UNDERSTANDING AND MANAGING WEEKEND TRAFFIC CONGESTION

Dr Carolyn O'Fallon and Dr Charles Sullivan

ABSTRACT

Weekend traffic congestion in the major urban centres in New Zealand has increased to the point where it is viewed as rivalling the weekday peak period commuting times. Regional and local government policy makers and planners are considering what action should be taken to manage weekend traffic. However, apart from alcohol and crash data analysis, very little study has been done internationally or in New Zealand to understand weekend travel behaviour and how to manage it.

In this initial investigation, we have analysed data from the 1997/98 New Zealand Household Travel Survey for the three main urban centres (Auckland, Wellington, and Christchurch) to identify the characteristics of weekend travel patterns compared with weekday travel behaviour. The variables considered include age, gender, mode, journey purpose, household characteristics, and vehicle occupancy, among others.

Based on the characteristics of weekend travel patterns and other research efforts, we discuss how managing weekend traffic congestion may differ from managing weekday traffic congestion and assess several possible policy tools for their suitability to address weekend congestion.

INTRODUCTION

Apart from alcohol and crash data analysis, very little or no study of weekend travel patterns has occurred in New Zealand, despite growing concerns that weekend traffic congestion in the major urban centres in New Zealand has increased to the point that regional and local government policy makers and planners may be forced to consider what action should be taken to manage weekend – especially Saturday – traffic.

Using data from the 1997/98 New Zealand Household Travel Survey (NZTS) for the three main urban centres (Auckland Wellington, and Christchurch), we have undertaken an initial investigation to describe the characteristics of Saturday and Sunday travel patterns compared with weekday travel behaviour. Based on these characteristics, we are able to discuss how managing weekend traffic congestion differs from managing weekday traffic congestion and provide a preliminary assessment of several possible policy tools for their suitability to address weekend congestion.

METHODOLOGY

We extracted from the 1997/98 New Zealand Household Travel Survey data concerning the three largest urban areas in New Zealand (Auckland, including Waitakere City, North Shore City, and Manukau City; Wellington, including the cities of Upper Hutt, Lower Hutt, and Porirua; Christchurch). Apart from being the areas in New Zealand with the greatest congestion problems and most extensive PT networks, these cities are also the ones for which we recently completed stated choice studies. Only data from respondents completing all travel survey interview forms was used.

In total, the dataset concerns 41,479 trip legs made by 4317 respondents (2293 in Auckland, 839 in Wellington, 1185 in Christchurch). Each respondent answered questions concerning two consecutive travel days; hence 1939 provided data about weekend trips (670 of these providing data about both Saturday and Sunday).

Based on our analysis of available overseas literature – there has been very little study of weekend travel patterns internationally – we determined that it would be appropriate to consider travel patterns on Saturday and Sunday separately, rather than as "weekend", because other studies (for example, Rutherford et al. 1997) have found that there are significant differences between these two days as well as between these days and weekdays.

The analysis focuses on "trip legs" or "trips" rather than a "trip chain" (Rutherford et al. 1997) or "journey" (NZTS). A "trip leg" (often reported simply as a "trip") is recorded each time travel is interrupted, whether it is to drop off / pick up someone, buy a newspaper, change modes, etc. Rutherford et al. (1997) review several international studies and concluded that a useful definition of a "trip chain" is that it may include one or several "trip legs" and is "broken" when an individual remains at a stop for 90 minutes or longer. By contrast, the NZTS definition of a journey makes no reference to how long an individual remains at a stop, instead only allows changing modes as the identifier for an incomplete trip chain. Future work will include a substantial effort to re-define the NZTS dataset to create the ability for trip chain analysis.

Given that the focus of our research is not on safety, but rather on contrasting Saturday and Sunday travel with the more common focus on weekday commuting, our definition of the weekend excludes Friday evening. In keeping with the definition of travel day in the NZTS, Saturday and Sunday are defined as being from 4 a.m. on Saturday through to 4 a.m. on Monday.

While the current NZTS dataset is now reasonably "old" (being compiled in 1997/98), it is important to note that the survey is in the process of being established as a continuous survey from 2003, so that analysis at this stage will provide a useful reference point for future monitoring of travel pattern trends.

ANALYSIS

Our analysis contrasts Saturday and Sunday patterns with weekday travel behaviour in order to be able to assess what types of policy tools could be available to decision-makers to manage weekend traffic congestion. The following sections describe the results of this comparative analysis.

Demographics and other personal characteristics

A comparison of the basic descriptors for weekend and weekday, in terms of share of trips, shows that they are very similar for the following characteristics:

- Gender
- Age
- Ethnicity (although there are slightly fewer Europeans in weekend sample)
- Household type
- Number of people in household
- Personal and household income.

Volume of travel

Before focusing on the different structure of travel between weekdays and the weekend, we summarise the main differences in the volume of travel. Fewer trip legs are made in the

weekend[1], particularly on Sundays (Table 1). However, this does not automatically translate into less kilometres of travel, because the typical length of a trip leg is longer in the weekend (median distances are reported first rather than means to avoid the potentially misleading influence of a few extreme values up to 1000 km).

To quantify the total travel of interest, taking into account both the number of trip legs and distance, we calculated a total daily distance using "surface transport" for each respondent. “Surface transport” excludes air travel (which is not of interest given our focus on urban congestion) and walking (because the distances for walking are not present in the database supplied). We also excluded the small number of other trip legs with distances 60 km or more. This was not just because extreme values might have a misleading impact on means calculated, but also because trip legs of this length will usually involve travel outside the three main urban areas under study[2]. Using this measure, Sunday showed less travel than the other days of the week (Table 1). Saturday showed as many kilometres of travel as weekdays despite fewer trip legs, but Sunday showed fewer. The Sunday differences with respect to distance **driven** are even greater (in part because higher occupancy rates in the weekend do not contribute to distance driven).

