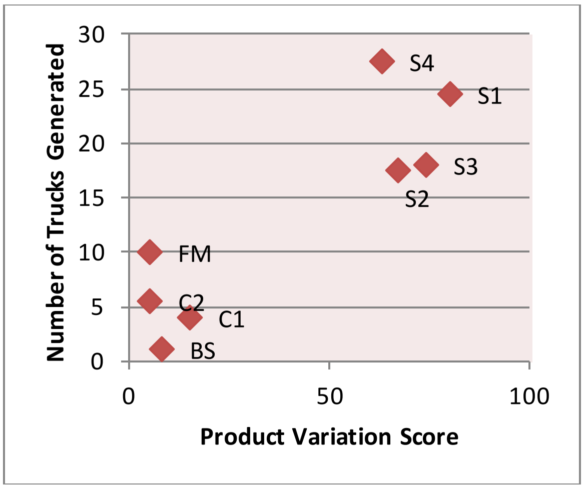


Figure 5: *Number of FTE and truck counts.*



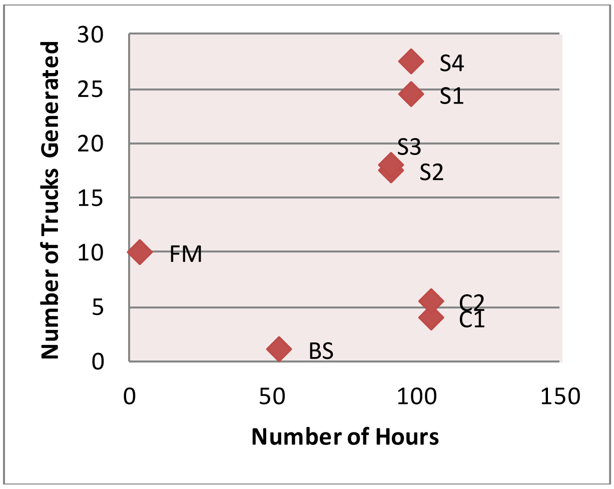


Figure 6: *Product Variation Score and truck counts.* **Figure 7:** *Number of weekly operational hours of the store and truck counts.*

Figures 2-4 show that the parameters pertaining to the physical size of the store given by the retail floor area, storage space and number of parking spaces have a direct correlation with the number of trucks generated by the store. Figure 5 illustrates that the number of employees of a store is logarithmically related to the number of trucks with a high R^2 value of 0.95. Figure 6 demonstrates the difference between the big stores (supermarkets) and the smaller stores as evident by the clustering behaviour on the graph. Meanwhile, the number of weekly operational hours has no direct correlation with number of trucks attracted as shown in Figure 7.

The next sets of parameters to be studied are the trip length distribution patterns and the truck type distribution for each store shown in Table 5-7. The trip lengths are calculated based on the interviews with the truck drivers on their origin of loading which could be the farm, warehouse, distribution centre or rail/port depot.

We set the following classification/bins for the trip lengths:

Table 5: *Trip length classification/bins*

Local	Origin of loading is <= 20 km from the store
Regional	Origin of loading is 20 – 200 km away from the store
Long-haul	Origin of loading is > 200 km away from the store. Goods came from another region including those hauled from the other island, that is if the town is located in the South Island, then the goods came from the North Island (by truck), was transferred by Ferry, then trucked down again to the store.

The truck types are determined using the FHWA 13-bin vehicle classification wherein a rough re-classification is done for all observed trucks into 3 major types: “Small”, “Medium” and “Large”.

Table 6: *Truck type classification/bins*

Small	Small trucks ranged from private cars, cars with trailers, pick-ups, and vans
Medium	Medium trucks ranged from 2, 3, 4-axle single units, 2-axle tractor 1-axle trailer, 2-axle tractor 2-axle trailer, and 3-axle tractor 1-axle trailer.
Large	Large trucks all those with a total of 5 or more axles.

Table 7: *Summary of the truck trip length and type distribution for each store.*

	Local			Regional			Long-Haul			
Store	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	**Total**
S1	5	9.5	0	1.5	3.5	5	0	0	0	24.5
S2	4	7	0	0	2.5	3.5	0	0.5	0	17.5
S3	5	6.5	0	0.5	2	3.5	0	0.5	0	18
S4	6	7.5	1	0	5.5	7.5	0	0	0	27.5
C1	0.5	3	0	0.5	0	0	0	0	0	4
C2	1.5	3.5	0	0	0.5	0	0	0	0	5.5
FM	5	0	0	4	1	0	0	0	0	10
BS	0	0.6	0	0.15	0	0	0	0.35	0	1.1*

*The Bulk Food Store Average of 1.1 per day is computed using the information given by the store manager on the trucks expected to come on a particular day in a typical month and this value may be not be as accurate as the actual counts for other stores.

