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The Estimation of Demand Parameters for Primary Public Transport Service in Brisbane Attributes

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Abstract

This paper outlines a scenario modelling approach developed for Brisbane that produced parameter and demand elasticities for primary service attributes such as travel times, service frequency and fare.

The parameters were based on a large scale market survey of bus, rail, ferry and car users. The survey used Stated Preference techniques to estimate the sensitivity of travel choice to service interval, travel time and fare. Key outputs were values of travel time and travel choice profiles.

Demand response to changes in fare and travel time was then summarised in terms of a set of demand elasticities. Demand response allowed for diversion to and from car, bus, rail, ferry, walk, cycle, taxi and “not travel”. The potential to over estimate demand response by using “stated” as opposed to “revealed” preferences was addressed by calibrating the parameters on “actual” travel and service level data.

Demand response was then summarised in "own", "cross" and transfer elasticities. For fare, the conditional elasticity was estimated - whereby all public transport fares change by the same amount as well as the unconditional fare elasticity whereby only one public transport fare is changed.

The final section comments on how the demand parameters are being used and draws some conclusions about the modelling approach.

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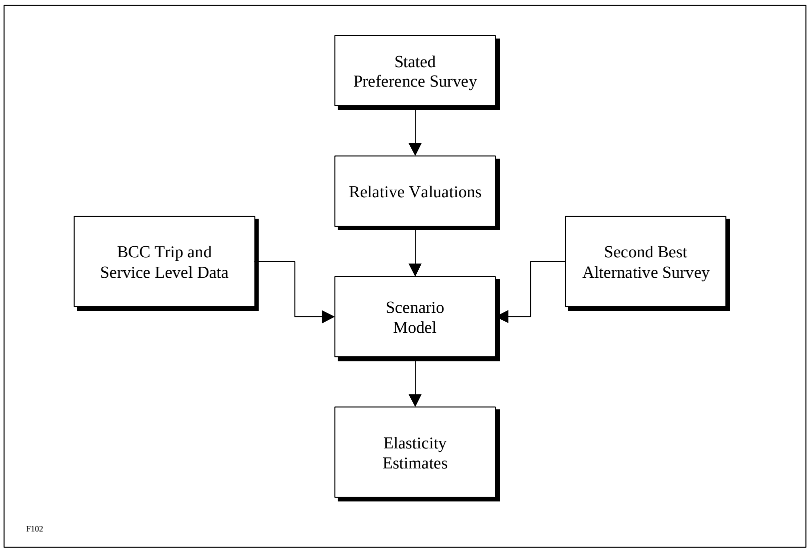
1. Introduction

This paper outlines a scenario modelling approach developed for Brisbane that produced parameter and demand elasticities for primary service attributes such as travel times, service frequency and fare.

The model was based on a large scale market survey of bus, rail, ferry and car users.
The market research involved two surveys: (i) a conventional Stated Preference survey that addressed "conventional" travel choices - bus, rail, ferry and car and (ii) a "Second Best Alternative" survey that widened travel choice to include walk, cycle, taxi and "not travel". Section 2 of the paper summarises the market research.

FIGURE 1: SCENARIO MODEL



Estimated demand response to changes in fare and service level were summarised in a set of demand elasticities. The potential to over estimate-demand response from using stated preferences rather than actual demand response was addressed by calibrating the model on Brisbane City Council (BCC) travel and service level data. Part 3 describes the calibration of the travel choice and the augmentation of the choice set to include walk, cycle, taxi and "not travel".

Demand response was summarised in a set of demand elasticities. For fare, the conditional elasticity was also estimated - whereby all public transport fares are changed by the same percentage amount as well as the more familiar "unconditional" fare elasticity whereby only one public transport fare is changed. Trip and passenger kilometre elasticities were also estimated. Part 4 presents the elasticities commenting on the range in elasticity by corridor.

Values of travel time and demand elasticity estimates are important parameters in the formulation and evaluation of transport plans and policy. Part 5 outlines how the demand parameters are being used and draws some conclusions about the modelling approach.

2. Stated Preference Market Research

Market research surveys were undertaken of bus, rail, ferry and car users in the Brisbane City Council area between November 2000 and June 2001. Two surveys were undertaken: A Stated Preference (SP) survey; and a Second Best Alternative (SBA) survey. The SP survey estimated the sensitivity of bus, rail, ferry and car use to variations in fare, in-vehicle time, service interval and other primary factors. The Second Best Alternative (SBA) survey assessed the relative importance of walk, bicycle, taxi and "not travel" as travel alternatives.

A total of 3,206 SP interviews of rail, bus, ferry and car users were undertaken over a six-month period between November 2000 and May 2001. Rail, bus and ferry interviews were undertaken onboard vehicles. Quotas were set by:

- Mode (rail, bus, ferry, car);
- Time period (peak and off peak); and
- Destination (CBD or non CBD).

Car interviews were undertaken at home or at major activity centres.

The SP surveys estimated relative values for travel time, fare, travel mode and service frequency. The SP survey was relatively conventional: respondents were presented with a series of hypothetical but realistic pair-wise travel choices. The choices were presented on show cards that familiarised the respondents with the journey attributes and made the exercise more inviting. Interviewers assisted by explaining the choices to the respondent and recording the preference.