Table 1 Volume of travel

	Weekdays	Saturday	Sunday
Unweighted sample size	*3649*	*1272*	*1337*
Number of trip legs (mean per respondent)	5.2	4.4	3.6
Distance, excluding walking (median km **per trip leg**)	4.0	4.4	4.8
Distance using surface transport, excluding walking and trip legs 60+ km or more (mean km / day per respondent)	26.6	26.3	22.7
Distance driven (mean km / day per licensed driver)	30.2	26.4	19.8
Distance driven (median km /day per licensed driver)	20.4	12.9	5.5

The frequency of trips across days of the week and the mean trip leg lengths for all modes is discussed in more detail in the following two sections.

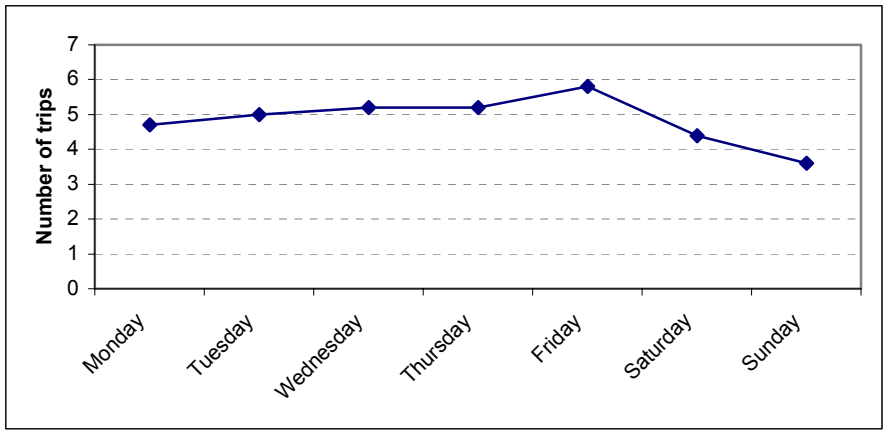
Number of trips

As shown in Figure 1, the number of trips per person has a discernable pattern, starting from a mean of 3.6 trip legs on Sundays, and increasing steadily through the week to a high of 5.8 trip legs on Fridays. Saturday shows the slacking off in number of trips, being more similar to the trip making frequency of a Monday or Tuesday. In terms of trip frequency, Sunday appears to remain a “day of rest” vis-à-vis the rest of the week.

[1] Given the large sample sizes involved, it is relatively obvious that the marked differences highlighted in the text will be statistically significant. Such intuition is confirmed by approximate tests comparing these means. These yielded t-values of 6.82, 6.60, and 15.41 (p<0.0001 in each case) comparing weekdays versus Saturdays, Saturdays versus Sundays, and weekdays versus Sundays respectively. These tests are approximate because it was not worth taking account of the extent to which some respondents were included both in the weekday and Saturday means etc, nor to deal with the post-stratification weighting in detail (beyond using unweighted sample sizes for significance tests), nor to deal with the clustering of respondents into households.

[2] Note that only 298 of the 32,824 non-walking trip legs had distances greater than 60 km, i.e., fewer than 1% were excluded, and 25 of these trip legs involved air transport).

Figure 1 Number of trips per person by day of travel



This pattern of trip-making (i.e. the average number of trips made on Saturday and Sunday are about 86% and 69%, respectively, of the average number of trips made on a weekday) is clearly reflected in the vehicle counts on both urban arterials, state highways and even suburban roads in the major urban centres. Unpublished vehicle count data collected for one week periods in 2001 for major urban arterials and state highways in Wellington region shows that mean Saturday traffic volumes are about 90% of the average weekday traffic flows, and in several cases (in the CBD and the suburbs of Newtown and Karori) are exceeding weekday traffic flows. Sunday vehicle counts are much lower, with flows approximately 73% (urban arterials) and 82% (state highways) of average weekday flows. In Christchurch, Christchurch City Council vehicle counts in 1999 for 3 significant suburban roads display similar trends (Paul Cottam, personal communication, 17 May 2001).

Trip purpose

The purpose of trip legs varies significantly between the weekdays and the weekend. There is very little variation in the trip purpose between Saturday and Sunday. As might be expected, Table 2 shows that the greatest number of trips to work and education occur on weekdays, while social/recreational and shopping trips take precedence on the weekend. Other trip types are reasonably constant.

Although "work" and "education" as the stated purpose for a trips leg is only 22% of the *total* weekday trips, there will be an equivalent percentage of work to home trips and some share of the "change mode" trips will undoubtedly be work- or education-related. This implies that upwards of 45% of weekday trips will be part of the home-work/education-home round trip, whereas the comparable figure on weekends is around 10%.

Table 2 Purpose of trip leg by day of travel

		Total	Weekday	Saturday	Sunday
	Unweighted Count	*N=41479*	*N=31007*	*N=5664*	*N=4808*
Purpose of trip leg	Home	29.5%	28.4%	32.4%	33.8%
	Work	14.4%	17.4%	5.3%	3.3%
	Education	3.7%	4.7%	.2%	.1%
	Shopping	10.7%	9.2%	17.2%	14.2%
	Personal business/services	5.3%	5.7%	3.9%	4.3%
	Social/recreational	17.0%	13.4%	26.7%	30.9%
	Change to another mode	9.1%	10.1%	6.1%	5.1%
	Accompanying someone else	10.3%	11.0%	8.1%	8.3%
	Left country	.0%	.0%	.1%	.0%
Total		100.0%	100.0%	100.0%	100.0%

Not surprisingly, the purpose of the trips varies by the time of day – on weekdays, over one-half (53%) of trips before 7:30 a.m. are for work and a further 16% are to "change mode" (presumably often on the way to work or education). Only 6% are social/recreational trips. By contrast, Table 3 shows that about one-third (33%) of the Saturday morning trips before 7:30 a.m. are for work, while 24% are social/recreational and 8% are to change mode. Between 7:30 and 9:00 a.m., on weekdays, 30% of trips are to work and 24% are to education while on Saturday, 19% are to work and 26% are for social/recreational purposes. Shopping trips on Saturday are spread throughout the shopping day (7:30 a.m. to 6:00 p.m.), with a slight peak between 9 a.m. and 12 noon, while on weekdays there is a marked peak between 9:00 a.m. and 3 p.m.

