PASS-BY AND DIVERTED TRIP RATES OF SUPERMARKETS IN CHRISTCHURCH

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ABSTRACT

Not all trips to land uses are simply to that destination and returning (primary trips); some trips may be as a result of passing by or deliberately diverting to the land use while travelling to another destination. This research project investigated these phenomena. The development chosen to investigate was supermarkets. Data was obtained to analyse the primary, pass-by and diverted trips generated by five different supermarkets in Christchurch. The results were taken for three different times; weekday peak, weekday off-peak and weekend peak. The data was obtained via face to face surveys at the location of interest. On average, 58% of trips were found to be either pass-by or diverted trips (roughly half-and-half). From statistical analysis, a number of factors were identified as possible reasons for differences between each of the surveys.

The location of the supermarket was seen to have a major influence in the proportion of primary, pass-by and diverted trips. The proximity of the supermarket to roads with large daily traffic volumes had a particularly large influence on the trip generation of the supermarket. Other factors observed to have some influence included time of day, size of supermarket, type of supermarket and proximity of competitors.

1. INTRODUCTION

When new developments are constructed, they generate a range of different types of trips. Some of these trips are already part of the existing traffic pattern (pass-by trips) while others are completely new trips (diverted trips). When planning a development these trips need to be considered in order to understand the effects on the surrounding road network.

As well as trips to land uses that simply travel directly to that destination and return to their origin (primary trips), some trips may be as a result of passing by or deliberately diverting to the land use while travelling to another destination. The goal was to find how developments affect the amount of these “pass-by” and “diverted” trips on New Zealand roads. There is a lack of data internationally in this area and so our findings will prove useful for the industry. This gives motivation to do the project in order to add a more specific type of data to existing traffic databases (TDB, 2015).

This lack of data is acknowledged in the UK, where recent work on pass-by and diverted trips had updated earlier 1995 advice due to “questions raised as to whether the application of a standard reduction in trip rate to account for pass-by and diverted trips is still accurate in a rapidly changing retail environment” (JMP Consultants Ltd, 2014). This gave an opportunity to investigate a field that lacks a detailed study in New Zealand. The UK report also states that there is a need for this type of research as shopping habits of people are rapidly changing and the effects of this on our transportation systems need to be analysed.

Methods used were adapted from similar surveys used by the UK-based TRICS (Trip Rate Information Computer System) organisation. Surveys have been performed by TRICS in the past that cover a similar scope as what we intended to accomplish with our project findings. However, they provide a more broad set of data that only contained a brief look into pass-by and diverted trips. As this only scratches the surface of the topic, we intended to give a more specific and detailed analysis of the pass-by and diverted trips topic. This paper summarises those findings.

1.1 Background

A primary trip is one that goes from the origin to a destination and back to the origin. An example of this is home-to-work-to-home. This is shown in Figure 1.

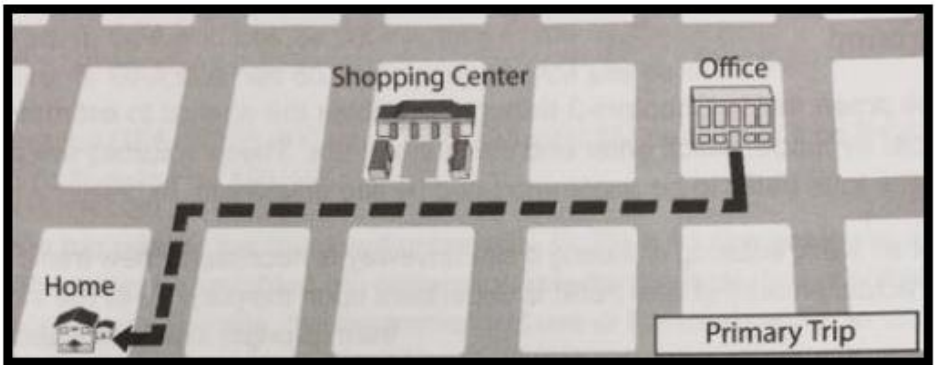

Figure 1: Example of a Primary Trip (ITE, 2014).

In the US *Trip Generation Handbook* a pass-by trip is defined as an intermediate stop on the way from an origin to a primary trip destination without route diversion. (ITE, 2014). An example of this can be seen in Figure 2, where a shopping centre is visited on the way from the office to home.