Two SP questionnaires were developed. One questionnaire presented a choice between two public transport journeys (PT vs PT) with different service features. The other SP provided a choice between public transport and car journeys (PT vs Car). Respondents completed one of the two questionnaires. Each interview provided either eight or nine travel choice observations (depending on the survey). In total, a data base of 27,000 travel choice observations was developed. Conventional mode choice models were fitted to the data.

The relative valuations were validated using a number of "tests" regarding parameter sign, size and accuracy (*t*-values). Some parameter revisions were necessary to about 15% of parameters where estimates were of wrong sign or incorrect size.

The value of PT in-vehicle time ranged from \$5.90 to \$10.70 per hour across the market segments. Ferry users had the highest values of time with bus users the lowest values. CBD trips had higher values of travel time than non-CBD trips with peak travellers having a higher value than off-peak travellers.

TABLE 2: VALUE OF PUBLIC TRANSPORT IN-VEHICLE TIME
Dollar value of one hour of PT in-vehicle time in equivalent PT fare

TRAVEL PERIOD	PT USERS	CAR USERS	PT + Car USERS
Peak	8.70	9.90	9.80
Off Peak	6.50	7.40	7.40
Weekday Average	7.60	8.30	8.20

MODE	SHORT (UNDER 30 MINUTES)				MEDIUM (30 – 45 MINUTES)			
	PEAK		OFF-PEAK		PEAK		OFF-PEAK	
	CBD	NON CBD	CBD	NON CBD	CBD	NON CBD	CBD	NON CBD
Bus	9.20	7.70	7.50	5.90	9.20	8.70	7.60	7.50
Rail	9.30	6.90	6.90	6.00	8.80	7.70	7.90	6.70
Ferry	10.70	-	8.30	-	-	-	-	-
Car	10.60	9.00	8.30	7.10	10.10	8.00	9.00	6.40

The values compare with $12/hr for commuters and $6/hr for non-commuters estimated by similar SP market research undertaken by PCIE and Ove Arup for longer distance travel in South East Queensland. SP Surveys used in the 1998 Parramatta-Chatswood patronage forecasts estimated a value of $7.40/hr. Surveys undertaken for the Sydney - Newcastle Rail Upgrade Patronage Study (2000) by PCIE/BNR Consulting estimated a value of $6.50/hr for medium distance rail peak. SP surveys reported by RPPK in the Liverpool-Parramatta Transitway Patronage Study established values of peak PT in-vehicle time of $6.40/hr for bus users and $10.30/hr for car users.

A minute of service interval (minutes between departures) was valued the same as 0.45 minutes of PT in-vehicle travel time with PT users having a higher value than car users. Off-peak PT users valued service interval more than peak users.

The value of service interval ranged from 0.15 for peak medium distance CBD rail travellers to 0.62 for peak non-CBD bus travellers. Service interval was valued higher for shorter distance trips. Rail users also valued service interval lower than bus users which may reflect better waiting conditions with ferry users having the lowest peak value.

The wide range in the value of service interval may reflect regular users of less frequent services “ending to know their timetable” and therefore timing their stop/station arrival. As a result, waiting time will be less than half the service interval with travellers tending to value timetable convenience (the degree to which the timetable coincides with their desired departure or arrival time). For more frequent services (every ten minutes or less) passengers will start to “turn up at random”. Then, the expected waiting time becomes half the service interval and the value of waiting will tend to reflect waiting conditions and service reliability.

TABLE 3: VALUE OF SERVICE INTERVAL

Value of one minute of service interval (mins between departures) in equivalent PT in-vehicle time

TRAVEL PERIOD	PT USERS	Car USERS	PT + Car USERS
Peak	0.49	0.44	0.44
Off Peak	0.56	0.46	0.46
Weekday Average	0.52	0.45	0.45

MODE	SHORT (UNDER 30 MINUTES)				MEDIUM (30 – 45 MINUTES)			
	PEAK		OFF-PEAK		PEAK		OFF-PEAK	
	CBD	NON CBD	CBD	NON CBD	CBD	NON CBD	CBD	NON CBD
Bus	0.39	0.62	0.39	0.30	0.21	0.28	0.30	0.19
Rail	0.37	0.61	0.41	0.41	0.15	0.34	0.21	0.19
Ferry	0.21	-	0.31	-	-	-	-	-
Car	0.38	0.50	0.38	0.38	0.18	0.31	0.25	0.21

For comparative purposes, the SE Queensland study of longer distance travel estimated a commuter valuation of service interval of 0.4 and a non-commuter valuation of 0.9 (PCIE/Ove Arup, op cit) . The Parramatta-Chatswood 1996 study valued a minute of service interval equal to 0.6 minutes of in-vehicle time - the same as a 1992 study of Sydney rail travel by SDG/Transmark. The Sydney - Newcastle Rail Upgrade Study estimating a value of 0.76. Higher values of 0.7 to 1.26 were estimated by the 1999 Liverpool-Parramatta Transitway Patronage Study.