Table 3 Variations in trip purpose between weekdays and Saturday[a]

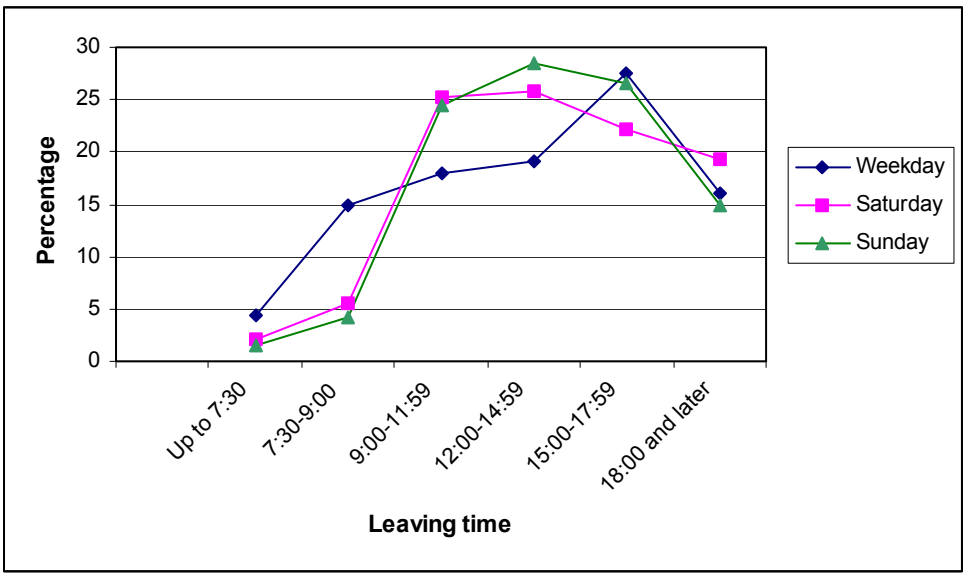
	Before 7:30		7:30 –9 a.m.	
Trip leg purpose	**Weekday**	**Saturday**	**Weekday**	**Saturday**
Work	53%	33%	30%	19%
Education	3%	0%	24%	1%
Change mode	16%	8%	13%	5%
Social/recreational	6%	24%	6%	26%
Shopping	4%	9%	3%	15%

[a] Percentages do not add up to 100 because only trip purposes showing key differences are shown.

Time of travel

The timing of trips varies considerably between the weekdays and weekend. Figure 2 shows that nearly one-fifth (19%) of all weekday trips occur before 9:00 a.m. as compared with 8% on Saturday and 6% on Sunday. Over one-half (51% on Saturday and 53% on Sunday) of weekend trips depart between 9 a.m. and 3 p.m. while just over one-third of weekday trips (37%) occur during this period. On weekdays and Sunday, there is a marked difference between late afternoon (between 3 and 6 p.m.) and evening trips, while on Saturday, there is a more even distribution of trips between late afternoon and the evening (after 6 p.m.).

Figure 2 Time of travel (leaving time) by day of travel



These differences in trip making habits mean that the early morning and late afternoon peak traffic periods experienced on the weekdays are absent on the weekend. Instead, the traffic flow is concentrated between 9 a.m. and 3 p.m., when over 50% of trips are undertaken. This time period and volume of traffic is comparable to the two periods of peak traffic flows on weekdays (up to 9 a.m. and between 3 and 6 p.m.), which together incorporate approximately 47% of all trips each day. As such, it corroborates the impression that weekend traffic congestion occurs throughout the day.

The urban arterials and state highway vehicle count data collected in 2001 for Wellington region also provides information on the "peak" traffic periods for each day of the week (J. Row, Greater Wellington RC, personal communication, April 17, 2003). On the weekdays, there are two 2-hour periods identified in Table 4, while for Saturday and Sunday there is one 4-hour period. As can be seen from the table below, these periods coincide almost exactly with the trip making patterns identified in the NZTS data.

Table 4 Peak traffic periods by day of week in Greater Wellington

Time period	Road type	Weekday	Saturday	Sunday
Busiest 2-hour morning period	Urban arterial	7:30-9:30		
	State highway	7:00-9:00		
Busiest 2-hour afternoon period	Urban arterial	16:00-18:00/15		
	State highway	16:00-18:00		
Busiest 4-hour period	Urban arterial		10:45-14:45	12:00-16:00
	State highway		11:00-3:00	13:00-17:00

Approximately 32% of the 24-hour traffic flow occurs during the 4-hour "peak" period on Saturday – similar to the 31-33% that occurs during the 4-hours of peak flow (2-hour morning and 2-hour afternoon peak periods) on weekdays.

Trip mode

The proportion of trips by "vehicle driver" is constant between weekends and weekdays, although a small decrease (5%) occurs on Sunday. As is seen in Table 5, most other modes (i.e. vehicle passenger, public transport, and walking) experience quite substantial shifts between the weekdays and weekend. Only cycling shows similar levels of use on the weekend as weekdays.