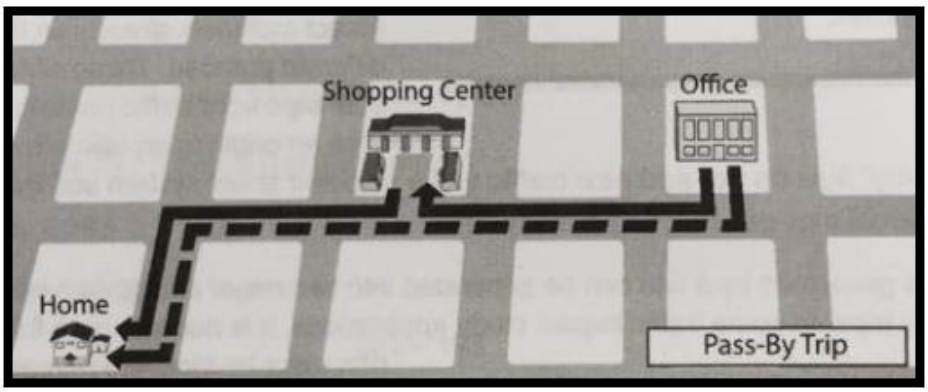

Figure 2: Example of a Pass-By Trip (ITE, 2014).

A diverted trip requires vehicles to travel out of their way to visit a location on their way to their final destination. This means that the route taken is not the shortest when travelling from the origin to final destination. This can be seen in
Figure 3, where a "gas station" is visited on the way from office to home.

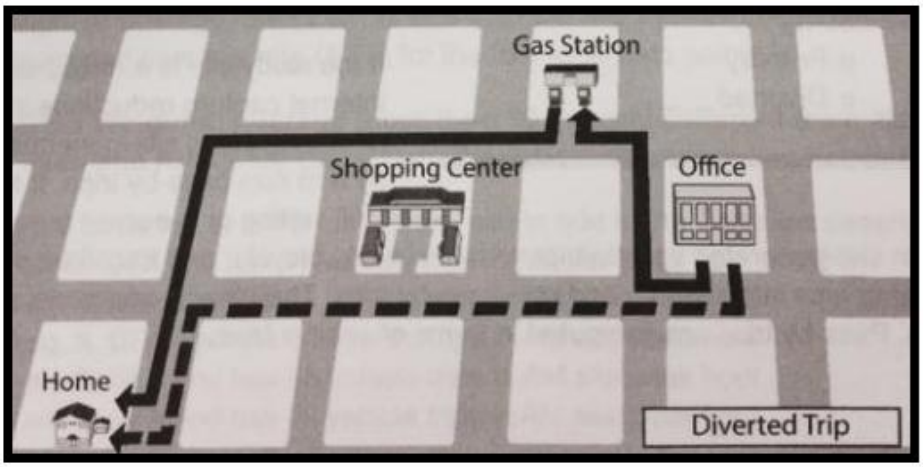

Figure 3: Example of a Diverted Trip (ITE, 2014).

Abley & Douglass (2011), in their study of trips and parking generation in New Zealand, suggest that surveys of this type are important as *"while the proportion of diverted trips may reduce the traffic generation effects of a new activity on the wider transport network, it does not change the number of trips that arrive 'at the gate'."*

2. METHOD

Data was obtained to analyse the primary, pass-by and diverted trips generated by five different supermarkets in Christchurch. The method of data collection was through on-site interviews of people entering the premises. To simplify the study, only motor vehicle trips were studied. The interviews were made up of four short answer questions. This made it possible to gain an appropriate amount of data without causing much disruption to the shoppers. Approval from supermarket managers was required before any surveys were undertaken on site. The data collected was also made available to the managers upon their request.

For each site a total of three surveys were conducted. This was done in order to collect data for afternoon peak, off-peak and weekend peak times. The afternoon peak was selected as this was expected to be the busiest time for supermarkets. Each survey included at least 50 participants so that a sufficiently useful sample could be gathered. The questions used in the survey are shown in Figure 4. These questions made it possible to determine what type of trip each person made while only taking a small portion of time to answer.