The survey also estimated a same mode transfer penalty of ten minutes with car users having a higher penalty of twenty minutes. A "park and ride" penalty was also estimated at seven minutes (in addition to any walking time). PT users were estimated to value walk time 1.7 times in-vehicle time with car users valuing walk time at 2.1 times in-vehicle time.

Car drive time was valued at $9.10/hr when measured in PT fare. PT users valued car drive time higher at $11.50/hr than car users ($10.60/hr). Off-peak values were lower at $9.60 /hr and $8.10 /hr respectively. Car users were suggested to value drive time 10% higher than PT in-vehicle time with PT users valuing car drive time 21% higher.
Evaluated in terms of car park charge however, the value of car drive time fell to $5.70 per hour, which was roughly half the PT fare value; this suggested a significant resistance to car park charge. Finally, car park search time was valued 15% more than car drive time with no significant differences estimated by market segment.

The Second Best Alternative (SBA) survey provided data on car availability - to segment the mode choice model and weight the relative valuations; and travel alternatives - to widen the travel set to include walk, bicycle, taxi and "not travel" which are often neglected in travel demand models.

A sample of 906 completed SBA questionnaires was obtained for bus, rail and ferry users. Car users were not surveyed. In terms of car availability, just under three-quarters (72%) of PT users could have made the trip by car either as driver or passenger. Car availability was highest at 77% amongst rail users and lowest at 68% amongst bus users. Car availability was higher at 80% for non-CBD peak trips and was lowest at 60% for bus users making peak trips to CBD destinations.

The SBA survey results suggested the potential to mis-forecast demand response by restricting the travel alternatives to PT and car. One quarter of PT respondents stated they would have walked, cycled, used taxi or "not travelled" if their current mode was unavailable,. For PT users who did not have a car available, walk, cycle, taxi or "not travel" would have been chosen by 50% or more of respondents.

TABLE 4: SECOND BEST TRAVEL ALTERNATIVE PROFILE BY MARKET SEGMENT
Travel alternative if current mode was not available

TRIP PROFILE			NO CAR AVAILABLE				CAR AVAILABLE				
PERIOD & LENGTH	TRIP DEST	FERRY AVAIL	PT	OTHER MODE	NOT TRAVEL	SAMPLE SIZE	CAR	PT	OTHER MODE	NOT TRAVEL	SAMPLE SIZE
Peak Short	CBD	Yes	44%	26%	30%	23	49%	33%	11%	7%	43
Peak Short	CBD	No	38%	38%	24%	37	64%	17%	7%	12%	104
Peak Short	Non CBD	No	32%	36%	32%	28	69%	11%	14%	6%	65
Peak Med	CBD	No	33%	23%	44%	39	66%	15%	7%	12%	105
Peak Med	Non CBD	No	-	-	-	8	82%	12%	-	6%	33
OffPk Short	CBD	Yes	-	-	-	9	57%	43%	-	-	28
OffPk Short	CBD	No	47%	13%	40%	32	58%	19%	8%	15%	62
OffPk Short	Non CBD	No	-	-	-	5	66%	19%	15%	-	27
OffPk Med	CBD	No	36%	24%	40%	58	66%	15%	6%	13%	154
OffPk Med	Non CBD	No	-	-	-	10	72%	14%	6%	8%	36

PT: bus, rail or ferry; Other Mode: walk, cycle and taxi. Note data was weighted by BCC travel market share data. Results for small sample sizes (10 or less) not shown..

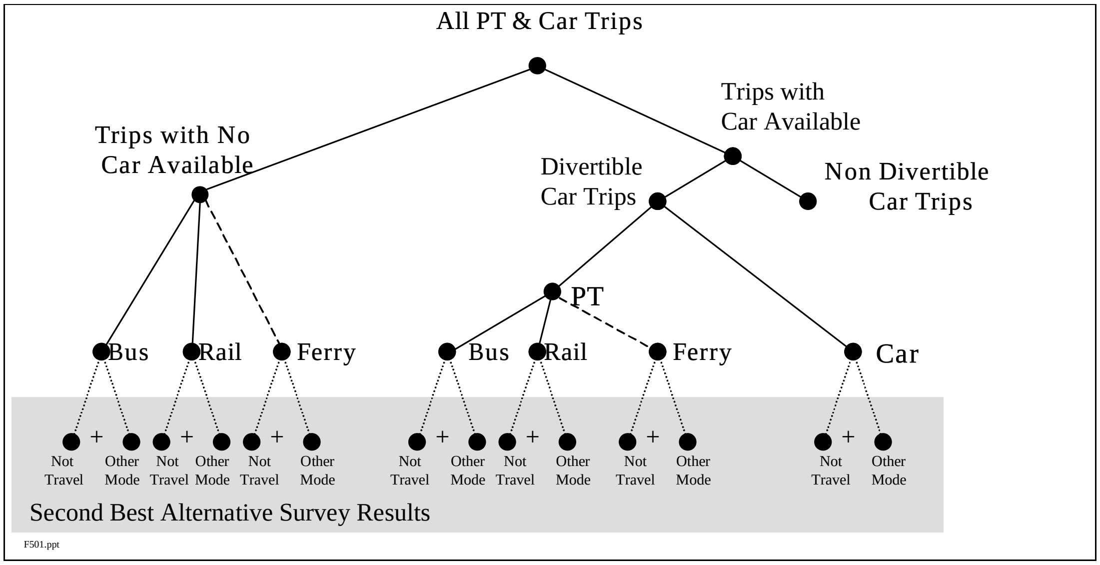
Choice of walk, cycle and taxi as the SBA ranged up to 15% for PT users with a car available. There was little difference between peak and off-peak respondents however. The percentage was higher for short non-CBD trips than for medium distance trips and for trips to CBD destinations.