Cyclists are generally under 25 years old – 50% of cycling trips on weekdays are undertaken by 15-24 year olds and 26% by 0-14 year olds. On the weekend, there are a few more people older than 25 who cycle, possibly for recreational and health reasons.

Table 5 Trip mode share by day of travel

		Total	Weekday	Saturday	Sunday
	Unweighted Count	*N=41479*	*N=31007*	*N=5664*	*N=4808*
Travel mode	Vehicle driver	47.8%	48.3%	48.1%	43.1%
	Vehicle passenger	24.5%	21.3%	32.0%	38.1%
	Walk	22.3%	24.2%	16.5%	15.8%
	Bus & train	3.0%	3.5%	1.4%	1.0%
	Cycle	1.6%	1.8%	.9%	.9%
	Other	.9%	.8%	1.0%	1.0%
Total		100.0%	100.0%	100.0%	100.0%

Walking as a mode of transport declines by nearly one-third at the weekend, while the public transport mode share declines from 3.5% to 1% on weekends. It is quite likely that the decline in walking and public transport use are linked, as many or even most public transport trips would have an associated walking component.

Given that vehicle drivers remain fairly constant over the week, the shift from walking and public transport use is primarily to "vehicle passenger", which increases by more than 50% at the weekends, from 21% to 32% on Saturday and 38% on Sunday.

Mode share by city

There is significant variation in mode share between the three cities. "Vehicle driver" is the dominant mode in all three cities, although on weekdays in Wellington car drivers account for 40% of all trips, compared with 51% in Auckland and Christchurch. Walking is more common on weekdays in Wellington (32% compared with 22% elsewhere) as is public transport use (6% compared with up to 3% elsewhere).

As can be seen from Table 6, cycling is fairly constant throughout the week and weekend in Christchurch as compared with Auckland and Wellington while public transport use remains consistently higher (although at low overall levels) in Wellington than the other 2 urban centres. The proportion of vehicle drivers is higher on Saturday in Auckland than elsewhere, although the levels are similar in the 3 cities on Sunday.

Table 6 Mode share by city and day of travel

		Total	Auckland			Wellington			Christchurch		
			Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday
	Unweighted Count	*N=41479*	*N=15673*	*N=2643*	*N=2279*	*N=6354*	*N=1278*	*N=1082*	*N=8980*	*N=1743*	*N=1447*
Travel mode	Vehicle driver	47.8%	50.8%	50.3%	43.7%	39.4%	45.7%	42.5%	50.9%	45.4%	41.9%
	Vehicle passenger	24.5%	22.9%	33.7%	39.4%	17.8%	27.3%	39.0%	20.5%	33.0%	33.7%
	Walk	22.3%	21.7%	13.8%	14.7%	32.8%	22.3%	14.1%	22.3%	16.6%	20.8%
	Bus & train	3.0%	2.9%	1.2%	.9%	6.0%	2.8%	1.4%	2.5%	.5%	1.0%
	Cycle	1.6%	1.1%	.4%	.2%	2.7%	.0%	1.5%	2.9%	3.4%	2.5%
	Other	.9%	.6%	.6%	1.1%	1.3%	1.9%	1.5%	1.0%	1.1%	.1%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The variation in mode use and mode share between the cities undoubtedly reflects the differing natures of the cities involved. Auckland is the least centralised, with a relatively low proportion of jobs in its central business district (CBD) and a lower (albeit increasing) population density; Wellington is the most centralised city with the highest proportion of jobs in the CBD and

highest population density; and Christchurch has a distinctively flat topography, encouraging extensive bicycle use (see key background facts in Table 7). The centralised nature of Wellington also facilitates the provision of public transport services that go where the potential users want to be.

Table 7 Key facts about urban areas

	Auckland	Wellington	Christchurch
Cities included	Auckland, North Shore, Waitakere, Manakau	Wellington, Lower Hutt, Upper Hutt, Porirua	Christchurch
Topography	Mixed	Hilly around main CBD; flat in Hutt Valley	Distinctively flat
Population*	1,074,507	339,747	334,104
Proportion of jobs in CBD**	14%	22%	17%
CBD population density (persons/ha)**	9.6	14.2	6.0

* Population figures from the 2001 Census (Statistics New Zealand, 2003).
** 1996 result from Bachels, Newman and Kenworthy (1999), p 55.

Vehicle trip characteristics

Number of household vehicles

The number of vehicles present in a given household also explains some of the variation in mode use and mode share. Households without any motor vehicles (approximately 6% of the population), not surprisingly, have the highest proportion of people making walking and public transport trips on the weekdays and weekend and the greatest share of cycling trips on weekdays.

Generally, Table 8 shows that the greater the number of vehicles available to a household, the less walking, cycling and public transport trips – and the more vehicle driver trips – occur within the household, irrespective of the day of travel.