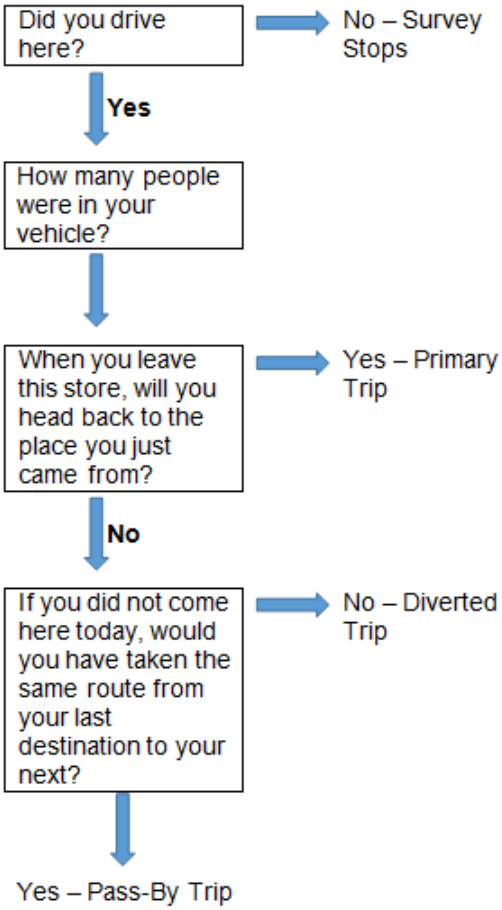

Figure 4: Survey Questioning Procedure

It was found that surveying 50 people per location gave a sampling error ranging from ±8.5% - 13% at the 95% confidence level. In order to reduce this error to ±5%, approximately 200 interviews would have to be carried out per time period at each location. This error (%) was calculated using Equation (1).

$$Error = \sqrt{\frac{\frac{x}{Total} \times \frac{1-x}{Total} \times 1.96^2}{Total}} \times 100 \qquad (1)$$

Where:

x = Number of motor vehicle trips for primary, pass-by or diverted categories
Total = Sum of all motor vehicle trips (primary, pass-by and diverted combined)

To gather a range of data, five different supermarkets were surveyed. Each had different characteristic, including size, and location. The characteristics of the five locations are detailed as below:

- Location 1 – This store has a small floor area (less than 3000 m^2) and is located on a minor arterial route. There are no major corridors that traffic would use as an alternative route.
- Location 2 – This store has a small floor area and is located on a major arterial route. The store is surrounded by a housing development. This is one of two supermarkets located in the area as they are position well outside of the CBD.
- Location 3 – This store has a medium floor area (between 3000 – 3500 m^2) and is located on a minor arterial route. There are many collector and distributor roads in this area.

- Location 4 – This store has a medium floor area and is located on a minor arterial route. This supermarket is positioned between a high volume minor arterial and a major arterial route. There are three competing supermarkets in close proximity to this store.
- Location 5 – This store has a large floor area (greater than 3500 m^2) and is located on the corner of a major arterial route and a distributer road. There are other supermarkets located in close proximity to this one.

3. RESULTS

3.1 Location Proportions

The primary, pass-by, and diverted trip proportions for each location across the three survey times were plotted and can be seen in Figure 5.

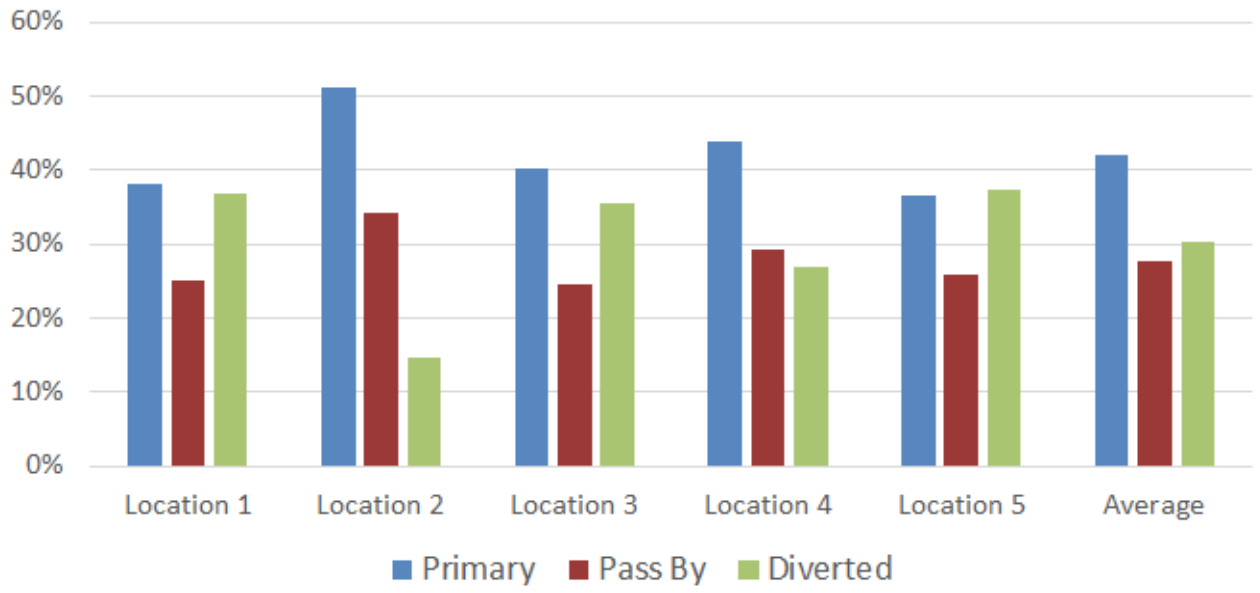

Figure 5: Trip Proportions for Each Location

From this plot is can be seen that Location 1, Location 3, and Location 5 all follow a trend of having similar primary and diverted proportions with a lower amount of pass-by trips.