Suppressed ("not travel") trips accounted for up to 15% with the percentage higher for CBD trips than non-CBD trips (12% compared to 6% for medium peak trips). However, for respondents with no car available, the percentage was higher ranging from 24% - 44%.

3. Scenario Model

The "scenario model" combined the SP and SBA parameter estimates together with BCC trip and service level data. Trip and service level data was provided for sixteen travel sectors including a "ferry zone" for peak and off peak travel. Trips were summed by direction to give 122 zone pair flows. The mode choice model included three sub-models.

FIGURE 1: SCENARIO MODEl



One sub-model estimated the market share between bus, rail and ferry (if available) for travellers without a car available. A second sub-model estimated the market share between bus, rail, ferry and car for travellers with a car available. The third sub-model incorporated the walk, cycle, taxi and "not travel".

For trips with a car available, a composite PT mode was compared with car, with only car trips considered divertible to PT included. Trips that require a car for work eg tradespeople, couriers etc were excluded). The next level down compared bus, rail and ferry (if relevant).

TABLE 5: DIVERTIBLE CAR MARKET[(a)]

	PEAK		OFF-PEAK	
	CBD	NON-CBD	CBD	NON-CBD
Car Trips Divertible to PT	85%	70%	75%	60%

(a). Percent of car trips divertible to Public Transport.

A generalised cost including fare, PT in-vehicle time, service interval and car drive time was estimated for each zone pair for the peak and off peak travel periods for each travel mode. For bus, rail and ferry, estimated generalised cost was estimated with and without a car available. The estimated SP parameters were used to express the service level attributes in equivalent public transport in-vehicle time.

The SP generalised cost models were calibrated on BCC trip data. The average of the "revealed preference" (RP) and SP mode choice sensitivity parameter was used (generally, the SP parameters gave the highest elasticity estimates and the RP parameters the lowest parameters). For each flow, the "constant" was internally calculated to ensure that the predicted share was equal to the BCC estimated share.

The generalised time parameter was estimated with accuracy in the Car vs PT sub-model with |t| values of 2.7 and 4.4 for the peak and off-peak respectively. The PT vs PT sub-models had lower |t| values for the generalised parameter ranging from 1.1 to 3.0. The estimated generalised time parameters had correct negative sign. The estimated parameters for the PT vs PT sub-models were larger than in the PT vs Car sub-models suggesting a greater sensitivity to differences in generalised time between PT modes than between PT and car.

TABLE 6: ESTIMATED MODE CHOICE MODELS

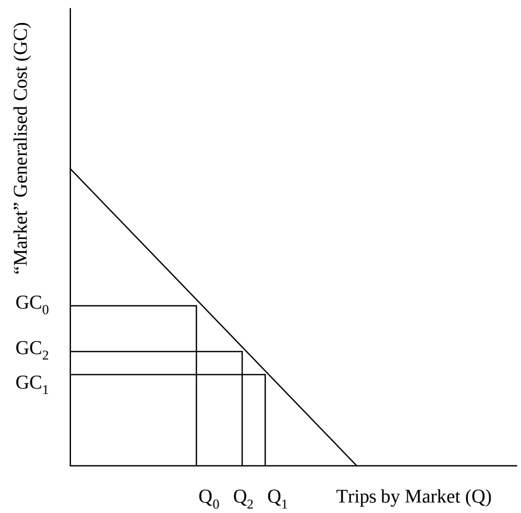
	PEAK		OFF-PEAK	
	CONSTANT	GENERALISED TIME	CONSTANT	GENERALISED TIME
Car v PT Car Available	-2.26	-0.02	-2.43	-0.03
|t| value	19.4	2.7	19.6	4.4
Flows Included[(a)]	122		100	
PT v PT Car Available	-0.93	-0.04	-0.27	-0.06
|t| value	3.5	1.5	1.3	3.0
Flows Included[(a)]	80		77	
PT v PT No car Available	-0.55	-0.03	0.126	-0.055
|t| value	2.1	1.3	0.6	2.9
Flows Included[(a)]	80		77	

(a). Percent of car trips divertible to Public Transport.

The model was extended to include walk, cycle, taxi and 'not travel' using the results of the Second Best Alternative (SBA) survey. The SBA survey provided the number of trips that would use another transport mode (walk, cycle or taxi) or would 'not travel' if their chosen mode was not available.