Table 8 Number of household vehicles and trip mode by day of travel

				Number of household vehicles				
Day of travel			Total	None	1	2	3	4 or more
Weekday		*Unweighted Count*	*N=31007*	*N=1590*	*N=8016*	*N=13595*	*N=5349*	*N=2457*
	Travel mode	Vehicle driver	48.3%	1.5%	42.0%	51.5%	59.3%	64.2%
		Vehicle passenger	21.3%	15.4%	22.5%	22.7%	19.8%	17.3%
		Walk	24.2%	61.3%	28.9%	20.7%	17.1%	15.1%
		Bus & train	3.5%	12.7%	3.7%	2.8%	2.5%	1.9%
		Cycle	1.8%	5.8%	1.9%	1.9%	.7%	.7%
		Other	.8%	3.2%	1.0%	.5%	.5%	.8%
	Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Saturday		*Unweighted Count*	*N=5664*	*N=204*	*N=1587*	*N=2774*	*N=790*	*N=309*
	Travel mode	Vehicle driver	48.1%	10.4%	43.9%	51.0%	61.0%	64.4%
		Vehicle passenger	32.0%	20.6%	33.2%	34.4%	30.5%	16.5%
		Walk	16.5%	61.2%	18.8%	12.0%	6.5%	15.3%
		Bus & train	1.4%	3.8%	2.2%	.8%	1.1%	.0%
		Cycle	.9%	2.0%	1.3%	.8%	.2%	.5%
		Other	1.0%	2.1%	.7%	1.0%	.6%	3.2%
	Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Sunday		*Unweighted Count*	*N=4808*	*N=154*	*N=1463*	*N=2296*	*N=506*	*N=389*
	Travel mode	Vehicle driver	43.1%	1.9%	37.5%	44.7%	53.9%	59.0%
		Vehicle passenger	38.1%	37.3%	39.9%	39.4%	29.2%	34.0%
		Walk	15.8%	54.5%	19.1%	13.5%	13.5%	4.8%
		Bus & train	1.0%	4.4%	1.6%	.5%	.6%	1.3%
		Cycle	.9%	1.2%	.9%	.9%	1.3%	.5%
		Other	1.0%	.8%	1.0%	1.0%	1.4%	.4%
	Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Not surprisingly, the proportion of trip legs involving vehicles owned by companies dropped on Sundays[3] (14.3% weekdays, 12.7% Saturdays, 10.2% Sundays), and trips in vehicles other than those owned by household member or companies (probably often owned by friends and family outside the household) nearly doubled (7.9% weekdays, 12.0% Saturdays, 14.6% Sundays).

Vehicle occupancy

Given the significant increase in the "vehicle passenger" mode share from weekdays to weekend, it is not surprising to find that there is a corresponding increase in vehicle occupancy. The proportion of "driver only" or single occupancy vehicles decline from 68% on weekdays to 54% on Saturday and further to 47% on Sunday. At the same time, the number of vehicles with 2 people increases from 20% to 31% on Saturday and 32% on Sunday. Table 9 reveals that there are also increases in the proportion of vehicles with 3 or more people (including the driver). Overall, the *mean* vehicle occupancy increases from 1.5 on weekdays to 1.7 on Saturday and 1.9 on Sunday[4].

Table 9 Vehicle occupancy (including driver) by day of travel

		Day of travel		
	Total	Weekday	Saturday	Sunday
Unweighted Count	*N=19763*	*N=15103*	*N=2643*	*N=2017*
1	64%	68%	53%	47%
2	23%	20%	31%	32%
3	8%	8%	8%	12%
4	4%	3%	5%	7%

[3] As an illustration, a rough significance test was calculated on this difference which is less marked than most others highlighted in the text. Statistical tests were not performed directly on these percentages because many of the trips are by the same person, violating the usual requirement of independent trials. Again this test was only approximate as explained in an earlier footnote, in addition to a further irregularity in the distribution relevant to this particular test. For each respondent (where applicable, depending on the days of the week they responded for), we calculated the proportion of their vehicle trips using household vehicles owned by companies separately for weekdays, Saturdays, and Sundays. The mean proportion for Sundays was significantly lower than the mean proportion for weekdays, $t(4982)=2.3$, $p=0.02$.

[4] These occupancy rates differ slightly from those in our paper focused on occupancy at this conference (Sullivan & O'Fallon, 2003). Among other modifications, calculations throughout that paper use a different weighting, incorporating distance.

5 or more		2%	1%	3%	2%
Total		100%	100%	100%	100%
	Mean	1.6	1.5	1.7	1.9

Children under 15 are more often car passengers than any other age group, irrespective of the day of travel (children are 52% of passengers on weekdays, 44% on Saturday and 35% on Sunday). This is true even though a greater proportion of children's *total trips* on the weekend are as vehicle passengers. Their lower share of passenger trips on the weekends, relative to other age groups, reflects the overall increase, across all age groups, in vehicle occupancy on weekends.

Vehicle occupancy rates are much higher between the hours of 9:00 to 6:00 on the weekend (approximately 45% of vehicles on Saturday and more than 55% on Sunday have 2 or more people in them) than they are on weekdays (about 30% have 2 or more). On Saturday, the occupancy rate peaks in the evening, as it does on weekdays – on the weekdays, the proportion of vehicles with 2 or more people in them is lower (40% compared with 58% on Saturday).

Parking

As is to be expected from the different destinations typically sought in the weekend, vehicle drivers used different parking places. Specifically, parking off-street on resident's property increased from 35.3% (weekdays) to 40.9% and 45.2% (Saturdays and Sundays respectively), whereas parking off-street in other private areas such as business premises fell from 28.3% (weekdays) to 20.4% and 18.5% (Saturdays and Sundays respectively).

Gender

There are significant differences between the genders in their modal use by day of travel. On weekdays, the mode use by men and women is very similar, with women somewhat more likely to be vehicle passengers and men more likely to be vehicle drivers. However, Table 10 shows there is more divergence in mode use on the weekend. Although both genders display some similar trends in modal shifts between weekdays and weekends, such as less walking, less use of public transport and greater proportion of trips as vehicle passengers, there is a sizable change in *who* drives on the weekend as compared to the weekdays.