Location 2 and Location 4 follow a different type of trend. These locations have a large proportion of primary trips and the proportion of diverted trips is less than that of the pass-by trips. This is most likely due to stores being positioned on high volume roads with little alternative for other routes. This is even more evident at Location 2 as it is located on a major arterial and is surrounded by a housing development. Due to this, the only option for a diverted trip to occur is if someone lived nearby, requiring them to make a very small diverted trip. It is very unlikely that someone would make such a large diverted trip from the CBD or other parts of the city.

3.2 Time Proportions

Each location was surveyed three times, each at a different time period. These periods were weekday peak (5:00pm-6:00pm), weekday off-peak (12:00pm-1:00pm), and weekend peak (1:00pm-2:00pm). The primary, pass-by and diverted trip proportions for each time period can be seen in Figure 6, Figure 7, and Figure 8 respectively.

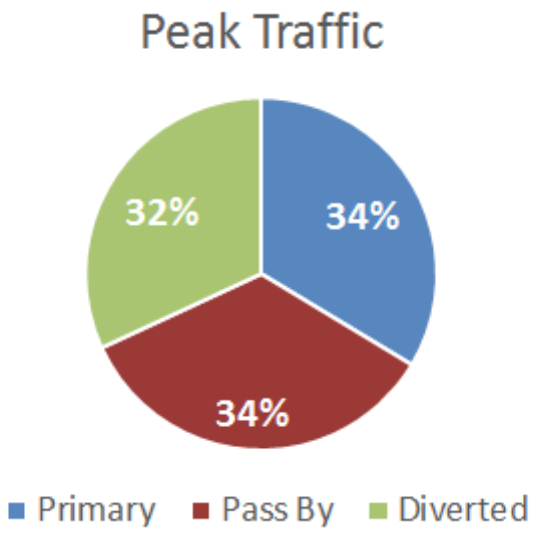

Figure 6: Trip Proportions for Weekday Peak Period

The trip proportions for the weekday peak were found to be equally split between the three types.

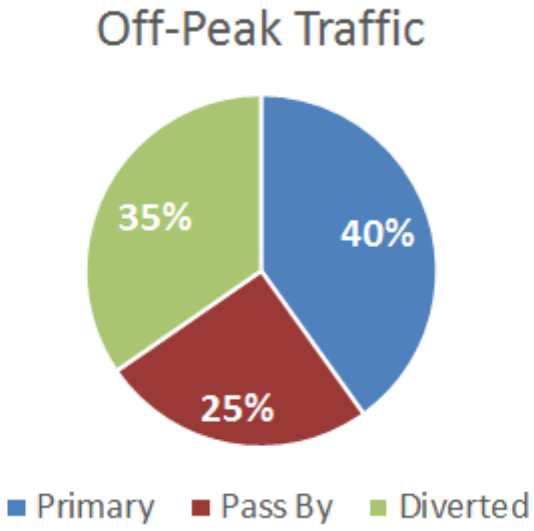

Figure 7: Trip Proportions for Weekday Off-Peak Period

The trip proportions for the weekday off-peak period show that there is an increase in primary and diverted trips, while a decrease in pass-by trips. This increase in primary trips is most likely due to people specifically heading to the supermarket from work or home to pick up some lunch.

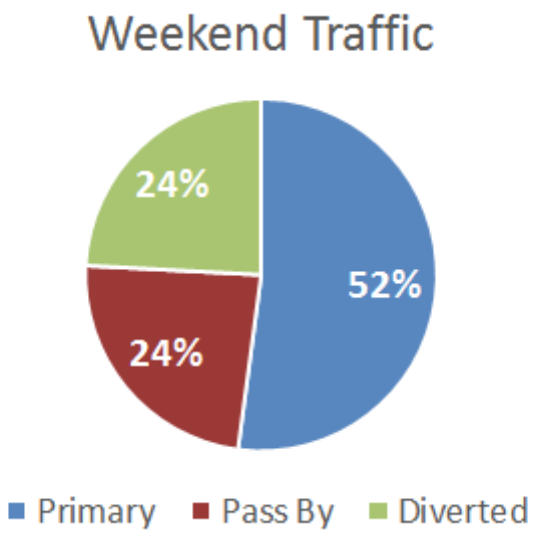

Figure 8: Trip Proportions for Weekend Peak Period

The weekend peak showed a further increase in primary trips. This type of trip made up more than half of the total trips. The likely reasons behind this is that many people tend to do their large shopping trip on the weekend where they have some extra time. This is also a possible reason why many of the trips are primary ones; people could tend to head straight home after shopping as they may want to get their groceries home and stored as soon as possible. This is possibly only a trend present in supermarkets as other land uses do not require the transportation of perishables. This is a good example of why it would be worth investigating other land uses.