This data was used in combination with an estimate of the total market generalised cost to derive a market demand curve for car, rail, bus and ferry travel. The impact of removing each primary mode was determined separately. For bus, the impact on trips was determined by applying the SBA proportion who would continue to use rail, ferry and car (i.e. one minus the proportion walking, cycling, using taxi or 'not travel'). The composite cost was determined before and after the removal of bus (using the log sum of the individual generalised costs). The market demand curve was assumed to be a straight line between the two points Q1GC1 and Q0GC0. The estimated market demand curve was then used to forecast the number of trips diverting to walk, cycle, taxi and 'not travel' by determining the impact on total market generalised cost of a 10% increase in bus fares.

FIGURE 2: IMPACT OF BUS UNAVAILABILITY



Q_0=SBA Proportion (1-{"not travel" + other (walk, cycle, taxi)}) . Q_1
GC_1= Base Composite Cost of Car, Bus, Rail and Ferry
GC_0=Base Composite Cost of Car, Rail and Ferry (No Bus Available)
GC_2=Composite Cost of Car, Bus, Rail and Ferry with Bus Fares Increased by 10%

FA1.ppt

The demand curve was separately estimated for trips with and without a car available for peak and off-peak travel for each of the 122 markets. Separate models were also fitted for bus, rail and ferry. The same approach was used for car assuming the same SBA profile as for PT users with a car available.

4. Estimated Demand Elasticities

Demand elasticities measure the percentage change in demand in response to a percentage change in a service attribute. Demand was measured in trips (number of single journeys) and passenger kilometres.

Where Q defines the patronage of mode i or j, X defines the service level attribute and Δ defines the change (new – base).

The 'own' elasticity measures the demand response to a change in 'own' mode service level (e.g.) the percentage reduction in bus patronage from a 10% increase in bus fare).

Own Elasticity: $$\frac{\%\Delta Qi}{\%\Delta Xi}$$

The cross elasticity measures the percentage response in rail or car patronage to a change in bus fare.

Cross Elasticity: $$\frac{\%\Delta Qj}{\%\Delta Xi}$$

The transfer elasticity disaggregates the "own" elasticity to indicate the response by source mode. Four transfer elasticities were estimated: PT, car, other travel modes and "not travel".

Transfer Elasticity: $$\frac{-\Delta Qj / Qi(base)}{\%\Delta Xi}$$

The sum of the transfer elasticities is the own elasticity. For example, in response to a 10% fare increase, bus patronage may decline by 3% giving a demand elasticity of –0.3. Of the reduction in bus patronage, 25% may divert to other PT modes, 35% to car, 20% to other travel modes and 20% might not travel. The transfer elasticities would be -0.075, -0.105, -0.06 and -0.06 respectively.

Elasticities were estimated for PT fare, PT in-vehicle time, PT service interval (minutes between departure) and car drive time. An overall PT elasticity was also estimated that summed the demand response across bus, rail and ferry. A conditional "own" and PT transfer elasticity was also estimated for fare[1]. Standard fare elasticities assume that only the fare of the PT mode in question changes. All other PT fares remain the same. The conditional PT fare elasticity measures the change in one PT mode's patronage in response to an "across the board" change in all PT fares (all PT fares changing by the same percentage amount).

Demand response to changes in service level was assessed for 122 individual zone pair flows then aggregated to derive an overall travel market elasticity. Peak, off peak and weekday elasticities were estimated. Peak refers to travel between 0700 and 0900 and between 1600 and 1800. Off-peak refers to travel during the rest of the weekday. Weekend and holiday travel was excluded. Elasticities were estimated for CBD and non-CBD flows. The maximum and minimum elasticity was also determined across the zone pair flows.[2]

The weekday bus fare elasticity was estimated at –0.36. For a 10% increase in bus fare all other PT fares and service levels held constant. Bus patronage was forecast to reduce by 3.6%. The rail fare elasticity was slightly higher at –0.38.[3] The highest weekday fare elasticity was –0.56 for ferry.

Fare elasticities were lower in the peak than in the off-peak. Peak elasticities were –0.25 bus, –0.28 rail and –0.38 ferry. Off-peak elasticities were nearly twice as high at –0.45 bus, -0.53 rail and –0.7 ferry.

The overall PT fare elasticities were lower due to intra-PT modal diversion being discounted and the response of the whole PT market being measured rather than just the PT mode experiencing the fare increase. The weekday PT elasticity was similar for bus and rail at –0.11 and –0.12 respectively. The PT elasticity for ferry was much lower at –0.01 due to ferry's much smaller PT share.