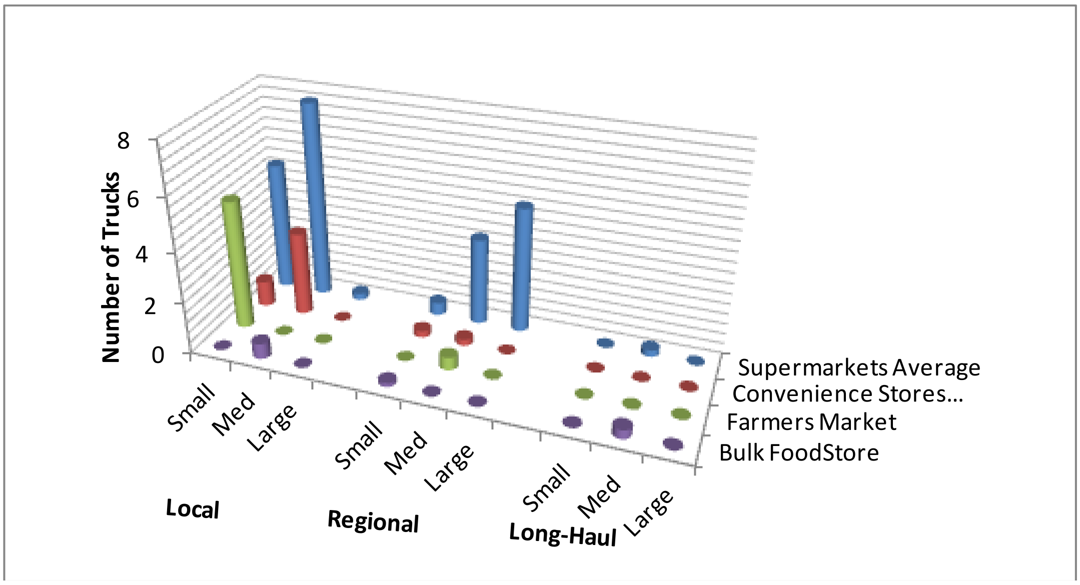


Figure 8: *Truck Type and Trip Length Distribution for the Stores*

Figure 8 shows that supermarkets utilises all types of trucks while convenience stores because they are smaller only uses small and medium-type trucks (getting their haul mostly from a local warehouse), the farmer's market uses the vendors own vehicle, while the bulk food store uses small and medium-type trucks, half of which are long-hauled. The smaller trucks that come to the supermarkets are mostly vans carrying couriered-type goods.

The programming language R used specifically for statistical computing is utilised to produce the following correlation analyses between the input parameters and the truck trip generation rates of the stores. Table 8 shows that the variables producing the strongest correlation with TTG rates are the Retail trading area, Number of parking spaces and the Product variation score. The last one is the novel variable included and this study and suggests that the more brands a store carries for a specific commodity, the higher the number of trucks it also needs to make the delivery. This inference is validated by the interviews with truck drivers to supermarkets citing that couriered-goods are mostly specialised items.

Table 8: *Results of Correlation Analyses*

Parameter	R^2 value with Number of Trucks Generated	Correlation type
Retail Trading Area	0.92	Very strong correlation
Storage Space	0.84	Strong correlation
Number of Parking Spaces	0.91	Very strong correlation
Number of Full-time Equivalent Employees (FTE)	0.86	Strong correlation
Product Variation Score	0.89	Very strong correlation
Number of Weekly Operating Hours	0.30	No correlation
Trip Length Distribution Parameter (Percentage coming from Local Warehouse)	-0.46	No correlation (Negative)
Truck Type Distribution Parameter (Percentage of small trucks)	-0.07	No correlation (Negative)

Compared to the results obtained in (Mc Cormack 2010, Shin and Kawamura 2005, Iding, Meester and Tavasszy 2002), our study suggests that size of store and employee number are good predictors of the TTG rates. In the Mc Cormack study (2010), the only parameter with a strong correlation to TTG rates is the size of the store which is negatively correlated suggesting that smaller stores could actually attract more trucks. This phenomenon was not exhibited in our study suggesting that larger storage space does not decrease the number of deliveries.

V. FREIGHT AND ENERGY

The truck trip generation characteristics of stores is a result of complex logistical decisions on different levels of the supply chain and may be used by bigger firms and chains to look at optimal trade-off between costs, reliability and timeliness of the deliveries. However this kind of analysis is basically done as part of their business strategy and may not take into account the vulnerabilities or susceptibilities of the system to rising fuel costs. The methodology of the study which included the gathering of information of the truck type, origin of loading and interview with truck drivers enabled the authors to derive a method for determining an approximate measure of freight energy usage of the deliveries.