3.3 Similarity Testing

Chi-square testing at a significance level of 0.05 was used to investigate statistical differences and similarities between locations and times. Two examples of this analysis are given in Appendix A and Appendix B. The p-value given in the test indicated the likelihood that the differences observed between the sets of data analysed were due to chance. The p-values for chi-square tests comparing the primary, pass-by and diverted trips at each location are summarised in Table 1.

Table 1: p-Values for Location Comparisons

Location	1	2	3	4	5
1	-	0.002	0.941	0.317	0.984
2	0.002	-	0.004	0.114	0.002
3	0.941	0.004	-	0.430	0.884
4	0.317	0.114	0.430	-	0.312
5	0.984	0.002	0.884	0.312	-

The shaded cells in Table 1 represent locations where statistically significant differences were found ($p < 0.05$), while the unshaded cells show the locations that were found to be similar. The table shows that Location 2 demonstrated statistically different characteristics of primary, pass-by and diverted trips. This suggested that it is very likely that this supermarket would demonstrate primary, pass-by and diverted trends significantly different to the other supermarkets consistently. This is supported by the chi-square test in Appendix A, which shows that Location 2 is significantly different to the average of the other four locations.

Low p-values represent large likelihood of differences and so, while all values are above the 0.05 threshold, the p-values for Location 4 are all relatively low. In contrast, Locations 1, 3 and 5 all produced very high p-values (other than with Location 2). From this it was determined that Locations 1, 3 and 5 would be expected to frequently have similar primary, pass-by and diverted

rates. Location 4 would be expected to display similar trends occasionally but would be more likely to have somewhat different rates.

Chi testing was also done for primary, pass-by and diverted trends depending on the time of day or week. An example of this can be seen in Appendix B. This testing showed that the type of trips made at most of the locations were largely independent of time. Location 1 was seen to be very dependent on time and Location 5 was slightly dependent on time; however, the testing suggested that the proportions of primary, pass-by and diverted trips were more sensitive to the location of the supermarkets.

3.4 Distance Results

The distance between the supermarkets being surveyed and their nearest competitors was determined. This information has been plotted in Figure 9. This shows the distance to the locations' nearest four competitors.

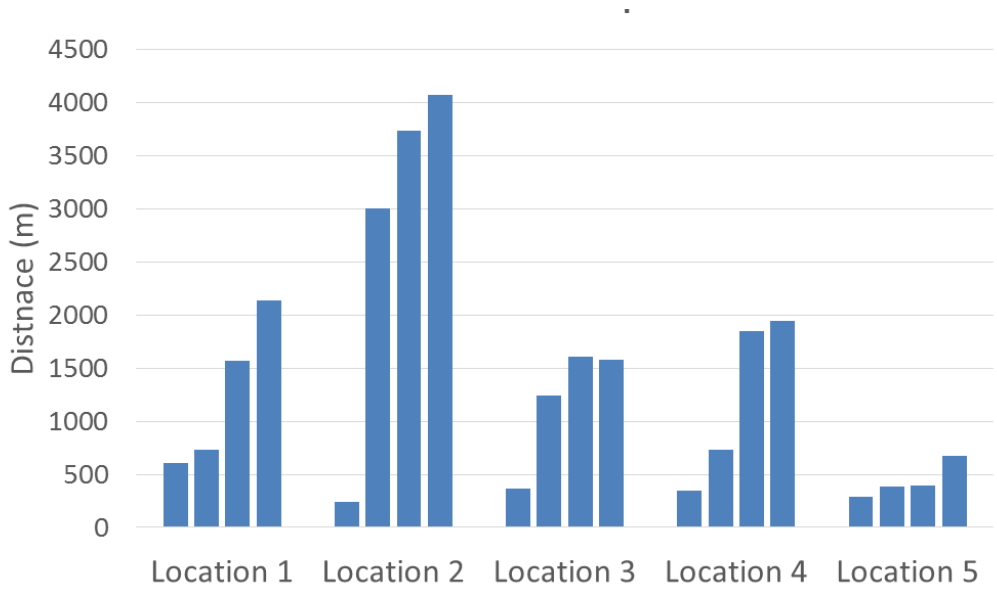

Figure 9: Distance from Survey Location to Nearest Competing Supermarket.

When these distances are compared to the trip proportions, two key aspects can be noticed. In the case of Location 2, the average distance to the nearest competing supermarket is 2760 m. On average the nearest competitor was located 1029 m away. This shows that Location 2 is isolated when compared to the other locations. The primary trips to this location were 51% which was higher than the average of 42%. From this it can be assumed that isolated stores will generate more primary trips than other locations.