Table 10 Gender differences in travel modes by day of travel

		Total	Weekday		Saturday		Sunday	
			F	M	F	M	F	M
	Unweighted Count	*N=41479*	*N=16359*	*N=14648*	*N=2890*	*N=2774*	*N=2488*	*N=2320*
Travel mode	Vehicle driver	47.8%	44.9%	51.9%		59.9%	32.2%	54.7%
	Vehicle passenger	24.5%	**23.8%**	18.7%		20.6%	**49.6%**	25.8%
	Walk	22.3%	26.2%	22.2%	16.6%	16.4%	15.3%	16.4%
	Bus & train	3.0%	3.7%	3.2%	1.7%	1.1%	1.5%	.5%
	Cycle	1.6%	.6%	3.1%	.8%	1.0%	.2%	1.7%
	Other	.9%	.8%	.9%	1.1%	1.0%	1.1%	.9%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

On the weekend, males switch from walking and public transport to vehicle driver or passenger, although not as extensively (especially on Sunday) as females switch from walking, public transport *and driving* to become vehicle passengers (refer Table 10). The latter change is quite remarkable: female trips as passengers double from the weekdays from 24% to 43% on Saturday and 50% on Sunday while their share of vehicle driver trips falls from 45% to 36% on Saturday and 32% on Sunday.

IMPLICATIONS FOR POLICY

Vehicle count data for a sample of roads in Christchurch and Wellington provide evidence that Saturday traffic volumes – and congestion – have been increasing to the point where they are close to or exceed weekday volumes at their peak. Sunday traffic volumes have not (yet) reached the same congested levels as weekdays or Saturday. Given that the weekend is only 2 more days of the week, it could be assumed that transport planners and policy-makers seeking to alleviate weekend traffic conditions (particularly Saturday) would first consider applying some of their current "weekday" travel demand management tools to the situation. However, there are some fundamental differences between weekdays and Saturday and Sunday in terms of travel behaviour and traffic patterns:

- *Trip timing:* The bulk of weekend trips (50% or more) are undertaken between 9 a.m. and 3 p.m. On the weekdays, the bulk of trips occur in the early morning and late afternoon peak periods
- *Trip purpose:* Shift from work and education on weekdays to social/recreational and shopping on weekends
- *Kilometres driven:* fewer trips are made on the weekend, with the overall effect that number of kilometres driven declines substantially between the weekdays, Saturday and Sunday
- *Mode choice:* The proportion of trips by drivers is relatively constant between the weekdays and weekend (although there is a change in *who* drives, in that more men drive than women on the weekend). There is a shift from walking, public transport (and, to a lesser extent, cycling) to travelling as a vehicle passenger
- *Vehicle occupancy*: higher on the weekend.

These differences mean that the application of policy tools that have been effective on weekdays may generate some quite different, unintended, results on the weekend. We consider a few of these tools below.

Electronic Road User Charging

The introduction of a charge per kilometre of vehicle travel could have a similar effect on weekend travel as weekday travel, insofar as car drivers may try to reduce their vehicle kilometres travelled in response. However, much will depend on the availability of alternative destinations and/or alternative modes to substitute for driving. Given that there is higher vehicle occupancy on the weekend, implying more people from the same household are going to the same destination, the relative costs of using the car for a trip may be less than on weekdays. Longer weekend trip leg lengths and generally lower public transport availability (in terms of routes and frequency of service – see Table 11) may also mean that alternatives to the car are restricted, unless the destination can be altered.

Cordon Tolls

In recent years, the possibility of cordon tolls to reduce congestion has been part of New Zealand's political agenda, particularly in the three main urban centres where the potential location for a cordon toll has generally been established. In a study of car commuters in Auckland, Wellington and Christchurch, O'Fallon et al. (in press) found that implementing a toll for entering the specified cordon area before 10 a.m. would have some impact on modal split, which was considerably greater in Wellington (8-11% of drivers would shift to other modes) compared with Christchurch (4.5%) and Auckland (2-4.5%). Much depended on *where* exactly people were travelling and their ability to be flexible about the timing and destination of their trips.

The vehicle count data from Wellington region indicates that Wellingtonians drive to the city centre nearly as frequently on a Saturday as they do on a weekday. However, given the nature of trip making habits described above, a cordon toll on Saturday that finished at 10 a.m. would have an almost nil impact on traffic flow in the central city area since the 4-hour peak in

Wellington is 11 a.m. to 3 p.m. Altering the toll schedule for Saturday may be possible, though the impact may not be so much as to encourage the use of alternative modes to the city centre than to encourage trips to alternative destinations, reached by private vehicle travel, outside the city centre.

Thus, if the purpose of the toll is to reduce congestion within the cordoned area, it *may* be successful – however, if the purpose is to reduce greenhouse gas emissions or other pollutants, there may be little or no change as car trips are simply re-directed to other areas. At the same time, central city retailers and services may find their customer numbers falling.

Parking mechanisms

Unless introduced uniformly *throughout a region*, mechanisms to manage parking – such as metered parking at strategic shopping or leisure/recreation destinations or reduced parking availability – may have unintended negative results, due to the facts that proportionately more trips on the weekend are by private vehicle (due to greater numbers of vehicle passengers) and that people are pre-conditioned or prepared to travel further on weekends (as evidenced by the longer trip leg lengths). Unless introduced across a region, the net result could be similar to that for implementing a cordon toll: a "positive" reduction in traffic where there are parking restrictions in place, accompanied by the negative effect of reduced patronage to the businesses and organisations located in the same vicinity.

Without more information about how flexible timing, activity and destination choices are on the weekend, it is difficult to assess the effect of introducing parking mechanisms. In situations where the activity, timing and destination of a trip is reasonably fixed (i.e. trips to work or education on weekdays), O'Fallon et al. (in press) found that parking mechanisms did not have a large impact on mode choice for commuting car drivers, even though alternative modes (i.e. public transport services) are generally more readily available in the main urban centres. The stated choice experiment, involving car drivers commuting to work during the morning peak period in Auckland, Wellington and Christchurch, introduced various on-street parking restrictions (2 hour time limit) or charges (up to $5 per hour) and a surcharge on car parking buildings / lots (up to $10 per day [$5 per day in Christchurch]). Generally, less than 5% of car drivers shifted to another mode / worked from home / etc., when confronted with these mechanisms.