[1] ***Although it is possible to calculate conditional elasticities for service interval and PT in-vehicle time, there is little practical relevance for such a measure. It is unlikely that bus and rail travel times or could ever be changed by exactly the same percentage amount.***

[2] ***Passenger passenger kilometre elasticities were also estimated although for brevity the results are not presented in this paper. The passenger kilometre elasticities were weighted by the road distance which attached greater importance to longer distance trips. Generally, the passenger kilometre elasticities were greater than the passenger trip elasticities.***

[3] ***All discussion of the relative size of elasticities ignores the negative sign.***

TABLE 7: FARE ELASTICITIES

Percentage change in trips to a 10% increase in service interval for each PT mode
(other PT modes remaining constant)

	PEAK			OFF-PEAK			WEEKDAY		
	BUS	RAIL	FERRY	BUS	RAIL	FERRY	BUS	RAIL	FERRY
Bus	-0.247	0.107	0.008	-0.449	0.138	0.018	-0.356	0.124	0.014
Rail	0.082	-0.281	0.003	0.174	-0.528	0.007	0.123	-0.382	0.005
Ferry	0.061	0.037	-0.378	0.162	0.060	-0.695	0.118	0.050	-0.559
PT	***-0.067***	***-0.096***	***-0.006***	***-0.160***	***-0.148***	***-0.016***	***-0.113***	***-0.122***	***-0.011***
Car	0.0043	0.0068	0.0005	0.0052	0.0052	0.0004	0.0049	0.0058	0.0004
PT	***40%***	***34%***	***44%***	***34%***	***34%***	***45%***	***36%***	***34%***	***45%***
Car	***35%***	***42%***	***35%***	***37%***	***30%***	***26%***	***36%***	***41%***	***28%***
Other	***13%***	***12%***	***12%***	***16%***	***13%***	***9%***	***15%***	***12%***	***10%***
NT	***13%***	***12%***	***8%***	***14%***	***13%***	***20%***	***13%***	***13%***	***17%***

Figures in bold = "own mode" elasticities; normal font = "cross" elasticities; bold italics = overall "PT" elasticities
Italics % is the percent diverting to each travel alternative with NT = not travel and Other = walk, cycle and taxi.

The estimated cross elasticities were positive. Patronage increases in response to a fare increases made to another mode. The rail and ferry weekday cross elasticities with respect to bus fares were the same at 0.12. However, the ferry cross elasticity with respect to rail fare was much lower at 0.05. The elasticities imply higher substitutability between bus and ferry than between rail and ferry. The cross elasticities with respect to ferry fare were much lower reflecting ferry's limited market penetration. The car cross elasticities were the lowest. With respect to bus fare, the weekday car cross-elasticity was 0.0049. For a 10% increase in bus fare, car trips are forecast to increase by just under half a percent. The small size reflects car's dominant market share and low substitutability between car and bus travel.

The largest diversion (hence transfer elasticities) was forecast to PT and car. The percent diversion to other modes (walk, cycle, taxi) and "not travel" was roughly half as large. Table 7 presents the diversion percentages. The implied transfer elasticities can be simply determined by multiplying the diversion percentage by the own elasticity. As an example, the implied weekday car transfer elasticity would be -0.128 with respect to bus fare (-0.356 x 0.36). The implied transfer elasticity for PT was approximately the same at 0.127 implying 1.27% of bus patronage would divert to rail and ferry combined. The transfer elasticity for other modes (walk, cycle, taxi) would be–0.053 and–0.047 for "not travel".

36% of bus patronage was forecast to divert to rail and ferry following a 10% bus fare increase, 36% to car, 15% to other modes and 13% would not travel. Therefore, "conventional modes" account for around three quarters of travel choice with walk, cycle, taxi and not travel accounting for the remaining quarter.

The off-peak transfer elasticities tended to be twice as high as in the peak. For peak travel however, car had a relatively higher transfer elasticity with that for "not travel" being correspondingly lower.

The estimated elasticities were of similar magnitude to other Australian and overseas estimates for urban public transport. For rail, NSW CityRail Planning and Development reports an overall fare elasticity of –0.45 with a peak elasticity of -0.4 and an off-peak fare elasticity of –0.55[4]. By comparison, the Brisbane elasticities were estimated at–0.39 (weekday), -0.28 (peak) and –0.53 (off-peak). The Brisbane peak elasticity is 30% lower with the off-peak elasticity 4% lower. Overall, the Brisbane weekday elasticity is 14% lower than the Sydney estimate. For Sydney ferries, Hensher and Raimond estimated a range for the commuter market of–0.18 to –0.34[5].

The conditional fare elasticities (the impact of an across the board (bus, rail and ferry) increase in PT fares) were lower reflecting less intra-PT diversion when all PT fares increase by the same percentage amount. The overall PT conditional fare elasticity was higher however reflecting a greater diversion from car, other modes and "not travel" with an across the board fare increase rather than increases in individual PT modes. For a 10% increase in all PT fares, PT patronage was forecast to reduce by 1.7% in the peak, 3.2% in the off-peak and 2.5% per weekday.

TABLE 8: CONDITIONAL FARE ELASTICITIES
Percentage change in trips to a 10% increase in all PT fares

	PEAK	OFF-PEAK	WEEKDAY
Bus	-0.133	-0.293	-0.219
Rail	-0.196	-0.350	-0.265
Ferry	-0.282	-0.479	-0.394
PT	-0.170	-0.325	-0.247
Car	0.0116	0.0109	0.0111

By comparison, London Underground estimated a conditional fare elasticity of –0.26 (conditional on Underground, bus, rail and underground fares rising at the same rate) for underground patronage[6] with the elasticity for an increase in underground fares alone estimated at –0.67 (160% higher than the conditional elasticity). For Brisbane, the weekday conditional fare elasticity was estimated at –0.39 for rail with the unconditional fare elasticity estimated at -0.27. The difference between the conditional and unconditional rail elasticities for Brisbane was therefore smaller than for London suggesting the substitutability between bus, rail and ferry in Brisbane to be less than between bus and rail and underground in London.