On the other end of the scale, Location 5 had four competitors within a 700 m radius. The effect of having four competitors in such a small area did not seem to affect the trip proportions. The trip proportions for this location were within 7% of the average. While carrying out the surveys at Location 5, it was noted that people said they specifically came to this store instead of going to others. With this in mind, the store's reputation may cause an increase in trips, even though there are several other options in the area.

Distances from the supermarkets to the nearest major alternate route (defined as a parallel arterial road) were also investigated. Of particular interest was how the distance to the nearest major road affected the proportion of diverted trips. This analysis can be seen in Figure 10.

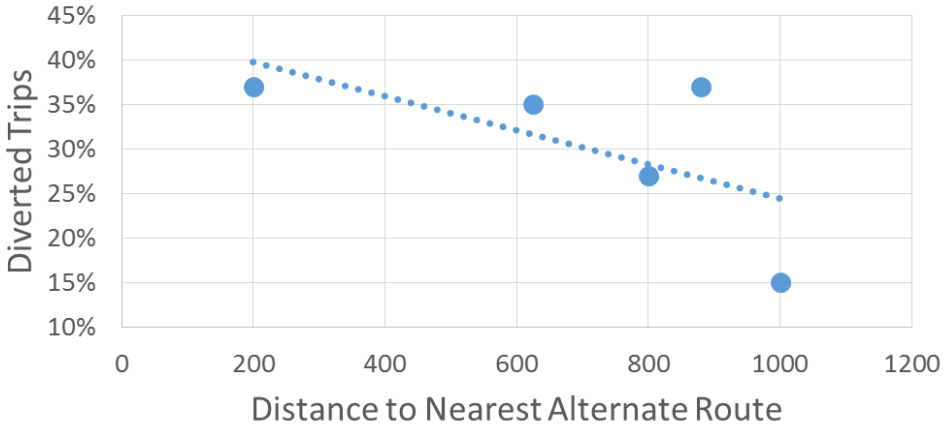

Figure 10: Distance to Nearest Alternative Route and the Rate of Diverted Trips

Figure 10 shows that as the distance to the nearest alternate route increases, the number of diverted trips decreases; the r^2 for the linear trend-line was 0.3972. The exception to this, which caused the r^2 value to be so low, is Location 5, which has both a high distance and a high diverted rate. The reason for this could be due to this type of supermarket being a discount price store. Because it was a discount price store, people appear to be willing to travel further out of their way to shop there. Apart from this one location, diverted trips appear to be highest at locations that have nearby major alternate routes. This was found to be particularly evident for Location 2, which has the largest distance and has a diverted rate that is much lower than any other location.

3.5 Proportions Based on Floor Area

The floor area of each location was recorded and plotted against their respective trip proportions. This relationship can be seen in Figure 11. The floor areas ranged from 2000 m^2 to 3900 m^2.