With potentially fewer alternatives to driving on the weekend (i.e. fewer public transport services operating and longer trips potentially mitigating against walking or cycling), there may be even less shifting of modes on the weekend – though the potentially greater flexibility in timing and/or choice of where shopping and social/recreational activities could be undertaken, may result in different destinations being chosen to minimise the impact of parking restraints on an individual or household.

Rideshare

Vehicle occupancy is higher on the weekends compared with weekdays. Thus, attempts to further increase ridesharing or carpooling are not likely to significantly alter Saturday traffic flows and could have even less effect on Sunday. The nature of the trips being made will also influence the potential impact of ridesharing. Overseas experience has found that, to be effective, ridesharing requires "habitual" trip patterns, with large numbers of people seeking a common destination and sharing a similar timetable (Department for Transport, 2002). Generally, work or education trips fit this definition more closely than most leisure, sporting and recreational activities at the weekend. Regular sporting activities (such as soccer or netball) or professional sporting fixtures may lend themselves to ridesharing, but probably only on a casually-organised basis, rather than through a more formalised system.

High occupancy vehicle lanes

Introducing high occupancy vehicle (HOV) lanes to encourage higher vehicle occupancy and to facilitate traffic flows throughout the 7-day week would see a greater number of vehicles

meeting the HOV criteria on the weekend than on weekdays (46% of vehicle trips on Saturday had 2 or more occupants, compared with 32% on weekdays). Investigation of the Puget Sound experience (Washington, USA) found that the trend for higher occupancy on weekends than weekdays persists even when HOV lanes have been in place for some time (Ishimaru et al. 2000). Ishimaru et al. (2000) also found that usage of HOV lanes depends on there being sufficient "congestion" on the other lanes of travel rather than on the number of vehicles qualifying to use such a lane. Generally speaking, in the Puget Sound, there were enough qualifying vehicles at any time to make the HOV lanes as full as general purpose lanes but use of the HOV lane only occurred once the general purpose lane experienced congestion (defined as speeds being restricted and changing lanes requiring care and effort). The net result suggests that re-designating an existing lane as a HOV lane may have a minimal effect on traffic flow and congestion on weekends.

Improved public transport services

Public transport use decreases dramatically on the weekends compared with the weekdays. It may be argued that this is because there are many fewer public transport options on the weekends (see Table 11 for example, which outlines the number of bus routes operating in Greater Wellington by time of day and day of travel).

On the other hand, it is very likely to reflect the differing nature of weekend trip making patterns, such as the shift in trip purposes from travelling to work and education on weekdays to leisure, recreation and shopping trips on the weekends. Proportionately more trips may require carrying equipment for sports or bags of shopping and such like, generally making trips on public transport much more difficult on the weekends. People may not want to be restricted by a "timetable" of public transport services when they engage in leisure, recreational and social activities – private vehicles offer the greatest flexibility and "freedom" to select where to go and what to do there. Furthermore, they are likely travelling to quite different destination on the weekend than the weekday and current service routings may not address these locations well.

Table 11 Number of bus routes operating by time of day and day of week in Greater Wellington[a]
Source: Saku Kunanayagam, Greater Wellington Regional Council (personal communication, 30 April 2003)

Time of Day	Weekdays	Saturday	Sunday
Morning/afternoon peak period[b]	58	21 (day services)	18 (day services)
Daytime – 1-2 services per hour	13	15	17
Daytime – 3 or more services per hour	45	6	1
Evening	19	16	14

[a]Greater Wellington includes Wellington City, Porirua, Hutt City and Upper Hutt.
[b]Morning peak is 7.00 am – 9.00 am and afternoon peak is 3.00pm – 6.00pm. Saturday and Sunday do not have "peak periods"; the number indicated is the number of routes operating during the day until 6 pm.

Increasing the availability of services, providing additional routes, or improving the frequency of services may be proposed as a means of addressing traffic congestion on the weekends. However, O'Fallon et al. (in press) found that, even on weekdays when the destination was well established and routinely attended (i.e. work or place of education), improvements to public transport – including significantly decreasing the fares, improving frequency, routing and/or trip timing – resulted in very few car commuters switching to public transport. It seems highly unlikely that, with fewer trips being made overall on the weekend and to more varied destinations than occurs on weekdays, improving public transport services on their own will entice drivers and passengers out of their cars. If services are improved in conjunction with some "sticks" (for example, electronic road user pricing or parking mechanisms) to affect the cost or convenience of car driving, the outcome may be more positive.

CONCLUSIONS

In this initial investigation, we have analysed data from the 1997/98 New Zealand Household Travel Survey for the three main urban areas of Auckland, Wellington and Christchurch to identify the characteristics of travel patterns on Saturday and Sunday compared with weekdays.