Method used to calculate the freight energy consumption and fuel intensity:

1. From Table 6 (classification of vehicles), give an estimate of the worst possible mileage to the best possible mileage for the vehicles. A lot of factors may go into this computation including engine size, truckload, and engine efficiency based influenced by age, make, amongst others, drag, driver habits, and so on. Interview with some of the truck drivers are also used as a gauge in choosing this range:

Table 9: *Estimated mileage range of vehicles.*

SMALL	8 – 11 L/100 km
MEDIUM	14 - 25 L/100 km
LARGE	20 – 33 L / 100 km

2. Take the median of the trip length distribution bins.

Table 10: *Median distances of the trip length bins*

Trip Classification	Trip Range	Median
Local	0 – 20 kms	10 kms
Regional	20 – 200 kms	110 kms
Long-haul	200 – 1800 kms	1000 kms

3. Combine the information from Table 9 and Table 10 to obtain a range of the litres consumed for each trip bin and denote this as the best mileage (litres consumed) and worst mileage (litres consumed).

Table 11: *Litres consumed for the deliveries depending on the truck types and the trip lengths.*

Median Trip Length (km)	10			110			1000		
Vehicle Type	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Best Mileage (L)	0.8	1.4	2	8.8	15.4	22	8	140	200
Worst Mileage (L)	1.1	2.5	3.3	12.1	27.5	36.3	110	250	330

4. Use Table 7 (Summary of the Truck Trip Length and Type Distribution for each store) and Table 11 to compute the estimated number of litres consumed for the deliveries.
5. Determine the energy equivalent in mega joules (MJ) based on the liquid fuel conversion formula taking into account the Higher Heating Value (HHV) (Hofstrand, 2008).

Table 12: *Liquid fuel conversion using HHV*

Diesel	1 litre = 38.7 MJ
Gasoline	1 litre = 34.8 MJ

Performing steps 5 and 6 on our data of participating stores (that is multiplying each entry from Table 7 with the corresponding entry on Table 11) we obtain the total number of litres consumed using best and worst mileage estimates. Multiplying by the liquid fuel conversion yields the following:

Table 13: *Total litres and energy consumed for the deliveries using the best and worst mileage assumption for the vehicles.*

Store	Total Energy (MJ) Best Mileage Assumption	Total Energy (MJ) Worst Mileage Assumption
S1	7523	12583
S2	7682	13262
S3	7558	12959
S4	10333	17498
C1	348	546
C2	534	935
FM	1900*	2833*
BS	1980	3515

*Note that Farmer's market vehicles being mostly private cars use gasoline instead of diesel.

The computation on Table 13 is an overestimation of the freight energy consumption as it assumes that the truck delivered only to one store from its origin of loading which only accounts for 19% of the total based on the driver interviews. If information on the number of delivery stops is known, then the energy consumption should have been divided amongst all stores on the driver's route.

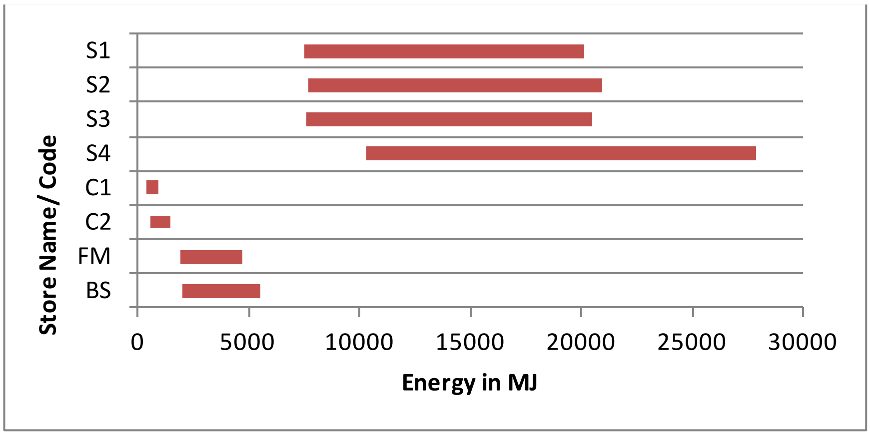


Figure 9: *Comparison of the freight energy usage of the stores.*

Figure 9 show that supermarkets with the highest TTG rates naturally also consume more energy.

6. The next step would be to give an approximation the fuel intensity of the deliveries to the stores. Ideally, fuel intensity is measured as total energy per unit of food delivered but since tonnage data are not available; the retail trading area is used as a proxy for this variable. The result of the correlation analyses showed that the retail trading area of the store is best gauge of the TTG. Also, as mentioned in Section III, it is a proxy for the customer based and demand of the store. Fuel intensity, in this study, is measured as the energy consumed per 100 m^2 of retail floor area.