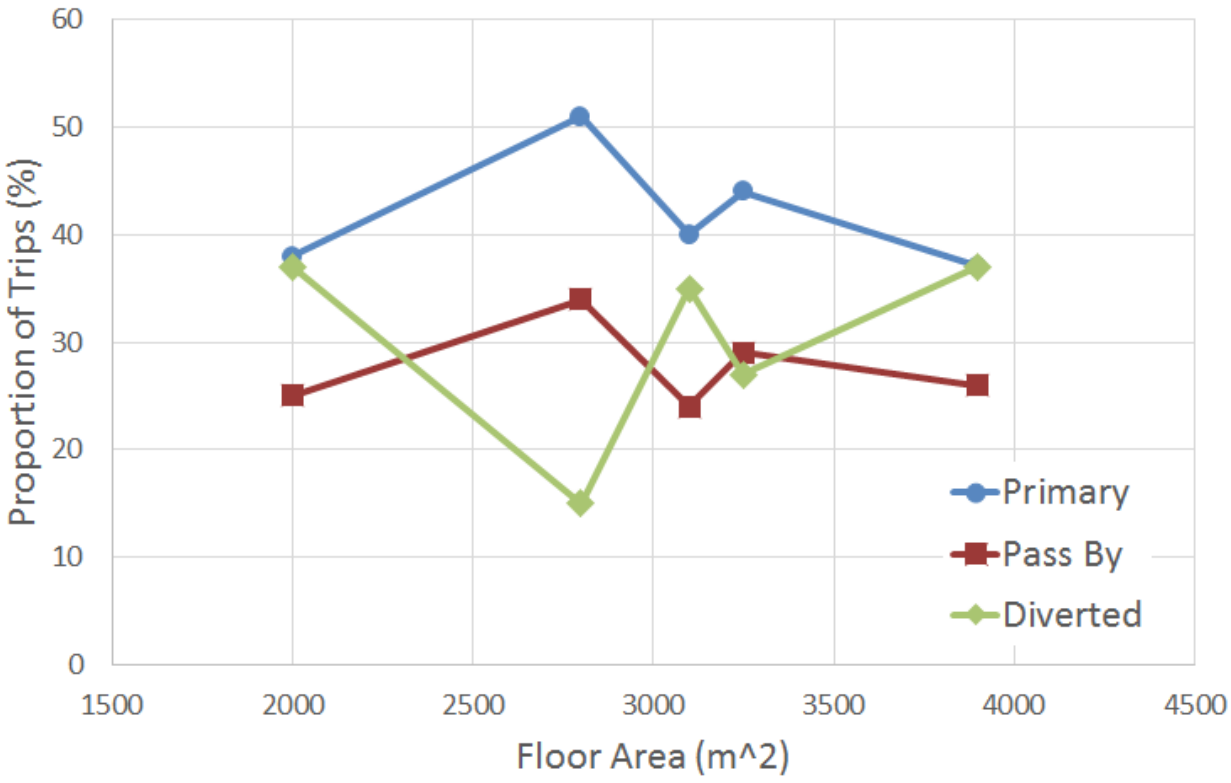

Figure 11: Floor Area of Each Location and their Respective Trip Proportions.

It was found there was no significant relationship between the floor area of the stores and their trip

proportions. This finding was also noted by ITE (2014). They found there was no relationship between stores with floor areas between 2800 m^2 and 6500 m^2. The reason behind a lack of significant relationship is possibly due to all of the surveyed stores being of the same relative size. It would be worth investigating the two extremes of floor area. This could be a corner dairy or convenience store and a much larger shopping mall. Testing that relationship might begin to show a trend. It would also be worth gathering more data points. Currently there are only five data points, which does make it difficult for an accurate conclusion to be made.

An alternative theory could be that different factors are cancelling out any effect of floor area on trip proportions. For example, a larger supermarket (especially with other adjacent shops) is likely to be seen by more shoppers as a "destination" store (i.e. for primary trips), thus reducing the proportion of diverted trips. However, such a store may also be likely to be located further away from many shoppers (being relatively fewer in number), thus increasing the proportion of diverted trips.

4. DISCUSSION

The survey method used worked well to gather the required information. There was minimal disruption to both the participants and the supermarkets that the surveys were carried out at. While carrying out the surveys, it was found that the people entering the supermarkets would come in waves. This made it difficult to interview every person. It was found that it was only possible to approach about 20% of the customers during the peak hour using two surveyors. As a result, the survey process took longer than expected, as it was not possible to talk to everyone and thus decreased the efficiency of the survey.

From the analysis of the results, there was seen to be a large number of factors possibly contributing to the primary, pass-by and diverted rates for the supermarkets. The proportions of trip types by location shown in Figure 5 displayed the different characteristics of trip types for each supermarket. Deeper analysis into the individual locations provided potential reasons for these differences.

A clear trend was seen between the diverted trip rate and the proximity to the nearest alternate major road. Diverted trip rates tended to increase the closer that the supermarket was to the nearest major road. This suggested that people were less inclined to travel large distances out of their way to go to a particular supermarket.

Distances to competing supermarkets also appeared to play a role in the primary, pass-by and diverted trips. Location 2 did not have many competing supermarkets nearby, unlike the other locations, which all had numerous competitors within a short distance of the location. Location 2 also displayed very different trip rates to the other locations, with its proportion of primary trips being 51%, significantly higher than the location with the second highest primary trip rate of 44%. This suggests that the primary trip rates were higher for the more isolated locations as the options for people to do their shopping were very limited.

Time of day also played a role in the proportions of primary, pass-by and diverted trips. Primary trips were found to be significantly higher for the weekend peak period. This was possibly due to the fact that people have more time to do their grocery shopping during the weekend. Unsurprisingly, the pass-by proportion was found to be greatest during the weekday peak period. This was likely the result of people stopping on their way home from work to pick up a few supplies. Relative to pass-by trips, the diverted trips remained reasonably consistent for all time periods surveyed. Diverted trips were slightly lower for the weekend peak time period but this was more a result of the increase in primary trips.

The only factor analysed that did not appear to affect the primary, pass-by and diverted trip rate was the size of the supermarket. It was expected that as the floor area increased, the proportion of primary trips would also increase. This was thought because people may tend to head to larger store to do their large weekly grocery shop. Conversely, stores with a small floor areas would

possibly have a higher proportion of pass-by trips as people might just pop in and pick up one or two items. However no correlation was found between the size of supermarket and the trips that the supermarket generated. It is possible that this is the case as this finding does agree with what is shown in the *Trip Generation Handbook* (ITE, 2014). However, it could also be the result of the small sample of locations that were surveyed and so a correlation between floor area and trip proportions for supermarkets should not be ruled out.