The model estimated significant variation in elasticity between corridors. Table 10 presents the maximum and minimum elasticity estimates derived for the bus market. Across corridors, those where bus competes most strongly with other PT modes (rail and ferry) were found to be over twice as elastic as the system average. On the other hand those corridors in which there was little or no competition had fare elasticities significantly lower than average.

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[4] ***CityRail 1997 "A Compendium of CityRail Travel Statistics – Second Edition, March 1997", Market Analysis Group CityRail Planning.***

[5] ***Hensher, D and Raimond, T., (1995) 'Evaluation of Fare Elasticities for the Sydney Region', Institute of Transport Studies.***

[6] ***London Underground "The Economic Benefits of London Underground" Business Planning, London Underground, 55 Broadway London SW1H 0BD, September 1994.***

TABLE 9: VARIATION IN BUS FARE ELASTICITY BY CORRIDOR

	10% INCREASE IN ONE PT FARE, OTHER PT FARES HELD CONSTANT		
	PEAK	OFF-PEAK	WEEKDAY
Bus Max	-0.47	-0.94	-0.78
Bus Av	--0.247	-0.449	-0.356
Bus Min	-0.16	-0.27	-0.24

The estimated in-vehicle time elasticities were higher than for fare. For bus, the weekday in-vehicle time elasticity was–0.69, just under twice the fare elasticity. The weekday rail in-vehicle time elasticity was slightly lower at -0.50, with the ferry elasticity -0.62.

TABLE 10: PT IN-VEHICLE TIME ELASTICITIES
Percentage change in trips to a 10% increase in service interval for each PT mode
(other PT modes remaining constant)

	PEAK			OFF-PEAK			WEEKDAY		
	BUS	RAIL	FERRY	BUS	RAIL	FERRY	BUS	RAIL	FERRY
Bus	-0.579	0.201	0.009	-0.781	0.247	0.019	-0.688	0.226	0.014
Rail	0.204	-0.501	0.004	0.327	-0.947	0.008	0.259	-0.700	0.006
Ferry	0.110	0.032	-0.468	0.238	0.040	-0.725	0.183	0.036	-0.615
PT	***-0.151***	***-0.168***	***-0.008***	***-0.269***	***-0.268***	***-0.016***	***-0.210***	***-0.218***	***-0.012***
Car	0.0097	0.0124	0.0006	0.0088	0.0096	0.0005	0.0091	0.0106	0.0005
PT	***42%***	***35%***	***44%***	***36%***	***33%***	***45%***	***38%***	***34%***	***45%***
Car	***34%***	***43%***	***36%***	***36%***	***41%***	***26%***	***35%***	***42%***	***29%***
Other	***11%***	***9%***	***12%***	***13%***	***11%***	***9%***	***13%***	***11%***	***10%***
NT	***13%***	***12%***	***8%***	***15%***	***14%***	***20%***	***14%***	***13%***	***16%***

Figures in bold = "own mode" elasticities; normal font = "cross" elasticities; bold italics = overall "PT" elasticities
Italics % is percent diverting to each travel alternative with NT = not travel and Other = walk, cycle and taxi.

The transfer percentages suggest intra-PT substitution to be the greatest for ferry and least for rail. For rail, car transfer was higher than intra PT transfers. "Not Travel" and "other" was forecast to account for one quarter of diversion with "not travel slightly higher than diversion to "other" (walk, cycle and taxi).

NSW CityRail Planning and Development estimated an overall rail in-vehicle time elasticity of –0.51 with a peak elasticity of -0.45 and an off-peak elasticity of –0.61. The Sydney elasticities are one fifth lower than the Brisbane estimates of –0.63 (weekday), -0.53 (peak) and –0.75 (off-peak). The Sydney elasticity was greater than for fare although the difference was proportionately less than for Brisbane (12% higher compared to 75% higher for Brisbane rail).

Service interval may be thought of as the mirror image of service frequency. Reducing the frequency of services increases the service interval between departures. The estimated service interval elasticities were the lower than the estimated in-vehicle time and fare elasticities. The weekday bus and rail elasticities were of similar size at –0.11 and –0.13

respectively. The ferry elasticity was twice as large at –0.25 reflecting shorter trips, lower service ferry frequencies and greater intra-PT competition.