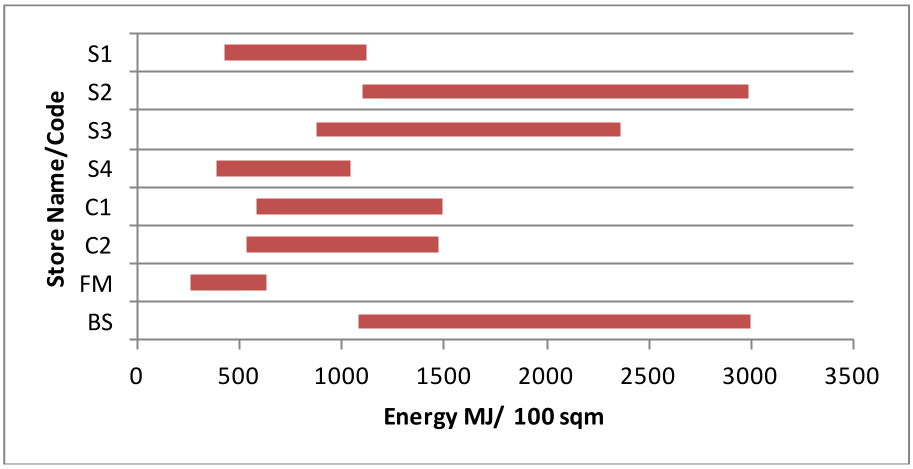


Figure 10: *Comparison of the fuel intensity of the stores.*

Note that even though retail floor area is the best parameter influencing TTG rates, the dynamics of the Farmer's market of having relatively large floor area but very short operational hours and smaller customer based may have skewed its result of the energy intensity calculations making it as the least-energy-intensive form of distribution.

Interestingly, supermarkets 1 and 4 with higher product variation scores and consequently higher TTG rates have lower fuel intensities which could be attributed to having bigger retail trading area and also because both didn't record any long-haul delivery. On the other end of the spectrum, the convenience stores, in spite of having most of their deliveries from a local warehouse, scored relatively high fuel intensities owing to their high truck rates relative to their size (customer demand).

VI. CONCLUSIONS AND RECOMMENDATIONS:

A. Conclusions:

The study conducted on the 8 stores in one town in New Zealand aims to capture the dynamics behind the different distribution patterns of different kinds of stores in the country. We tested the link between the truck trip generation rates of different food distribution systems such as supermarkets, convenience stores, and Farmer's market and bulk food store with physical and operational characteristics of the store, employment information, and distribution patterns from its origin of loading.

The retail trading area and parking space of the stores present the strongest factor in determining the number of trucks generated but new parameters such as product variation and trip-length and truck-type distribution are also analysed. Product variation has a strong correlation with the number of trucks because as more deliveries are needed for specialised brands that a store carries. Supermarkets owing to their larger customer based, shown by their bigger store dimensions, also attracts the highest number of trucks but has slight differences from each other which is highlighted by their product variation scores.

Meanwhile trip lengths and truck types showed no link with the number of trucks attracted negating our hypothesis but are used in the calculation of the freight energy consumption of the deliveries and the fuel intensity. The Farmer's market with all of its goods coming from local or regional farm may have the lowest fuel intensity amongst all participants but some factors need to be taken into account in the calculations such as trip chaining. Nevertheless, the results of the fuel intensity calculation could serve as a springboard for further studies about how the local distribution system will be the most resilient form of distribution system in the end of the cheap fossil fuel era.

B. Recommendations:

Limited number of data set to produce a statistically relevant conclusion or model but it established the main framework in obtaining a trip generation model for different type of stores and a method for the calculation of freight energy consumption and fuel intensity of the stores. The input parameters to these calculations may be improved in succeeding studies. Likewise, trip chaining which is a significant result of complex tactical and operational logistics of both store chains and freight distributors was not considered in the computation of the freight energy usage of the trucks. The data about other store deliveries were initially planned to be collected but due to the rushed nature of the driver's job, it became impossible to determine actual trip chaining.

The next step would be to explore the oil supply risk exposure of the distribution scheme for different food retail systems. After which, develop an energy-constrained logistics analysis method to assess the feasibility and risk mitigation of local production and alternative warehousing and distribution systems.

Regarding the influence of the geographical location of the store on its TTG rates, a separate study of the socio-economic indicators of its market shed (determined using accessibility analysis in ArcGIS 10) is also being conducted by the authors as of this writing.

ACKNOWLEDGEMENTS:

This work is supported under Contract C01X0903, Towards Sustainable Urban Forms, National Institute of Water and Atmospheric Research Ltd. (NIWA). The authors would also like to acknowledge the help of Mr. Thomas Sanchez with the data collection, Mr. Stacy Rendall for proofreading the documents, Dr. Nadine Roth for the useful suggestions on freight trip generation studies and Dr. Elena Moltchanova for the help on the statistical analysis.

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