The one exception to most of the findings was Location 5. People were willing to go out of their way to specifically get to this supermarket. This was the result of Location 5 being a discount price store and suggests that the type of supermarket is definitely a factor when considering the primary, pass-by and diverted trips generated.

The results found in this study were compared to results previously observed by the ITE. Table 2 shows the comparison between the results observed during the weekday peak with what had previously been found by the ITE for the same time period.

Table 2: Comparison of Weekday Peak Period

Weekday Peak	Christchurch Results	ITE 2014 Results
Average Primary	34%	34%
Average Pass-By	34%	37%
Average Diverted	32%	29%

Table 2 shows strong similarities between the collected data and the ITE data. This suggests that results found by the ITE for weekday peak times may be applicable to a New Zealand setting and vice versa.

The same comparisons were then made for the weekend peak time period as shown in Table 3.

Table 3: Comparison of Weekend Peak Period

Weekend Peak	Christchurch Results	ITE 2014 Results
Average Primary	52%	39%
Average Pass-By	24%	35%
Average Diverted	24%	26%

It can be seen that the ITE results had much lower primary trip rates and significantly higher pass-by trip rates. More data would need to be collected in the New Zealand context in order to determine whether these results will converge. If they do not converge, this would indicate that New Zealand supermarkets may have different trip proportions and that ITE results may not be applicable for the weekend peak time in this setting.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Interview surveys were conducted in order to obtain data on supermarket customer travel habits. This data was used to analyse the primary, pass-by and diverted trips generated by five different supermarkets in Christchurch. Three different times were analysed; weekday peak, weekday off peak and weekend peak.

The results that were found through surveying multiple supermarkets suggested that there are many factors that contribute to the primary, pass-by and diverted trip rates of locations.

It was found that the time period of surveys had an effect on the results. Pass-by trips were found to be the highest during the weekday peak with 34 % of the total trips being pass-by. The weekend

peak showed that more than 50 % of the trips made were primary trips.

The distance of supermarkets to the nearest major road was seen to affect the diverted trip rates generated. As distance to the nearest alternate route increased, diverted trips were found to decrease.

Distance to competing supermarkets also had an effect on diverted trips. If a supermarket was isolated from its competitors, its proportion of diverted trips would be expected to be lower than average. The primary trip proportion would also be expected to increase.

The type of supermarket was found to affect the trip proportions. This was shown by Location 5 which was a discount price store and contrasted some of the results. People would tend to head out of their way to specifically go to this store

When analysing the effects of the floor area it was found that there was no significant relationship between floor area and trip proportions. It was hypothesised that, as the floor area increased, so would the number of primary trips. This however was not the case for the small number of locations surveyed.

As there has not been a lot of previous analysis of primary, pass-by and diverted trip generation, it is suggested that more data should be acquired on the subject to either confirm or contrast the results found.

5.2 Recommendations on survey techniques

Overall the survey method worked well. Participants found it easy to understand and it caused them very little inconvenience due to the short time that it took. Seeing this, people were happy to undertake the surveys which made it easy to collect the data that was required.

If this survey method was to be used in the future, and a large sample in a limited time is desired, it would be recommended that 3 – 4 surveyors were used. This would allow for two surveyors per door as many supermarkets had two entrances.

Other land uses such as petrol stations and fast food restaurants could be investigated in the same manner. This would provide a deeper understanding of pass-by and diverted trips as a whole.

6. ACKNOWLEGEMENTS

We would like to acknowledge industry professionals Dave Smith (Abley Consultants) and Stuart Woods (NZTA), representatives of the NZ Trips Database Bureau, for providing their advice and assistance on various aspects of the project.

7. REFERENCES

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8. APPENDICES

Appendix A: Chi-Square Test of Location 2 against Average of other locations

	Average (excluding Location 2)	Location 2	Totals
Primary	40 (45.50) [0.66]	51 (45.5) [0.66]	91
Pass-by	26 (30.0) [0.53]	34 (30.0) [0.53]	60
Diverted	34 (24.5) [3.68]	15 (24.5) [3.68]	49
Totals	100	100	-
p-value	0.007583		

Appendix B: Chi-Square Test of Location 4 against Time

	Peak	Off Peak	Weekend	Totals
Primary	15 (19.71) [1.12]	23 (21.90) [0.06]	22 (18.39) [0.71]	60
Pass-by	18 (13.14) [1.80]	11 (14.60) (0.89)	11 (12.26) [0.13]	40
Diverted	12 (12.15) [0.00]	16 (13.50) [0.46]	9 (11.34) [0.48]	37
Totals	45	50	42	-
p-value	0.226838			