TABLE 11: SERVICE INTERVAL ELASTICITIES
Percentage change in trips to a 10% increase in service interval for each PT mode
(other PT modes remaining constant)

	PEAK			OFF-PEAK			WEEKDAY		
	BUS	RAIL	FERRY	BUS	RAIL	FERRY	BUS	RAIL	FERRY
Bus	-0.111	0.046	0.005	-0.265	0.091	0.016	-0.195	0.070	0.011
Rail	0.034	-0.127	0.002	0.104	-0.329	0.007	0.065	-0.217	0.004
Ferry	0.033	0.015	-0.248	0.082	0.038	-0.590	0.061	0.028	-0.443
PT	***-0.032***	***-0.045***	***-0.004***	***-0.094***	***-0.089***	***-0.013***	***-0.063***	***-0.067***	***-.009***
Car	0.0020	0.0031	0.0003	0.0030	0.0030	0.0003	0.0026	0.0030	0.0003
PT	***36%***	***32%***	***45%***	***34%***	***36%***	***45%***	***34%***	***35%***	***45%***
Car	***36%***	***43%***	***34%***	***35%***	***37%***	***25%***	***35%***	***39%***	***27%***
Other	***15%***	***14%***	***13%***	***17%***	***15%***	***9%***	***16%***	***15%***	***10%***
NT	***13%***	***11%***	***8%***	***14%***	***12%***	***21%***	***13%***	***12%***	***18%***

Figures in bold = "own mode" elasticities; normal font = "cross" elasticities; bold italics = overall "PT" elasticities
Italics % is percent diverting to each travel alternative with NT = not travel and Other = walk, cycle and taxi.

Peak elasticities were lower than off-peak elasticities. For bus, the peak elasticity was –0.11, 52% of the off-peak elasticity of –0.27. For rail, elasticities of –0.13 and –0.33 were estimated for the peak and off-peak. The off-peak ferry elasticity was the largest elasticity at –0.59 compared to 0.25 in the peak. Douglas and Parrish estimated a weekday service interval of –0.16 for NSW rail services. Compared to the weekday rail elasticity for Brisbane, the Sydney elasticity is 20% lower. For Sydney CBD rail trips, a peak elasticity of–0.11 and an off-peak elasticity of –0.17 were estimated. For non-CBD rail trips, the service interval elasticities were slightly higher at –0.15 and –0.23 respectively.

The car drive time elasticity was lower than PT in-vehicle time with a 10% increase in car drive times estimated to reduce car trips by 0.4%. The peak elasticity was slightly higher than the off-peak elasticity at –0.03 and –0.027 respectively. Rail had the highest peak cross elasticity of 0.28. Rail also had the highest off-peak cross elasticity of 0.59. The ferry peak cross elasticity was lowest at 0.09. Overall, peak PT trips were estimated to increase by 2.3% in response to a 10%increase in car drive times. Diversion to PT was forecast to be greater in the off peak than in the peak with transfer elasticities of –0.025 and –0.026 respectively. The transfer elasticities suggest that over 61% of trips lost to car from a 10% increase in drive times would divert to PT. 38% would use another travel mode or not travel.

TABLE 12: CAR DRIVE TIME ELASTICITIES
Percentage change in trips to a 10% increase in car drive time

	CAR DRIVE TIME INCREASED BY 10%		
	PEAK	OFF-PEAK	WEEKDAY
Bus	0.19	0.31	0.26
Rail	0.28	0.59	0.42
Ferry	0.09	0.13	0.11
PT	***0.23***	***0.42***	***0.33***
Car	-0.038	-0.043	-0.041
PT	***69%***	***58%***	***62%***
Other	***18%***	***20%***	***19%***
NT	***13%***	***22%***	***19%***

Figures in bold = "own mode" elasticities; normal font = "cross" elasticities; bold italics = overall "PT" elasticities
Italics % is percent diverting to each travel alternative with NT = not travel and Other = walk, cycle and taxi.

5 Conclusions

Spreadsheet forecasting models have development markedly over the last decade with the advancement in personal computers. The scenario model developed for Brisbane has integrated large scale Stated Preference survey data into a spreadsheet corridor forecasting model. The resultant model provides a flexible, efficient and transparent way to model the impact of public transport service level and fare changes.

The approach also augmented the conventional choice of car versus public transport to take account of walk, cycle, taxi and not travel. These less conventional alternatives are shown to account for one quarter of demand response; their inclusion is considered to result in an improvement forecast accuracy of demand response to fare and service level changes.

However, the substitutability of different travel alternatives was found to vary markedly from corridor to corridor. Walk and cycle were important for shorter trips but less important the longer the trip. Ferry had only limited availability with bus and rail competing within limited catchments. Car availability and the need for car were also important choice determinants within the scenario model.

As a result, overall demand response and the composition of demand response varied by corridor. By using a disaggregated method to determine the overall demand elasticities, the scenario model was able to take account of spatial as well as temporal (peak – off peak) variation.

The parameters have been used in the Brisbane Strategic Travel Model (BSTM) and the Translink fares model. The BSTM has adopted the value of time for public transport users; value of time for car users; service interval weights; access time weights and transfer penalty into the mode choice and assignment sub-components. The BSTM Mode Choice Module is now being used to analyse the impacts of public transport service level changes and also travel demand management measures. As part of the Queensland Government movement to integrated ticketing system in South East Queensland, a fares model has been developed to analyse patronage and fare box revenue impacts. The Translink model has been based on existing ticketing information and has used the elasticities derived from the scenario model.

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