The analysis has revealed several differences in weekday and Saturday and Sunday travel patterns, including divergences in:

- *Number of trips and kilometres travelled:* fewer, longer trip legs – with the fewest and longest occurring on Sunday – are made on the weekend compared with weekdays. This is true across all modes
- *Trip purpose:* there is a lot of variation in trip purpose between the weekdays and weekend, although not between Saturday and Sunday. On the weekdays, nearly 45% of trip legs can be attributed to work and/or education, while on the weekend this figure is around 10%. Social / recreational trips are much more prominent on weekends
- *Time of travel:* The bulk of weekend trips (50% or more) are undertaken between 9 a.m. and 3 p.m. On the weekdays, the bulk of trips occur in the early morning and late afternoon peak periods
- *Mode choice:* The proportion of trips by drivers is relatively constant between the weekdays and weekend (although there is a change in *who* drives, in that more men drive than women on the weekend). There is a shift from walking, public transport (and, to a lesser extent, cycling) to travelling as a vehicle passenger on weekends. Weekday mode choice varies by city, although most of these differences disappear on the weekends, when the mode choice is very similar across all three cities. The exceptions are:
    - In Auckland, the proportion of vehicle drivers is higher on Saturday compared with Wellington and Christchurch
    - Wellington has consistently higher PT use on the weekend
    - Christchurch has consistently higher cycle use on the weekend
    - Walking as a mode choice varies somewhat across the three centres on weekends, with Auckland having the least on both days (14-15%), Wellington having the highest share on Saturday (22%), and Christchurch having the highest on Sunday (21%)
- *Vehicle characteristics:* the greater number of vehicles available to a household, the higher the proportion of vehicle driver trips
- *Vehicle occupancy*: higher on the weekend.
- *Traffic volumes*: additional analysis of traffic counts in Christchurch and Wellington shows that traffic volumes on Saturday are close to or exceeding weekday traffic volumes. Sunday traffic volumes are not yet approaching weekday traffic volumes.

These differences have implications for policy- and decision-makers and transport planners seeking to alleviate weekend – particularly Saturday – traffic conditions. In summary, applying policy tools that have been successful in dealing with weekday traffic congestion to Saturday may result in some quite different, unintended, results on the weekend or may have very little impact.

For example, unless in operation during the middle of the day, (eg from 11 a.m. to 3 p.m.), early morning cordon tolls would have very little effect on traffic entering the central city area. Even if they are operational during the Saturday peak period, it may be that people will simply continue to use their cars, but drive to other locations – thus lessening traffic congestion, but not reducing energy use, greenhouse gas emissions or other pollutants. In addition, central city merchants may lose valuable clientele. Parking mechanisms may have a similar effect, given that people apparently are willing to travel further on weekends and may have more flexibility about their choice of destination than they do on weekdays.

Rideshare programmes are more successful when there are reasonably large numbers of people travelling to the same destination, such as work or a place of study. The more disparate nature of destinations on the weekend does not lend itself well to ridesharing. Similarly, improvements to public transport, on their own, may not find significant modal shift, as people may want to retain their flexibility and "freedom" by using their cars. Given the greater emphasis on social / recreational trips on the weekend, it is possible that different service routings are required than for weekdays

The most successful tool may be the electronic road user charge which affects each kilometre driven, as this will, where possible or feasible, encourage people to drive shorter distances – provided that they do have flexibility in destination choice (which would need to be confirmed with further research). If electronic road user charges were introduced in conjunction with public transport improvements, this may result in more significant modal shift.

Future Research Directions

Based on our analysis, we believe that further investigation is required into the characteristics of the trip purpose or activity, including such things as:

- the nature of shopping or social / recreational trips
- the destination (central or suburban business district, residential area)
- the possible flexibility in the timing or location of an activity
- the growth in weekend travel over time, including the source and nature of growth and establishing future trends.

This would provide a better understanding of the effect of implementing various policy tools.

This initial investigation has focused on trip legs, rather than trip chaining. Understanding trip chaining behaviour is seen by some as "crucial" to understanding individual travel behaviour (Rutherford et al. 1997). We have just begun a project to re-define the NZTS database to create the ability to undertake trip chain analysis and to "prioritise" trip purpose. The differences in travel patterns shown through the trip leg analysis are quite likely to be mirrored in a trip chaining evaluation and other variations may be discovered.

Further investigation may be warranted to determine if there is variation in mode share within different suburbs depending on the availability of public transport services and shops, etc. For example, Rutherford et al. (1997) make a tentative finding that people residing in "mixed use" neighbourhoods, where shops, services and employment were mixed in with residential areas, travelled shorter distances per day than those who did not. In areas where public transport services are available more regularly (i.e. every 15 minutes or more frequently) throughout the weekend day, the effect on the modal mix could be analysed to determine if there are less vehicle trips or if vehicle occupancy is affected. Examination of these factors requires access to a database with sufficient sample sizes of "neighbourhoods" or, at the very least, "suburbs".

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REFERENCES

Bachels, M., Newman, P. and Kenworthy, J. March 1999. *Indicators of urban transport efficiency in New Zealand's main cities: an international city comparison of transport,*

land use and economic indicators. Australia: Institute for Science and Technology Policy, Murdoch University.

Department for Transport. 2002. Making travel plans work – lessons from UK case studies. UK: Department for Transport.

Ishimaru, JM, Hallenbeck, ME and Nee, J. 2000. *Weekend Freeway Performance and the Use of HOV Lanes on Weekends*. Prepared for Washington State Transportation Commission, April 2000 (accessed from USFHWA website on 26 July 2002).

Land Transport Safety Authority. 2000. Travel Survey Report 1997/1998. Wellington, New Zealand: Land Transport Safety Authority.

O'Fallon, C., Sullivan, C. and Hensher, D. (in press). Constraints Affecting Mode Choices by Morning Car Commuters. *Transport Policy* (10).

Rutherford, GS, McCormack, E and Wilkinson, M. August 1997. Travel Impacts of Urban Form: Implications from an analysis of Seattle area travel diaries. *Final Report from Urban Design, Telecommuting and Travel Forecasting Conference: Summary, Recommendations and Compendium of papers.* Accessed on 26 July 2002 from: http://tmip.fhwa.dot.gov/clearinghouse/docs/udes/ .

Statistics New Zealand. 2003. www.stats.govt.nz/census.htm, (accessed 27 March 2003).

Sullivan, C, and O'Fallon ,C. 2003. Vehicle occupancy in New Zealand's three largest urban areas. Submitted to ATRF conference, October 2003, Wellington, New Zealand.